Surigao City Campus

Bachelor of Science in Electrical Engineering

SURIGAO STATE COLLEGE OF TECHNOLOGY

SSCT

"For Nation's Greater Heights"

I.4.7. development of low-cost sustainable eco-materials for electric installation

1.4.7

APPROVAL SHEET

This Project Study entitled **"DESIGN OF A SOLAR PUMPING STATION FOR RICE PADDY IN CAGNIOG,SURIGAO CITY"** prepared by **Reymart L Abapo, Jonard R.Becerro , Gemmar D.Celmar, Eldo S. Eder, Miguelito A.Virtudazo Jr.,** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

ENGR. VICENTE Z. DELANTE, M.ENG'G
Co-Author

==

PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 06, 2022.

ENGR. ROBERT R. BACARRO, MECE, MBA
Chairman

ENGR. VIRNE P. PORTUGUES
Member

ENGR. FEDERICO A. AVES, Jr., MST, M.ENG'G
Member

==

Accepted and approved in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical Engineering.

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, College of Engineering and Information Technology

Date: June 10, 2022

1.4.7

APPROVAL SHEET

This Project Study entitled **"THE IMPLEMENTATION OF THERMOELECTRIC SYSTEM"** prepared by **Delf Enriq Aloyon, Lord John Kevin Bangcoyo, Reiolvi Orcullo, Lowie Pejer, Hannie Bert Quinalagan** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

ENGR. JERRY I. TELERON PhD. PCpE
Co-Author

==

PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 07, 2022.

ENGR. ROBERT R. BACARRO, MECE, MBA
Chairman

ENGR. VICENTE Z. DELANTE, M.ENG'G
Member

ENGR. FEDERICO A. AVES, Jr., MST, M.ENG'G
Member

==

Accepted and approved in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical Engineering.

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, College of Engineering and Information Technology

Date: June 10, 2022

1.4.7

APPROVAL SHEET

This Project Study entitled **"DESIGN OF AUTOMATIC IRRIGATION SYSTEM"** prepared by **Luzyl M. Baguinaon, Stephane Grace D. Coquilla, Jeorgie G. Cutamora, Kessah Jean B. Navarro, Khey Sheenamae E. Tampipi** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

ENGR.ROBERT R. BACARRO, MECE, MBA
Co-Author

==

PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 06, 2022.

ENGR. VICENTE Z. DELANTE, M.ENG'G
Chairman

ENGR. JERRY I. TELERON, Ph. D.
Member

ENGR. FEDERICO A. AVES, Jr., MST, M.ENG'G
Member

==

Accepted and approved in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical Engineering.

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, College of Engineering and Information Technology

Date: June 10, 2022

7

PERFORMANCE ANALYSIS OF MICRO ELECTRIC DIAPHRAGM PUMP WITH SOLAR PANEL CONNECTIONS

Geno U. Borja[1], Michael Paul M. Saldivar[2], Robert Bacarro[3]
Surigao State College of Technology, Surigao City, Philippines
gborja@ssct.edu.ph, msaldivar@ssct.edu.ph, ssct.bacarro@gmail.com

Abstract: The purpose of this study is to determine the best connection for the micro electric diaphragmpump[1]. The system is connected directly from the solar panel to the pump to determine the best connection for thepump[2]. The solar irradiance in our region is abundant with an average of 76183 lux/day or 601.8483w/m2/day[3]. Based on the experiment that we conducted the best connection for the system is to connect in parallel for higher flow-rate and the pump operation isnormal[4].

Keywords:*Solar Panel, Micro Electric, Pump, Series, Parallel*

1. INTRODUCTION

The sun has produced energy for billions of years, and it is the most important source of energy for all life forms. It is a completely renewable source of energy unlike non-renewable sources such as fossil fuels. The sun provides a consistent and steady source of solar irradiance. Solar Power technologies use the sun's energy to light homes, produce hot water, heat homes, and produce electricity.[1]

In the Philippines, the potential is even greater than the inspirational target of 1,528MW attributed to solar in the National Renewable Energy Plan until 20130. According to the DOE's 2009-2030 Power Development Plan (PDP), the country's energy consumption is seen reaching 149,067 gigawatt-hours (GWh) by 2030, from an estimated demand of 86,809 GWh by 2018 and actual demand of 55,417 GWh in 2008.[2]

The yearly monthly daily average irradiance yield received in the horizontal plane of Surigao city is about 7.5 kW h/m2 /day. With theLatitude: +9.8 (9°48'00"N) andLongitude: +125.4 (125°28'12"E)[3]

Photovoltaic (PV) technology converts solar light directly into electricity using semiconductor PV cells. Photovoltaic or solar cells are composed of semiconductor materials, such as silicon, single-crystalline thin films, and polycrystalline thin films. A key feature of solar cells is the built-in electric field. This is because of the different semiconductor materials placed in contact with one another in the cell. One semiconductor is an n-type that has an abundance of electrons, which have a negative charge, while the other semiconductor is a p-type that has an abundance of "holes" with a positive electrical charge. The two semiconductors are globally neutral,
But when they come into contact with each other, a p-n junction forms creating an electric field.[4]

A Micro Electric Diaphragm Pump is a Positive displacement pump uses a combination of a reciprocating action and either a flapper valve or ball valve to transfer liquids. This pump is sometimes referred to as a membrane pump. Diaphragm pump are self-priming and are ideal for viscous liquids. Most models are available in electric, engine manual, air- operated, or hydrail configuration.[5]

1.2 Related Literature

Across the Saudi remote desert regions, the citizens use traditional systems to drawdown water from the wells, by using internal combustion engines, as diesel pumps. The yearly monthly daily average irradiance yield received on the horizontal plane is about 7.5 kW h/m2 /day and mid static levels of water ground sources are varying between 40 m and 120 m in Bahra valley (25 km of Madinah city). A comparative study has been done to select an optimum PVWPS configuration, based on experimental performance results of a helical pump, PV powered by 24 PV modules (75 W) in different configurations. Through the tests of each PVWPS configuration, the daily flow rate, hydraulic energy, and electrical energy are determined. Also, the pump efficiency and the total system efficiency curves are plotted. The goal of this work is to select an optimal combined PVWPS configuration, which can work at the optimum conditions in terms of cost and demand of the load.[6]

Over the past few years, UNICEF has explored new and innovative approaches to water supply, with a focus on affordable, scalable, environmentally-friendly, and climate-smart systems. Solar-powered water systems have the potential to meet all of these criteria. The systems can also help provide a higher quality service to multiple communities through the use of small piped water schemes and therefore play a key role in helping to accelerate the achievement of the Sustainable Development Goal (SDG) on water and sanitation.[7]

Renewable energy sources in general, and solar energy in particular, have the potential to provide energy services with zero or almost zero emissions. Solar energy is abundant and no other source of renewable energy is like solar energy. The solar-powered pumping system can be used everywhere but is suitable for rural areas facing an energy crisis. Due to its geographical position, the Sultanate of Oman and the Gulf region have ample sunshine throughout the year, which makes it an ideal location for the utilization of solar energy. Small farms, villages, and animal herds in developing countries require a hydraulic output power of less than a kilowatt. Many of these potential users are too far from an electrical grid to economically tap that source of power, and engine-driven pumping tends to be prohibitively expensive as well as unreliable due to the high cost of purchasing fuel and insufficient maintenance and repair capabilities.[8]

Like most other developing countries, Nepal has an extremely critical energy situation. So, the electricity generation from alternative sources has become the crying need for Nepal. Nepal is blessed with renewable energy resources and the availability of alternative energy creates opportunities for utilization in the power sector. Among different renewable energy sources like solar, wind, biomass, and others, the abundant availability of solar energy makes it the most promising one for Nepal. Nepal is situated at 28 degrees 00' N and 84 degrees 00' E which is an ideal location for abundant solar radiation. The daily average solar radiation in Nepal is 3.6 to 6.2KWh/m2 which is better compared to many nations that are working on solar energy on a large scale.[9]

Since the sharp oil price rises of the early 1970s, renewable energy sources have become a significant component of many rural development activities. In these areas, pump operation using renewable sources of energy is becoming popular. Worldwide, more than 20,000 solar pumps have been installed. Most of them are small systems for remote homes and communities. At present solar pumps are most cost-effective for applications with low power requirements (200 W-5 kW) in remote places. They are therefore well suited in developing countries to rural village applications.[10]

1.2 Theoretical Framework

Ohm's Law - states that the voltage or potential difference between two points is directly proportional to the current or electricity passing through the resistance, and directly proportional to the resistance of the circuit.

$V = I \times R$

Where:

V = impressed voltage (volt)

I = current drawn (ampere)

R = resistance (ohm)

Photovoltaic (PV) cell/Solar cell connection.

Parallel Connection - the current of each cell adds up.

$$I_t = I_1 + I_2$$

Series Connection – the voltage of each cell adds up.

$$V_t = V_1 + V_2$$

Electrical power - defined as the energy delivered from the electrical source to the loads.

$E = P \times t$ or $P = I \times V$

Where:

E = energy (joules)

P = power (watts)

t = time (seconds)

V = voltage (volt)

I = current (ampere)

1.3 Conceptual Framework

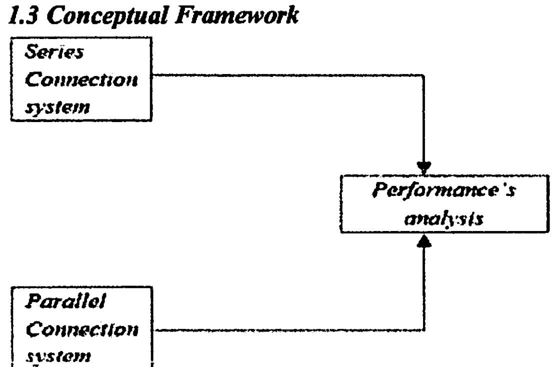

Fig. 1.*Theflow of the conceptual framework*

The general overview of project design is composed of three blocks, Series connection, Parallel connection, and performance analysis. Series/parallel will manage the power, voltage and current.Performance analysis data collected and stored. Consequently, through data gathered will determine the Performance analysis of micro electric diaphragm pump with solar panel connections as shown in fig. 1

1.4 Objectives

The general objective of this study is to determine the most effective connection of solar panels when connected to the micro electric diaphragm pump.

The specific objectives are the following:

1. To document the system configuration;
2. To analyze the solar radiation effectiveness to the solar panel;
3. To determine the performance of the pump when connected to:
    3.1. Series connected solar panel;
    3.2. Parallel connected solar panel;

2. METHODS

2.1 Research Design

The research design applied to our project study is case study design and descriptive design. For the case design, is in an in-depth study of a particular research problem rather than sweeping statistical survey. It is often used to narrow down a very broad field of research into one of a few easily researchable examples. The case study research design is also useful for testing whether a specific theory and model actually applies to phenomena in the real world. In our situation, we test the two solar panel with a rated of 50watts, 12volts a mono-crystalline type solar panel and a micro electric diaphragm pump 80watts, 6.6amperes to get the best performances of micro electric diaphragm pump in supplying water needed. For descriptive research designs to help provide answer to the questions of who, what, when, where and how associated with a particular research problem; a descriptive study cannot conclusively ascertain answer to why. In descriptive design we will answer what is the best connection to get the best performances of the system.

2.2 Project Design

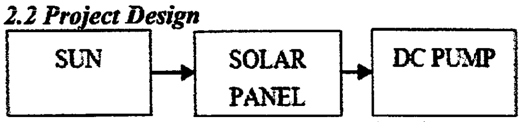

Fig. 2. ***Block diagram of the project design.***

Fig. 2 shows the first block represent the input; through the sun the Solar panels create energy from the sun that will produce different current. And the solar panel direct to the dc pump.

2.3 Project Development

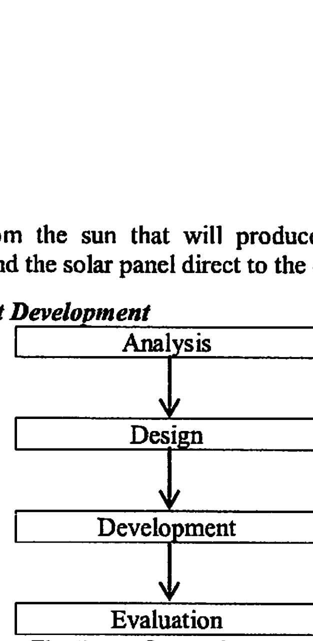

Fig. 3. ***The flow of Project Development***

Fig. 3 shows the flow of the development of the study. To achieve the solution of the problem identified analysis phase obtain in this study, searching for different technologies that will applicable and feasible to the problem identified. After analyzing the study, the block diagram is also obtaining to represent the design, to overview the structure of this system.

At this point, we obtain the development project by applying the different stages. We used the Gantt chart to monitor and accomplish the target time allocated for this project.

In this process, we evaluate the characteristic of the performance of the system to obtain an accurate and efficient output.

2.4 Project Implementation

To accomplish all the requirements of the project, the availability of the components online and local and obtain the computation cost of materials must be checked. The required components must be purchased and checked for markdowns of the product to avail discounts. Project based on the proposed design must be assembled and have the recommendation from advisers to achieve the quality and functionality.

2.5 Project Setting

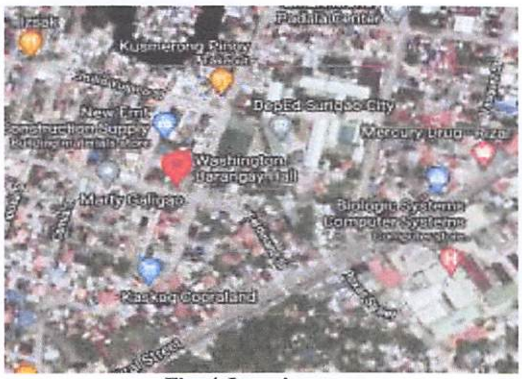

Fig. 4. ***Location map***

The project setting of the project was held in Brgy. Washington, Surigao City at my boarding house.

2.6 Instruments

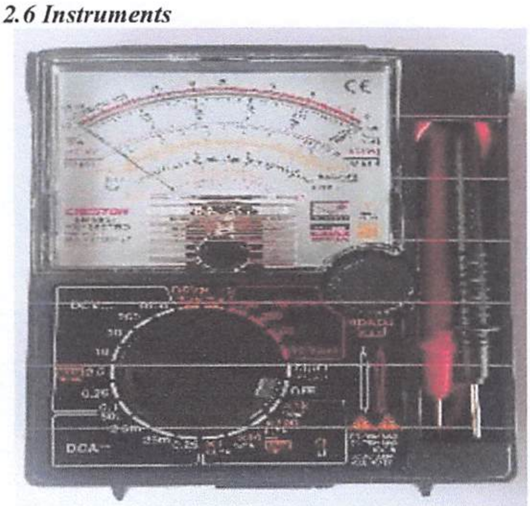

Fig. 5. ***Multi-tester/Multimeter.***

Fig. 6. ***Lux meter.***

For the quantitative instruments, we will use a multi-tester to measure the voltage, current, and resistance of the electrical connection. And Lux meters are used for measuring brightness or light intensity in lux.

2.7 Research Ethics

The proposed project study is to provide and implement accurate, precise results, methods, and procedures without falsification, fabrication of data gathered. To apply standard and balance evaluation of design, transparency of data analysis, and objectivity of interpretation of data are applied. The privilege of the group for the opportunity that of being part of this study, and for the development of the project study in the future was often to accept recommendations.

2.8 Data Collection Procedure

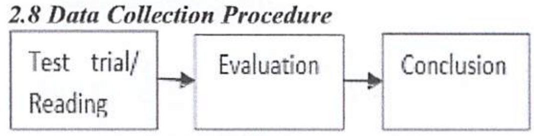

Fig. 7. ***The flow of Data collection.***

General overview and flow of diagram gathered quantitative and qualitative data. First, Test trial/Reading is chosen, it enables to ensure that the evidence obtained to enable the researcher to effectively address the research problem, where an understanding of a problem was developed and plans are made for some form of strategy. Questionnaires and interviews were the instruments that were obtained in this project study. Questionnaires to gather, and record the data categorically. Interviews to evaluate the performance and efficiency of the output of the project study.

2.9 Financial Analysis

Table 1. ***Financial Analysis of the Study***

Item/Size	Materials	Price(P)
2 pcs	Solar Panel	P 5000.00
1 pc	Micro Electric Diaphragm Pump	P 1380.00
6 meter	Electrical Wire	P 240.00
2 pcs	Electrical Tape	P 40.00
1 pair	Alligator Clip	P 10.00
8 meter	Portable Hose	P 320.00
1 pc	Multi-tester	P 650.00
	Total	P 7640.00

In this table, show all item/size, materials, and the prices are estimated.

3. RESULTS AND DISCUSSIONS

3.1 System Configuration of the Pump with Solar panel.

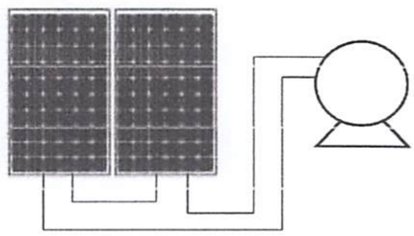

Fig. 8.*Series Connected Solar panel and pump.*

Figure 8 shows that the solar panel direct to connect the pump with series connection.

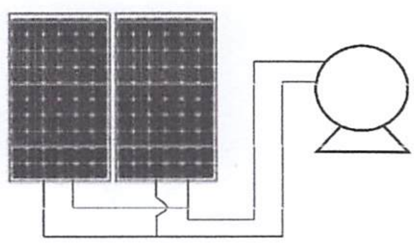

Fig. 9.*Parallel Connected Solar panel and pump.*

Figure 9 shows that the solar panel direct to connect the pump with parallel connection.

Fig. 10.*Micro Electric Diaphragm.*

Figure 10 show the micro electric diaphragm pump have a specification of 80 watts, 12 volts DC, 6.6A and 5.5L/min.

Fig. 11.*Solar Panel.*

Figure 11 shows the solar panel has a specification of 50 watts each.

Fig. 12.System Diagram.

Figure 12 shows that the system was installed.

3.2 Solar Radiation Effectiveness of the Solar Panel.

Table 2. *Parallel Connection No Load*

Time (H)	Solar Irradiance (lux) * 10	Voltage (V)	Current (A)	Power (W)
8:00	1380	20	5	100
9:00	7887	21	4.761	100
10:00	8382	21	4.761	100
11:00	8951	20.5	4.878	100
12:00	9217	20.9	4.784	100
1:00	9571	20.5	4.878	100
2:00	9571	21	4.761	100
3:00	8808	20.5	4.878	100
4:00	5845	20	5	100

Table 2 shows the data of the accuracy of output hourly for parallel connection no load for solar radiation effectiveness of the solar panel. As you can see the total power generated of two solar panel is 100 watts.

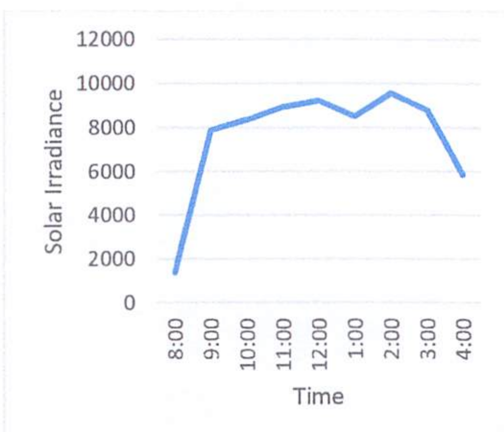

Fig. 13.*Graph of Parallel Irradiance of Solar Panel with no load*

Figure 13 shows the graph of hourly solar irradiance from 8am to 4pm with no load parallel connection.

Table 3. ***Series Connection No Load***

Time (H)	Solar Irradiance (lux)*10	Voltage (V)	Current (A)	Power (W)
8:00	2502	42	2.380	100
9:00	7969	44	2.272	100
10:00	8419	44	2.272	100
11:00	9097	44	2.272	100
12:00	9055	42	2.380	100
1:00	8971	42.5	2.352	100
2:00	9576	42.5	2.352	100
3:00	8487	42	2.380	100
4:00	4489	42	2.380	100

Table 3 shows the data of the accuracy of output for series connection no load for solar radiation effectiveness of the solar panel. The table show the solar irradiance hourly from 8am to 4pm. As you can see the solar irradiance hourly is different, it's because of the position of the sun.

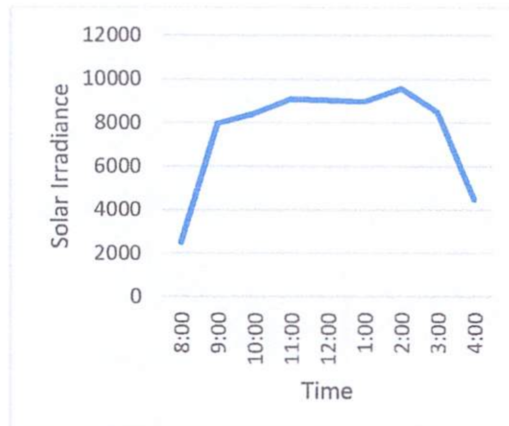

Fig. 14.*Graph of Series Irradiance of Solar Panel with no load*

Figure 14 shows the graph of solar irradiance hourly with no load series connection.As you can see the graph rising from 8am to 12noon, then down to 1pm to 4pm.

3.3 Pump Performance.

Table 4. ***Series Connection with Load***

Time (H)	Voltage (V)	Current (A)	Flow rate (l/m)	Power (W)
8:00	0	0	0	0
9:00	39	2.051282051	3.785	80
10:00	39	2.051282051	3.785	80
11:00	39	2.051282051	3.785	80
12:00	37	2.162162162	4	80
1:00	37.5	2.133333333	4.1	80
2:00	37.5	2.133333333	4.1	80
3:00	37	2.162162162	4	80
4:00	0	0	0	0

Table 4 shows the data of the accuracy of output hourly for series connection with load for micro electric diaphragm. The micro electric diaphragm pump needs 80 watts of power in order to pump.

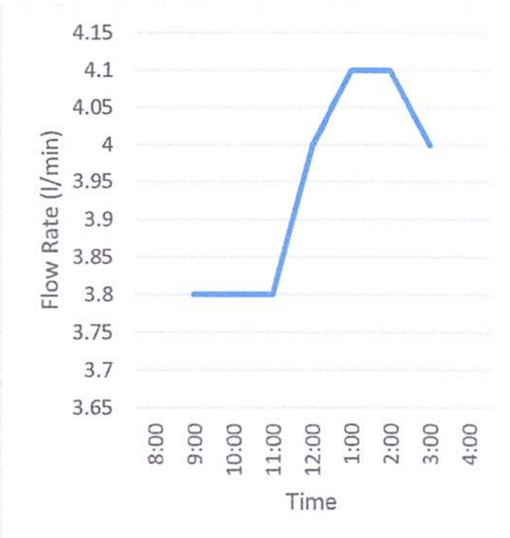

Fig. 15. ***Graph of Series flow rate for Solar Panel***

Figure 15 shows the graph of time versus flow rate with series connection. As you can see, 8am and 4pm there is no reading of voltage and current. The reason is the position of two solar panel can't receive enough energy from the sun.

Table 5. ***Parallel Connection with Load***

Time (H)	Voltage (V)	Current (A)	Flow rate (L/m)	Power (W)
8:00	0	0	0	0
9:00	19	4.210526316	4.8	80
10:00	20	4	4.6	80
11:00	19	4.210526316	4.8	80
12:00	19	4.210526316	4.8	80
1:00	18	4.444444444	5	80
2:00	20	4	4.6	80
3:00	19	4.210526316	4.8	80
4:00	0	0	0	0

Table 4 shows the data of the accuracy of output hourly for parallel connection with load for micro electric diaphragm. The micro electric diaphragm pump needs 80 watts of power in order to pump.

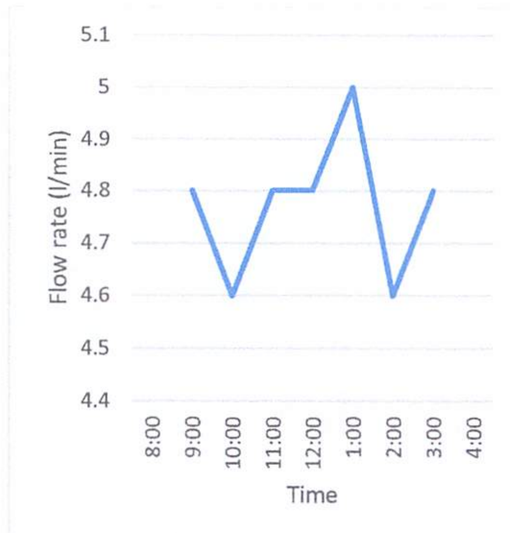

Fig. 16. ***Graph of Parallel flow rate forSolar Panel***

Figure 16 shows the graph of flow rate with parallel connection.As you can see, 8am and 4pm there is no reading of voltage and current. The reason is the position of the sun. At 9am to 3pm the solar panel receive enough solar energy. The system is now functional. The flow-rate is 4.8L/min it's much higher rate than series connection and the micro electric diaphragm pump is not hot.

Table 6. ***Average Voltage, Current, Power, and Flowrate that connected in Series and Parallel***

Connection	Voltage (V)	Current (A)	Flowrate (L/min)	Power (W)
Series	38	2.106	3.89	80
Parallel	19.14	4.182	4.77	80

In this table, shows the total average ofseries and parallel connection. The micro electric diaphragm pump needs a power of 80watts to operate.

4. CONCLUSIONS ANDRECOMMENDATIONS

Conclusion:

Two solar panels, a micro electric diaphragm pump, and a water tank makes up the system configuration of our project study. To establish the best performance of our micro electric diaphragm pump, the system was linked in series and parallel.

The solar panel's solar radiation effectiveness is high if the solar panel receives enough solar energy to generate its maximum power. Surigao city receives 3361.9 KwH/m2-months of solar radiation throughout the summer.

When the pump is linked in series, the flow rate of the pump is reduced due to the low current. Because of the higher voltage, the pump body warms up faster. When the pump is linked in parallel, the flow rate of the pump is substantially higher than when it is connected in series. Because the current in a parallel connection is twice as much as it is in a series connection. Because of the decreased voltage in the system, the pump body is at normal temperature.

Recommendations:

1.) We recommend to put a solar tracker. it is a device that orients a payload toward the sun. For more access of the solar energy.

2.) Based in our experiments we recommend to connect the system in parallel connection for better pumping and higher flowrate of the system.

5. ACKNOWLEDGEMENTS

The researchers consider self-privileged to express deep sense of gratitude to the CEIT Researcher Coordinator Engr. Robert R. Bacarro for his admirable and valuable guidance, keep interest, encouragement constructive suggestions during the course of the project. We would like to express our hearty gratitude to our co-author Engr. Bacarro, without his insightful guidance and help, we could not have completed this work. We would also like to thank our family, brothers, sisters and friends who have been our Almighty God for giving us life, knowledge and wisdom, guidance and for helping us to complete our report without any difficulties. With him, anything is possible.

6. REFERENCES

[1] Ghoneim AA. Design optimization of photovoltaic powered water pumping systems. Energy Convers Manage 2006;47:1449–63.

[2] Amer EH, Younes MA. Estimating the monthly discharge of a photovoltaic water pumping system: model verification. Energy Convers Manage 2006;47:2092–102.

[3] Hadj Arab A, Benghanem M, Chenlo F. Motor-pump system modelization. Renew Energy 2006;31:905–13.

[4] Moechtar M, Juwono M, Kantosa E. Performance evaluation of a.c. and d.c. direct coupled photovoltaic water pumping system. Energy Convers Manage 1991;31(6):521–7.

[5] Hamid M, Metwally B, Anis WR. Dynamic performance of directly coupled photovoltaic water pumping system using D.C. shunt motor. Energy Convers Manage 1996;35(9):1407–16.

[6] Grassie T, MacGregor K, Muneer T, Kubie J. Design of PV driven low flow solar domestic hot water system and modeling of the system collector outlet temperature. Energy Convers Manage 2002;43(8):1063–78.

[7] Lara David D, Merino Gabriel G, Pavez Boris J, Tapia Juan A. Efficiency assessment of a wind pumping system. Energy Convers Manage 2011;52(2):795–803 docs/gen/fy97/21732.pdf

[8] Anagnostopoulos John S, PapantonisDimitris E. Pumping station design for a pumped-storage wind-hydro power plant. Energy Convers Manage 2007;48(11):3009–17.

[9] MokeddemAbdelmalek, MidounAbdelhamid, Kadri D, Hiadsi Said, Raja Iftikhar A. Performance of a directly-coupled PV water pumping system. Energy Convers Manage 2011;52(10):3089–95.

[10] SkretasSotirios B, Papadopoulos Demetrios P. Systematic procedure for efficient design of electric water pumping systems fed by PV or/and WECS: application using measured meteorological data for the city of Xanthi/Thrace. Energy Convers Manage 2008;49(4):596–607.

[11] AL-Ajlan SA, Smiai MS. Performance and development of PV – plant for water pumping and desalination for remote area in Saudi Arabia. In: Proceedings of WREC-IV, vol. 8, nos. 1–4; June 1996. p. 441–6.

[12] Benghanem M, Hadj Arab A. Photovoltaic water pumping systems for Algeria. Desalination 2007;209(1–3):50–7.

[13] Benghanem M, Hadj Arab A, Mukadam K. Data acquisition system for photovoltaic water pumps. Renew Energy 1999;17(3):385–96.

[14] Hadj Arab A, Chenlo F, Benghanem M. Loss-of-load probability of photovoltaic water pumping systems. Solar Energy 2004;76(6):713–23.

[15] Wagdy RA, Nour MA. Optimum design of a photovoltaic powered

pumping system. Energy Convers
Manage 1994;35(12):1123–30.

FEASIBILITY DESIGN OF A GRID-TIE SOLAR POWER IN SSCT ENGINEERING BUILDING

Roeld M. Canibel,Christian Niel L. Gallardo, Francis V. Jamero, Jemielou Fideles
Surigao State College of Technology, Surigao City, Philippines
roeldcanibel@gmail.com, christiangallardo@gmail.com, franssjamero@gmail.com, jemieloufideles@gmail.com

Abstract: This study is to design a grid tie solar power system for SSCT Engineering Building. A grid tie solar power system is a semi-autonomous electrical generation which links to the mains to feed excess capacity back to the local electrical grid. The function of this solar power system is to supply the building which corresponds to the power needed. When the sun hit the modules on the solar photovoltaic or PV installation, the modules converts the sun energy into electricity that can be used to power the SSCT engineering building. While the electricity is being drawn from a PV installation or utility company the building power performance will stay the same. The direct current or the DC power that the installation produces is wired into an inverter this inverter converts the DC power into an alternating current better known as AC power. The electrical current then flows from the inverter to the building electrical service panel. During the day if the solar system production exceeds the building electrical needs, the excess electricity is feedback into the power grid, when this occurs you can observe the electrical meters spin backwards. At night or anytime a building is using more electricity that the solar installation is producing, the extra energy needed to power the building is pulled from the grid as its normally would be. And for the profit development it is shown from the calculation that it can be expensive due to the materials to be used, but it can also save because its duration can run for 25 years. The researchers had a consultation of the study; it is the location of the study where the solar power system will be installed considering the area of the installation area, loading, whether the building can withstand the weight of the solar panels, and lastly the wind load to have an efficient output. then the researchers conducted a load calculation to the engineering building lastly the researchers were able to design a grin tie solar power system for SSCT Engineering building and expected to show the design in lumion 3D architectural visualization.

Keywords: Grid Tie, PV Solar, Energy Management System, Load Management

1.INTRODUCTION

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaics (PV), indirectly using concentrated solar power, or a combination. Concentrated solar power system use lenses or mirrors and tracking system to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect.

As this technology has been developing, the people have been very busy in consuming the electricity especially for the common home appliances. It has become very inevitable to humans to control the use of modern technology like personal computers, the electric fan, air conditioner and other appliances. Energy demand is increasing day by day due to increase in population, urbanization and industrialization. The rate in energy consumption is increasing, supply is depleting resulting in energy shortage.

The researchers found out, that the SSCT Engineering Building is also one that experience power shortage. And this is due to the big loads that have been added to the building. The source cannot supply the overall load on its electricity needs. Thus, it may damage the equipments by means of a low distribution of power in every load.

In some other way, there are a lot of things that can be done to prevent power shortage. Solar power also can be used as one of the alternative source of electricity. Solar power is the conversion of energy from sunlight into electrical energy. A solar panel works when the sun hits the panelthe panel converts the sun energy into electricity. That's a technical way of saying that the panel's photovoltaic cells convert the energy in sunlight to electricity specifically, direct current (DC).

Solar energy creates clean, renewable power from the sun and benefits the environment. It is an alternative to fossil fuels thereby reducing carbon footprint and greenhouse gases around the globe. Other than that, extracting and using fossil fuels is expensive and harmful to the environment. It has become one of the needs of the people in a society. Solar energy's greatest benefits are the long term cost savings, it is noise free and is the most abundant renewable source of energy.

With this, the researcher had come up to an idea in making a design of a grid-tied solar power at SSCT Engineering Building to meet its electricity needs. With this, the distribution of power through the loads will improve. By the help of solar grid-tie power as an additional source of electricity, power shortage can be prevented.

Related Literature

Our research design is related to the study in which solar power is generated from the sun in the form of electric or thermal energy. Solar energy is captured in a variety of ways, the most common of which is with photovoltaic solar panels that convert the sun's rays into usable electricity. Aside from using photovoltaic to generate electricity, solar energy is commonly used in thermal applications to heat indoor spaces or fluids. Residential and commercial property owners can install solar hot water systems and design their buildings with passive solar heating in mind to fully take advantage of the sun's energy with solar technology [1].

Another study which our research design was related to is in grid tied solar systems. Grid tied solar electric system generate electricity silently and without any moving parts. The DC electricity is converted into AC electricity by an inverter. The AC electricity is fed into electric meter and circuit breaker panel. The electricity either goes to our appliances and lights, or to the grid. This all happen silently and automatically every day. Grid intertied power system are for folks who are connected to utility company power lines.

They plan to use a grid to supplement what they are able to make with renewable energy sources like the sun [2]. Grid-connected systems generally use a billing process called "net metering" or "net billing." In this process, any energy generated by the solar modules that your home does not use immediately is sent to the utility grid. However, when the solar electric system is producing less power than is needed, you can draw additional power from the grid. If your system is connected to the grid through a single electric meter, your meter can actually run backwards as you contribute excess energy to the utility. The excess electricity is being credited to you at the same retail rate as the electricity you use from the utility. Your utility may require the use of two meters—one that meters your consumption of energy from the grid and the other that meters your contribution to the grid. In this case, your solar-generated excess energy could be credited at the retail rate or possibly at a lower wholesale rate, depending on the utility. In addition, some utilities bill their customers according to a "time-of-use" rate system. Under this system, customers are billed at a higher rate during certain times of the day, such as during the sunniest daytime hours of summer when air conditioners are working at their peak. If this is the case with your utility, it may be able to excess energy to the utility at these same rates. Therefore the benefit from the solar electric modules produces the most power during those sunny summer days. When you need power from the utility during the off-peak periods, such as in the evening, the rate is usually lower. It is nice to have a grid-connected solar electric system, because your system produces enough energy in any given month so that you do not have to draw from the grid, you may still receive a small monthly bill. This is because many utilities charge monthly fees for meter reading. Again, check with your local utility [3].

There are corporations like Kyowa Exeo grid and its subsidiary Exeo Infra Co Ltd (Ota-ku, Tokyo) designed and constructed the mega-solar plant, adopting three PV inverters with a rated capacity of 665kW each manufactured by Toshiba Mitsubishi-Electric Industrial Systems Corp (TMEIC). The PV inverters support direct current (DC) 1,000V input[4].

Solar panels and satellite dishes on the roof are the new mounting system for elevating and supporting objects. The mounting base for attachment to a roof rafter incorporates a threadable elongated member or stanchion and only requires a single lag bolt which is positioned directly beneath the stanchion for fastening to a roof rafter. A guide tunnel is also provided on the roof mount for proper drill angle into the rafter. The solar panel support utilizes C-shaped extruded aluminum horizontal members where, upon fastening the solar panel to the members enhances the strength properties from a C-shape to a square structural member [5].

The use of solar panel in a roof mounted array wherein each panel having ridges protruding outwardly and adjacent to side edges that use to receive a standing seam cap between side adjacent panels. Each solar panel is formed as an integral structure having a photovoltaic module an edge of which is sealed by a base substrate. The base substrate is configured to have lipped top and bottom edges which interlock to form a watertight seal between top-adjacent and bottom-adjacent solar panels. The solar panel array can be mounted on a roof, in place of shingles or the like, to provide environmental protection for the interior of a building[6].

A device to generate electricity from solar rays is provided. A photovoltaic solar cell unit comprises a first cover and a second cover. The second cover is generally parallel to the first cover and the second cover is spaced from the first cover. The first and the second cover have a longitudinal axis. The photovoltaic solar cell unit also includes a solar cell disposed between the first cover and the second cover with the solar cell being disposed at a predetermined angle relative to the longitudinal axis[7].

Our study is also related to the application of Zener diode for light current-voltage (LIV) characterization of a solar panel. A typical solar panel is simply a configuration of large number of solar cells connected in series. In order to characterize solar panel light current-using either one of three approaches: variation of resistance, current, or voltage across its output. In this paper, the solar panel LIV data acquisition system is based on variation of computer-controlled direct current (DC) power supply in conjunction with a Zener diode. At the start of the measurement, power supply voltage is set to zero and is slowly increased to balance the solar panel voltage. As power supply voltage becomes larger than solar panel voltage, it becomes reverse-biased under light illumination. The solar panel voltage is reduced to zero and its short-circuit current (Isc) value is measured. For the open-circuit voltage (Voc) measurement, no current must flow through the circuit. Ideally, this condition requires an infinite resistor in the measurement circuit. In order to approximate the infinite resistor for Voc measurement, a Zener diode was investigated. A Zener diode has the ideal characteristic that under reverse bias conditions, it allows no current flow until its breakdown voltage is reached. The breakdown voltage of Zener diodes is configurable over a broad range. Solar panel LIV measurements were successfully demonstrated over a voltage range of up to 22 V[8].

This paper presents the design and performance analysis of an efficient solar energy harvesting single axis sun tracking system employing dynamic offset parabolic mirrored reflector dish to increase the efficiency of solar energy harvesting system. The performance of proposed solar energy harvesting system has been analyzed by comparing the output of proposed system with static solar panel and solar panel with static mirrored reflector system. [9].

One of the advantages of Grid-Tied Systems is to save more money with net metering and allow saving more money with solar panels through better efficiency rates, net metering, plus lower equipment and installation costs such as batteries, and other stand-alone equipment that are required for a fully functional off-grid solar system and add to costs as well as maintenance. Grid-tied solar systems are therefore generally cheaper and simpler to install. Your solar panels will often generate more electricity than what you are capable of consuming. With net metering, homeowners can put this excess electricity onto the utility grid instead of storing it themselves with batteries.Net metering plays an important role in how solar power is incentivized. Without it, residential solar systems would be much less feasible from a financial point of view. Many utility companies are committed to buying electricity from homeowners at the same rate as they sell it themselves. The utility grid is a virtual battery Electricity has to be spent in real time. However, it can be temporarily stored as other forms of energy (e.g. chemical energy in batteries). Energy storage typically comes with significant losses. The electric power grid is in many ways also a battery, without the need for maintenance or replacements, and with much better efficiency rates. In other words, more electricity and even money goes to waste with conventional battery systems. According to EIA data, national, annual electricity transmission and distribution losses average about 7% of the electricity that is transmitted in the United States. Lead-acid batteries, which are commonly used with solar panels, are only 80-90% efficient at storing energy, and their performance degrades with time. Additional perks of being grid-tied include access to backup power from the utility grid. At the same time you help to mitigate the utility company's peak load. As a result, the efficiency of our electrical system as a whole goes up. There are a few key differences between the equipment needed for grid-tied, off-grid and hybrid solar systems. Standard grid-tied solar systems rely on the following components: Grid-Tie Inverter (GTI) or Micro-Inverters Power Meter Grid-Tie Inverter (GTI). The job of a solar inverter is to regulate the voltage and current received from your solar panels. Direct current (DC) from your solar panels is converted into alternating current (AC), which is the type of current that is utilized by the majority of electrical appliances.

In addition to this, grid-tie inverters, also known as grid-interactive or synchronous inverters, synchronize the phase and frequency of the current to fit the utility grid. The output voltage is also adjusted slightly higher than the grid voltage in order for excess electricity to flow outwards to the grid.[16]

Having a solar panel installation in the Philippines is one of the best decisions you can do for your home. Have you ever wondered how the technology behind the solar energy system works? Then, you have come to the right article.

How solar power works is fairly easy to understand and the grid tie solar component is one of the components that you should utilize. A grid tie solar electric system is also referred to as grid-tied and utility intertied photovoltaic system. This is different from an off-grid or standalone solar system, where your structure is not hooked up to a utility power.

If you are a homeowner or a business establishment owner in the Philippines, solar panel installations should be on top of your list of investments. Many case studies that utilize the solar system has spoken about the benefits that they have harvested from having them installed in their properties. Turning sunlight into electricity is a sustainable solution for your home and the environment. Get to know how grid tie solar works and learn how it can help you in the future; just continue reading below.[17]

The 5.4 kWp grid-tie solar system kit by Solar Systems Philippines our grid-tie solar system include everything you need to start generating energy from your home or business. Depending on the size of the system and your energy usage, you will be able offset a portion of your energy bill, or feed back into the grid for reimbursement from your local utility. This system is designed to generate an estimated monthly electricity output of 640kWh.[18]

The solar market is flooded with one size fits all systems, under-qualified product retailers, and promises of lottery-win investment returns. Some of the same sellers that offer do it yourself solar kits also sell garden supplies. And many contractors that provide complete solar installations give all their clients the same unimaginative options. The straightforward grid-tied solar system is currently the most popular choice for both homes and businesses. Grid-tied simply means this type of system is connected to, and relies on, the existing utility electrical grid as an essential system component. A grid-tie solar electric system – also referred to as grid-tied PV (photovoltaics) – uses solar panels and other components to turn sunlight into electricity for your use, while your home remains hooked up to the local utility. An array of solar panels is installed (usually on the roof of the building) and connected to the home's electrical system. The electricity is used first to power the home's immediate electrical needs. When those needs are met, the additional electricity is sent out to the grid through your utility meter. In this instance, your utility grid functions as a part of the overall solar system, which is why it is referred to as grid-tie solar. This is different from an off-grid, or stand-alone, solar system where your structure is not hooked up to utility power. Once the electricity goes into the grid, your utility company tracks the energy sent into the grid from your solar production. What credit you get for your energy depends on your local regulations and utility company's rules. Whether or not you're using an installer, it is important to know how to best take advantage of your local programs to get the best return on your investment in solar..[19].

Theoretical framework

Series and parallel connection – components connected in parallel are connected along multiple paths so that the current can split up; the same voltage is applied to each other component. A circuit composed solely of components connected in series is known as a series circuit; likewise, one connected completely in parallel as parallel circuit.

Ohms law – A law stating that the electric current is proportional to the voltage and inversely proportional to resistance.

$$I = \frac{V}{R} \qquad [1]$$

Where: I = Current in ampere

R = Resistance in ohms
V = Voltage in volts

Sizing a solar PV module – Divide the total output to be delivered by the solar PV system by the daily peak sun hours. It gives approximate array size in kWh. To get the power output of the solar panels is you have to divide the value by the efficiency factor of the solar panels.

$$\frac{monthly\ usage\left(\frac{kWh}{month}\right)}{30\ days\ avg.} = daily\ usage\ \text{(kWh/day)} \quad [2]$$

$$\frac{daily\ usage\left(\frac{kWh}{day}\right)}{avg.sun\ hour\ for\ region(h)} = solar\ energy\ (kW) \quad [3]$$

Determining the number of panel needed.

$$number\ of\ panel = \frac{solar\ energy\ (kW)}{kW/panel} \quad [4]$$

Proper sizing of a PV inverter breaker – For over current protection.

$$I = Im * 125\% \quad [5]$$

Where: Im = maximum output current in ampere
I = standard breaker size in ampere
125% - safety factor

Conductor resistance – the opposition to the flow of electric current through a conductor.

$$R = \rho\frac{L}{A} \quad [6]$$

Where: R = resistance in ohms
ρ = resistivity of the copper in ohm-meter
L = length of the cable in meter
A = cross sectional area of the cable m2

Permissible voltage drop – the voltage drop between the origin of the installation (usually the supply terminal) and the fixed current using equipment should not exceed 4% of the normal voltage of the supply.

$$VD = \frac{2 * I * L * R}{1000} \quad [7]$$

$$I = \frac{S}{\sqrt{3} * Vs} \quad [8]$$

Where: VD = voltage drop per unit circuit length in Volts
I = full load current in ampere
L = one way circuit length in meter
R = resistance in ohms per meter
S = apparent power in Volt-Ampere
Vs = operating voltage in volts

Conceptual Framework

The purpose of this project is to provide a feasibility design of a grid-tie solar power in SSCT Engineering Building. Before any decisions are taken, the views of the school administration should be taken into account to avoid inevitable conflict regarding the said proposal. By following steps, the researchers should be able to come up with the appropriate solution to problems stated in the next stage of our study.

INPUT
Building design
Solar power system
Internet data

↓

PROCESS
Evaluation of the system
Analysis of the specifications of the solar panel and other materials needed
Analysis of the grid tie solar power system design and the loads of the building

↓

OUTPUT
Grid-Tie Solar Power System for SSCT Engineering Building

Figure 1. ***The IPO Block diagram***

Figure 1 illustrate the Input-Process-Output (IPO) diagram that shows and briefly exemplify the intention of the study. Inside the first box is the description on the input. In particular, to solicit the information specified in the first box, the researchers was able to get the design of the SSCT engineering building at the building and state department and gathered some data's through internet to see if the design align to the objectives of the study. To determine if the building design is suitable for the study, the researchers visited at the said area, collect information by site viewing to identify possible design solutions and to visualize the research project.

The second box encloses the process that shows the procedures on what tactics does the researcher used to pinpoint and to successfully forge the output. The preferred strategies of the researchers were presented in this box which are first is the evaluation of the system wherein the researchers critically examine the program if there were something to improve its effectiveness, because it is important to assess or evaluate before adapting the system to ensure if they are as effective as they can be. Second information detailed in the second box, the researchers also use of the analysis of the specification of the solar panel and other materials needed. The researchers identified and documented the materials to be used for the project design. This is the critical step to ensure success in the development of the project because you have to check and analyze the requirements if they are clear, complete and unambiguous so that the researcher can formally agree with and what is to be used, and so can evaluate the cost and benefits of the project, to confirm it is in the necessary to do it, and that is has a net benefit. Lastly is the analysis of the grid tie, the researchers then analyze if the design are capable for the system. To come up with these strategy, the researcher were planning and figuring out how success or failure will be measured, estimating the cost, time and resource usage of requirements and design an alternatives with creative problem solving through series of steps which lead from initial concept to realization.

The design of a grid tie solar system for SSCT engineering building is the output of the study that explain all the expected outcome which designed to seek extensive information on results just to ensure that the objectives being set are successfully achieved. It is expected to show the design though Lumion 3D architectural visualization.

Objectives

The general objective of this study is to conduct a feasibility design of a grid-tie solar power in SSCT Engineering Building. The specific objectives are:

1. To determine the structural integrity of SSCT Engineering Building.
[8]
2. To design a grid-tie solar power system for SSCT Engineering Building.
3. To determine the power generation profile of solar power system.
4. To determine the financial feasibility of the project.

2. METHODS

Project design

The block diagram shows the flow of the research design The diagram shows how it's all connected and help in understanding how solar panels work.

It all starts from the light of the sun that hits the 1200 solar panels and connect to the combiner box, this combiner box is a device that combines the output of multiple strings of PV modules for connection to the inverter, the inverter converts the direct current (DC) into an alternating current (AC) suitable for injecting into an electrical power grid at the same time the inverter is also connected to the electrical panel board that divides an electrical power feed into subsidiary circuits while providing a protective fuse or circuit breaker for each circuit in a common enclosure.

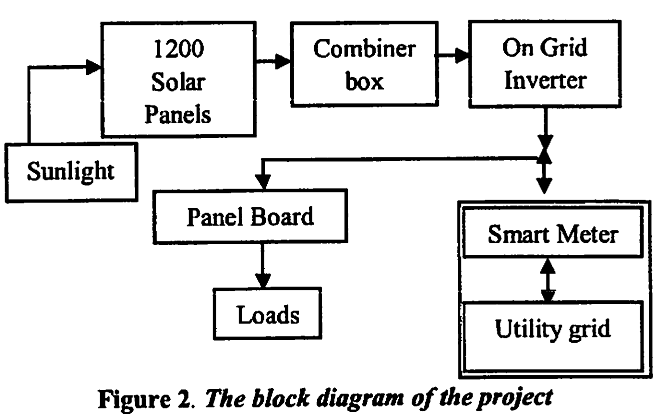

Figure 2. ***The block diagram of the project***

Project development

In developing this project design the researchers follow this following steps:

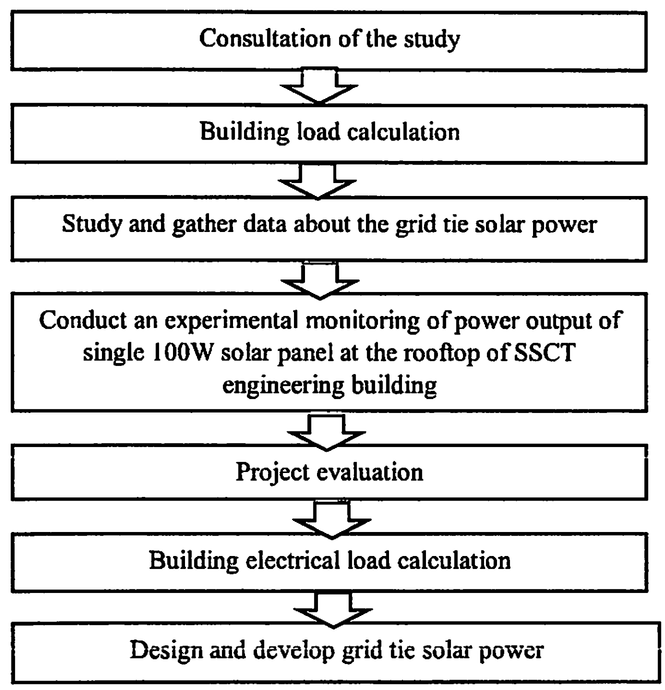

Figure 3. ***Project Development Flow Chart of the Project***

The flowchart in Figure 3 shows the process on how the researchers developed the project. As shown in the figure the researchers started with the consultation of the study. It is the location of the study where the solar power system will be installed. Consideration of the area of the installation are loading, whether the building can withstand the weight of the solar panels, and lastly the wind load to have an efficient output. Then, collecting of data will follow through an experiment. The researchers will then conduct an experimental monitoring of power output of single 100W solar panel at the rooftop of SSCT engineering building. Then, have an electrical load calculation to the building. Lastly, the design of a Grid-Tie Solar Power System for SSCT Engineering Building is the output, and expected to show the design in Lumion 3D architectural visualization.

Project Evaluation

The project study will be evaluated with the results obtained throughout the process and these are the following to be evaluated in the project study:

System reliability

Is the solar power system is consistent, efficient and can meet the electricity demand?

Stability of the voltage

Does the designed project study presents a stable voltage stability of the solar power system into the electricity grids?

Efficiency

Does the project study attain the needed maintenance in order to maintain the power system efficiency?

Applicability is the designed project study appropriate to the project location and application?

Participants of the design

The participants of this design are the people who give much contribution; three electrical engineers and two civil engineer. These engineers are needed for precise calculation of the system and Identifying the place and position of the panels for safety, getting the desired stability power and maximizing the lifespan of the system.

Table 1. ***Participants Involved in the Project Study***

Participants	f(n=5)	%
Electrical engineer	3	60
Civil engineer	2	40
TOTAL	5	100

Project setting

The project design is sited at the rooftop of the SSCT engineering building as presented in figure 4. This is a perfect area for the solar panel to be place because it is wide and no disturbance for the sun light.

Instrumentation

Solar Panels - are devices that convert light into electricity. They are called "solar" panels because most of the time, the most powerful source of light available is the sun, called sol by astronomers. Some scientists call them photovoltaics which means, basically, "light-electricity"[5].

Solar Array Mounting Structure - Are used to fix solar panels on surfaces like roofs, building facades, or the ground. These mounting systems generally enable retrofitting of solar panels on roofs or as part of the structure of the building called Building Integrated Photovaoltaics (BIPV)[6].

DC to AC Inverter - Is a power electronic device or circuitry that changes direct current to alternating current. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry[7].

Disconnect Switches - a switch that isolates a circuit or one or more pieces of electrical apparatus after the current has been interrupted by other means[8].

Utility Power Meter - The utility company charges you for the power you use based on the monthly readings of an electric meter that measures the current passing through the service entrance into a customers electrical service panel. The meter can either be a mechanical analog meter that is read monthly by a utility service person who visits your home, or a newer digital meter that may send information via internet or radio signals.[9].

Figure 4. ***SSCT engineering building map and satellite view***

Wiring & Fuse Box Connections - Is a component of a system which divides an electrical power feed into branch circuits, while providing a protective circuit breaker or fuse for each circuit, and protect branch circuits from overloads and short circuits[10].

Data Collection Procedures

Data collection flowchart shows the process on how the researchers collect for this project. As shown in the figure the researchers started to experiment, it is output of a 100 w solar panel at the rooftop of engineering building. Then record the data of 100 w solar panel daily output and calculate its average output. After recording the data, the researchers proceed to the study load calculation of SSCT engineering building to determine the daily power needed by the building then analyze the result.

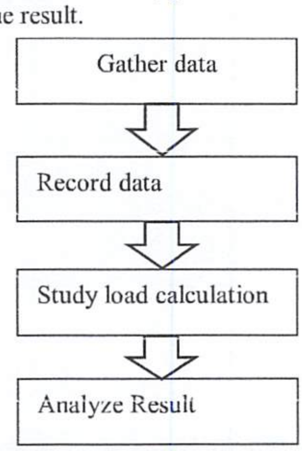

Figure 5. ***Data collection flowchart***

3. RESULTS AND DISCUSSIONS

3.1 *Structural Integrity of SSCT Engineering Building*

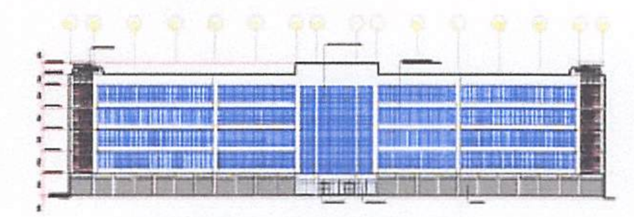

Figure 6. ***Front View Elevation***

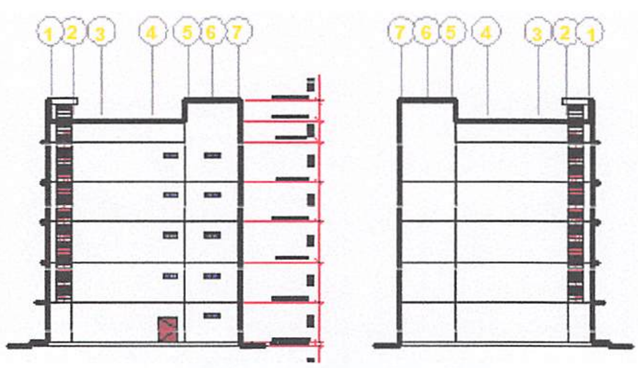

Figure 7. ***Right and Left side View Elevation***

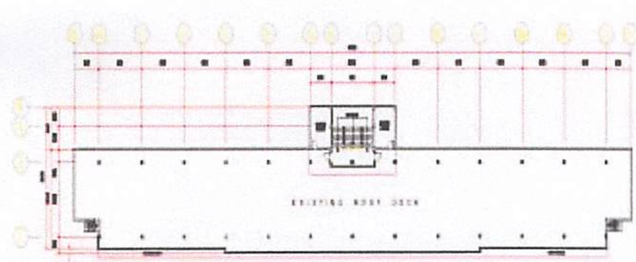

Figure 8. ***Top View Roof deck plan***

(12 kg * 1200)/(0.72 m^2) * (9.81/1000) = 0.196KN. This calculation shows that the rooftop of SSCT engineering building can handle all the loads to be place because the maximum load can be place to the rooftop is 2KN.

3.2 *Design of Grid-Tie Solar Power System*

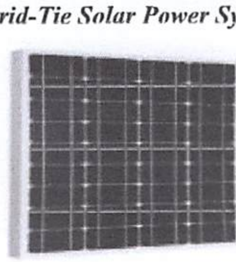

Figure 9. ***Photo-Voltaic (PV) module***

A PV module is an assembly of photo-voltaic cells mounted in a framework for installation. Photo-voltaic cells use sunlight as a source of energy and generate direct current electricity.

Figure 10. ***Grid-Tie Inverter***

This device is use to convert the direct current (DC) into an alternating current (AC) suitable for injecting into an electrical power grid.

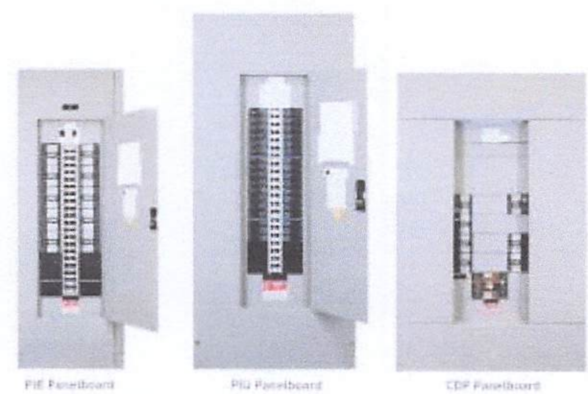

Figure 11. ***Electrical Panel Board***

A component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure.

Figure 12. ***Kilowatt Hour Meter***

Kilowatt Hour meter is the electric meter that measures the amount of electrical energy in kWh that was consumed in the house. The KWh meter has a counter display that counts units of kilowatt-hour (KWh). The energy consumption is calculated by calculating the difference of the counter's reading in the specified period.

The sun produce light energy and goes to the solar panel, the tilt angleof the solar panel should be 25^0-30^0 angle, the solar generate energy and produce DC power and goes to the inverter and the inverter invert DC power to AC power and delivered it to the kilowatt-hour meter which is connect to the grid utility service line. The power of the tied up solar power and grid power will delivered and supply the loads of the building.

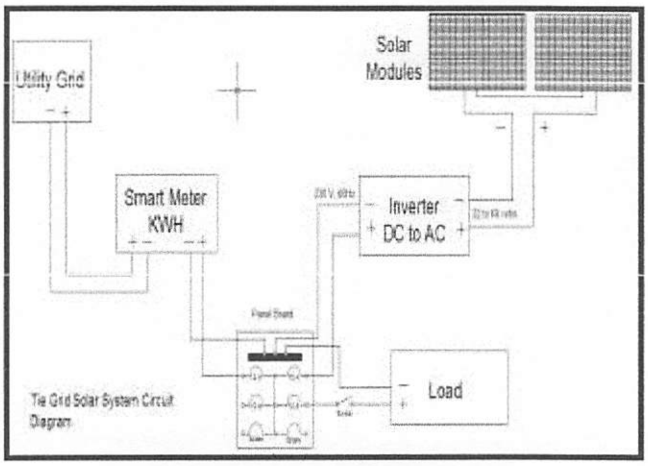

Figure 13. *Schematic Diagram*

3.3*Average Power Generation Profile of the Solar power Panel Day 1 to Day 4*

Area of the solar panel (A_P) = 0.72 m^2

Area of the rooftop on engineering building (A_B) = 864 m^2

Number of panels = (A_B) / (A_P)

= (864 m^2) / (0.72 m^2)

= 1200 panels (But we use only 320 panels)

Power per panel (P_P) = 53 Watts

Power generated = 320*53 Watts = 16.96 kW

Daily power generation = (8 hours)(16.96 kW) = 135.68 kWhr

This 135.68 kWhr is the output during direct sunlight.

Energy per month = (135.68 kWhr) (22 days)

= 2984.96 kWhr

Energy per year = (2984.96 kWhr) (12) = 35819.52 kWhr

Table 2. Solar Panel correlation between Temperature and Power Generation

Time and Date	Temperature in Celsius	Power Produced (Solar) in Watt
7am-8am	20°	736
8am-9am	24°	3424
9am-10am	26°	6528
10am-11am	28°	8080
11am-12pm	28°	17096
12pm-1pm	29°	15968
1pm-2pm	28°	14400
2pm-3pm	27°	6464
3pm-4pm	25°	4736
4pm-5pm	20°	832
Total Average Power Produced		78264

Due to covid-19 pandemic which the world's facing right now, the researchers were not able to conduct the power output monitoring of the solar panel on the rooftop of the engineering building. However, the researchers know one person from Mat-e, Surigao City that uses grid tie solar power system and it was found that he recorded first the data of the power output with 100W solar panel if he can save money if he use this kind of system before he continue investing money. All the data gathered and the table above represents the power output of the solar panel being utilize for four days, focusing the discussion only in day two wherein the power output is higher on this day compared to the other days, The power produced within ten hours could create enough power to operate three 9W lamp load operate also in ten hours. However in a real miniature operation, a 9W load has been tested and the load is not operative during day time yet it runs during night time for ten hours. The power produced by the solar panel is not consumed by the lamp and it is being exported to the utility grid. By these, the researchers decided to adapt these method in order to collect data and information from the solar and to evaluate how much capable the miniature and to identify the power being exported during daytime and the power being imported from the grid during nighttime. Moreover, as you observe from the data 265 watts is exported to the grid upon the operation of the system under daytime and the load (9 watt) utilize 90watts power from the utility under nighttime (10 hours). And to check the system if it would aid to reduce the consumer's consumption, the researchers perform their calculation to evaluate how the system could give contribution.

Computation comparison (theoretical):

3 lamps * 9 watts (operate in 20 hours, 10 in daytime and 10 in nighttime)

3 x 9 x 10 (day time) = 270 watts

(270 watts)/1000 = 0.270 kWh same as night time

The usage of lamp will still illuminate even though it was lack of supply in solar because its lamp is connected on SURNECO.

With grid tie solar system (actual):

Day time = 0.265 kWh (power produce by solar panel in 10 hours)

Night time = 0.270 kWh (power imported from the grid in 10 hours)

Total usage = 0.265 kWh + 0.270 kWh = 0.535 kWh

Net power usage = 0.535 kWh - 0.265 kWh = 0.270 kWh

Total cost = 0.535 kWh * (13peso, SURNECO rate) = 6.955pesos

Avoided cost = 0.265 kWh * 13 pesos = 3.445 pesos

Total bill = 6.955 pesos - 3.445 pesos = 3.51 pesos

The computation comparison show that you'll save 49.53% from your total bill if you use this system.

The actual energy produced by the solar panels during measurement is only 0.265 kWh. However, this would have increased with an increased sunlight intensity. The 0.270 kWh needed by the three lamps will always be provided because the system, a grid-tie solar power system, will produced the remaining energy needed by the three lamps from the utility grid. This does not mean less profit from the system since during peak sunlight energy absorption of the solar system, where power produced by the panels exceed the demand, this power will be exported to the utility grid, allowing for even more profit.

Without grid tie solar system (actual):
Day time = 0.2700 kWh (power imported from utility in 10 hours)
Night time = 0.2700 kWh (power imported from utility in 10 hours)
Total usage = 0.2700 kWh + 0.2700 kWh = 0.5400 kWh
Total cost = 0.5400kWH * 13(peso, SURNECO rate) = 7.02pesos
Avoided cost = 0 kWh * 13 pesos = 0 pesos
Total bill = 7.02 pesos – 0 pesos = 7.02 pesos
Without the system all the bills of your power usage, must be paid not like with the system of tie grid solar half from the bill is saved.

3.4*Financial Feasibility of the Project*
Engineering building estimated monthly energy consumption = 7,000 kWh
Load of the building = 32 kW (approximate load)
Amount of generation paid to SURNECO monthly = (7,000 kWhr)(13 Php, SURNECO rate) = 91,000 Php
For one year = (91,000 Php)(12) = 1,092,000 Php

Table 3. Material Cost of Grid-Tie Solar Power System

Description	Quantity	Cost/unit in Php.	Amount in Php.
Solar Panel (100 watts)	320 pcs.	4,000	1,280,000
MC4Wire solar cable 4mm^2	5 box	2,000	10,000
Grid-Tie Solar Inverter	1 pc.	30,000	30,000
Solar mounting bracket	18 sets	4,000	72,000
Total cost of installation			1,392,000

Comparison of generation
Engineering building monthly energy with solar
= 7,000 kWh - 2984.96 kWh
= 4,015.04 kWh
Amount of generation paid to SURNECO monthly with Grid-Tie solar system = 4,015.04 kWh*13 Php. = 52,195.52 Php.
For one year = (52,195.52 Php.)(12) = 626,346.24 Php.
Difference amount per year (Grid-Tie solar power system VS. without Grid-Tie solar power system)
D =1,092,000 Php – 626,346.24 Php.
=465,653.76 Php

Return of Investment
Recovery period = (1,392,000 Php)/(465,653.76 Php/year)
= 3 years

4. CONCLUSION AND RECOMMENDATIONS

Conclusion
These are the following conclusions made after discovering the results of the study:

1. It was found out that having proper inspection on the area is necessary to ensure that structures are safe and reliable, and base on the study, the area of engineering building was perfect for this project because it was wide and lofty.
2. The researchers conclude that the design of the project was quite effective based from the result because the output meet the desired objective being set and it was then come within the reach of the Grid-Tie Solar Power System design to operate during day time.
3. It can be further interpreted from the data gathered by the researchers that the power being produced by a solar panel produces enough energy to operate and supply the loads of the building.
4. The results revealed from the calculation that the total cost of installation is 12,080,000 Php it is expensive due to the materials to be used for the installment, However it can also save much more from any other expenses since the length of the life of this project can run up to 25 years.

Recommendations
By means of this project that gives realistic results, the researchers recommend the following:

1. Make sure that the area can support solar panels and it must not covered in shade most of the day throughout the year.
2. Use large panel to save more energy and be more economical.
3. Identify the availability and durability of materials, acquisition of equipment and extent of location before installing to surely produce much more energy and to avoid outbreak.
4. Prepare for the allocation of funds for the installment. In addition, financial feasibility study should be conducted before proceeding to the installment of project to determine the economic viability of a proposed plan and to determine the return of investment.

5. ACKNOWLEDGEMENT

This project study has been made successful through the help and support of many people. The researchers would like to express their genuine gratitude and appreciation to all the people behind the completion of this study. First and foremost to the Almighty God for the wisdom, strength, optimism, good health and guidance He unconditionally gave to the researchers. To our co-author Engr. Jemielou Fideles, we also give our gratitude for sharing us his knowledge, motivation, and continuous support in making this study successful. To Engr. Robert R. Bacarro, MECE, MBA, for his effective teachings which made this project study one of the best achievements of the researchers so far. To the researchers' beloved parents and family, for the financial, emotional, and spiritual support they have provided to the group. Finally to our friends, relatives and other loved ones whose names were

not mentioned but showed their support and trust in our potentials.

6. REFERENCE

[1] D. Ghosh et al., "Grid-tie rooftop solar system using enhanced utilization of solar energy," 2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON), Bangkok, 2017, pp. 275-277.

[2] Alex Dumais and Sabarish Kalyanaraman, Grid-Connected Solar Microinverter Reference Design", Microchip application note AN1444.

[3] M. Joshi, V. Agarwal, S. Shinde and R. Birari, "A low cost bi-directional grid tied solar PV microinverter," 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC), Portland, OR, 2016, pp. 1819-1824.

[4] Kulkarni and K. Agbossou, "Development of a MPPT method for photovoltaic systems", Canadian Conf. Elect. Comput. Eng.,pp. 123-126, 2004.

[5] M. Ciobotaru, R. Teodorescu and F. Blaabjerg, "A new single-phase PLL structure based on second order generalized integrator", Proc. 37th IEEE PESC, Jun. 2006

[6] Dhaneria and H. Khambhadiya, "Hardware Implementation of Grid connected Solar PV Inverter," 2019 International Conference on Power Electronics & Iot Applications in Renewable Energy and its Control (PARC), Mathura, Uttar Pradesh, Inida, 2019, pp. 28-32

[7] S. A. Bashar, "Solar power as a prime energy source in Bangladesh", The daily Star (thedailystar.net), December 2009, [online] Available: http://www.thedailystar.net/newDesign/print_news.php?nid=119244

[8] K. Wilson, D.D. Ccuster and R.A. Sinton, "Mcasuring the effect of cell mismatch on module output", 2006 IEEE 4th World Conference on Photovoltaic Energy Conference, pp. 916-919, 2006.

9] B. G. D. Wicaksono et al., "Reflector Installation Analysis to Enhance the Power Output of Solar Panel on the Roof at the Building of PLTDG Pesanggaran," 2018 Conference on Power Engineering and Renewable Energy (ICPERE), Solo, 2018, pp. 1-4.

[10] G. Guvench, C. Gurcan, K. Durgin and D. MacDonald,"Solar simulator and i-v measurement system for large area solar cell testing", Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, pp. 71-71, 2004.

[11] E.M.G. Rodrigue, R. Melicio, V.M.F. Mendes and J.P.S. Catalao, "Simulation of a Solar Cell considering Single-Diode Equivalent Circuit Model", International Conference on Renewable Energies and Power Quality art. 339, 2011.

[12] K.A. Emery, "Solar simulators and i-v measurement methods", Solar Cells, vol. 18, pp. 251-260,1986.

[13] V. C. H. Lim, C. S. Leong, K. Sopian and S. H. Zaidi, "Pulsed solar panel light current-voltage characterization based on Zener diode," 2016 IEEE Conference on Systems, Process and Control (ICSPC), Bandar Hilir, 2016, pp. 177-180

[14] M. Billah, S.K. Das, M. T. Islam, M. A. Haque and B. B. Pathik, "Design, simulation and implementation of a grid tied solar power controller integrated with instant power supply technology," 2015 IEEE Innovative Smart Grid Technologies Asia (ISGT ASIA), Bangkok, 2015, pp. 1-6.

[15] M. Nahid Hossain, Tushar Kanti Routh, Abdul Hamid Bin Yousuf, M. M. Asasduzzaman, M. Iqbal Hossain and U. Husnaeen, "Design and development of a grid tied solar inverter," 2012 International Conference on Informatics, Electronic & Vision (ICIEV), Dhaka, 2012, pp. 54-58.

ENHANCEMENT OF POWER, BLADE AND CHANNEL DESIGN IN HYDRO-ELECTRIC WHIRLPOOL TURBINE

Darriel C. Benedicto, Darwin L. Cariaga, Junrymar B. Ocampo, Engr. Conrado B. Delosa
Surigao State College of Technology, Surigao City, Philippines
darriel.benedicto7@gmail.com, darwincariaga85@gmail.com, junrymar2@gmail.com, dondondelosa@gmail.com

Abstract: The study focuses on the enhancement of blade, and channel design to increase the power produce by a hydroelectric whirlpool turbine using single phase alternator motor with a power of 1.5hp to have a 800 watts output. The study aims to develop more power from the desired designs of the blade and its channel for the whirlpool to operate well. The system starts by constructing the channel design which is the basin of the area followed by the blade to be installed in the basin and after that setting up the alternator belt to operate with enough force to rotate the blade. Much attention has been paid to the design of the turbine blades in cylindrical basin systems, with the aim of increasing the efficiency of energy conversion. The researchers uses cylindrical whirlpool design in which it enhanced in terms of the discharge of water from its outlet with a measurement of 2.65 liters per 1.11 seconds compared to the previous design which has a measurement of 2.25 liters per 1.78 seconds. The researchers find a characteristic of turbines to enhance the power and found out the two designs of blade which are the rectangular blade (that has been use in the previous study) and the rectangular curve design is being used by the researchers for it is tested that the rectangular design is the better design for the whirlpool turbine.

Keywords: Whirlpool, Turbines, Basin, Computation, Penstock, Vortex

1. INTRODUCTION

As energy costs continue to rise, the carbon dioxide level in the atmosphere continues to increase, and the world's fossil fuels are depleted, reliable new sources of energy will be needed. Hydroelectric power generation is a clean, effective means of generating "green" renewable energy that will continue to be a viable supplement to energy demands long into the future. This is because population and technology will keep on increasing and thus the demand. In such increasing demand, there is a lot of alternative solution through a renewable source of energy. It will help meet the demand.

Today, more than 85% of renewable energy comes from rivers and most of the hydropower plants are situated in the hilly areas because hydro plants need the potential difference in the water level to rotate the turbine. Though it is considered as renewable energy, it harms nature at a high extent in its construction. However the problem seems to be solved as a new and innovative concept of hydropower plant has been given [24].

Whirlpool is a revolving current in an ocean, lake, or river. If a whirlpool is powerful enough it can sink a big ship. Engineers figured out that this type of energy can be used to generate electricity at the same time it consumes less space in its surroundings.

This study is to enhance the power, change the blade and channel for the better output of hydroelectric whirlpool turbines which generate electricity using water through its newly designed blades. Its sustainability mainly depends on the velocity of water which passes through the blades. In this study, the whirlpool turbine blades are designed with the aim of increase the efficiency of the turbine. The various ways to optimize the whirlpool basin in its enhancement process will be also investigated.

For example, in remote areas where electric cooperative doesn't reach them, it is suitable to have an own source of electricity to light up their dark night. By using whirlpool turbines, they can obtain their needs in electricity.

Review of Related Literature

Over the year's hydroelectric turbine blades has gone through many phases of development. The researchers are still trying to improve the efficiency and performance of the turbine. As the most reliable renewable energy, hydro-power energy is widely used throughout the world. Hydroelectric power captures the energy released from falling water. In the most simplistic terms, waterfalls due to gravity, causes kinetic energy to be converted into mechanical energy which in turn can be converted into a usable form of electrical energy by the water turbine and generator [1]. Hydroelectric power plants are categorized according to size. They fit into one of four different size ranges: micro, mini, small, and large. A micro sized plant is one that generates less than 100 kW of electricity. A mini facility can serve an isolated community or a small factory by generating 100kW-1MW of electricity. A small plant generates 1MW-30MW and can serve an area while supplying electricity to the regional grid. Lastly, a large facility generates more than 30MW of power. There are two major types of hydroelectric, impounded type and diversion type. An impoundment hydroelectric, typically a large hydro-power system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity.

In the last decades, the development of devices that use renewable sources of energy increased in order to protect the environment and reduce the greenhouse effects as a result of fossil fuel use. This initiative in developed countries is already a state policy that has given a boost to the research and development of alternative forms of power generation, complementary to the conventional ones. The new devices generate power on a small scale and in a decentralized fashion, without affecting or changing the environment. Taking into account these characteristics, a variety of devices that work with the most common sources of renewable energy has been developed: hydro, solar, wind and from biomass [5]. Human imagination has created different devices to convert hydraulic energy into power on its axis [6-9]. [10] Describes some forms of power generation starting from the most basic machines to those made in the second half of the 20th century, showing several choices of energy conversion based on hydropower. These devices have evolved so much that now there are even technologies that harnessed the vortices with boundary layer separation of the flow around the blunt body. An example of this is the power converter that uses vibration induced by vortices of von Karman [11], similar to the VIVACE system at the University of Michigan [12], but with a non-contact magnetic device to produce electricity. The research, [13] illustrates the current interest in improving energy extraction with hydraulic wheels partially in contact with a water flow, by using hydrostatic pressure.

Lately, the growing demand for electrical power that brings modernization increased the development of new devices to utilize the energy from water movement. Thus, [11] mentions some new alternatives to transform energy in low head conditions (Baker mill, turbine Division, screw turbine, etc.), and argues that they are redesigning known turbines of action and reaction (Pelton, Francis, Kaplan, etc.) in order to operate at loads below 3 m. [12] performed a review of this type of machines, which focuses on its classification, behavior, operation and costs.

Water vortex is a phenomenon where water flow in a swirl motion. It is always described by cylindrical coordinate, with tangential, radial, and axial axis. In 1858, Rankine already published his study on water vortex by introducing mathematical model for the tangential velocity of the water vortex [17]. Afterward, other researchers, Odgaard [18], Hite and Mih [19], C. Yun-Liang *et al.* [20] also studied water vortex and tried to modify and to improve the mathematical model of the water vortex. Their focus is on the vortex generated with the hydraulic intake in a free surface flow, where the formation of vortex is undesirable as it will decrease the efficiency and damage the devices.

In process industry, water vortex also been studied for the purpose of mixing process. The mixing process uses a rotor to rotate the liquid inside either a baffled or unbaffled vessel. The knowledge of vortex shape is important in this area for design purpose. Torre *et al.* [21] use CFD to model the free surface in a partially baffled vessel while Busciglio*et al.* [22] investigate the vortex shape in unbaffled stirred vessel by digital image analysis.

A literature review on devices that generate electricity through a vortex of gravity and other energy conversion systems [13-16] shows that free vortex power plants have been developed. Parametrically studied variables affect the power generated by a plant with a gravitational vortex, with a discharge hole of constant diameter. In their paper, they claim that, currently, optimal conditions of generation with this principle of operation are unknown and that the maximum efficiency achieved in their experiment was 12.31%. A similar study, but using CFD, was independently carried out by [14, 15], concluding that output speed grows when it increases the height of the water in the tank and its diameter gets reduced. They argue that those results require experimental verification.

Theoretical Framework

For the design of the hydroelectric turbines to be efficient, the blade of the turbine and the basin should be observed

Calculation of theoretical power is given by

$$P = Q\gamma h \qquad [1]$$

Where: γ is specific weight of the water, N/s^3

Q is volumetric discharge of the water, m^3/s.

H is the effective head of the water, m.

Calculation of basin design is given by

$$Q = AV \qquad [2]$$

Where: Q is the volume discharge, m^3/s.

A is the cross-sectional area of the water at the source.

V is the velocity of water at the penstock.

Calculation of efficiency is given by

$$\eta = \frac{P_{out}}{P_{in}} \qquad [3]$$

Where: P_{out} is the output power of the alternator, W.

P_{in} is the input power, W.

The calculation of the specific speed of the turbine is given by

$$Ns = \frac{5050}{H+32} + 19 \quad [4]$$

Where: h is the effective head of the water(foot).

The calculation of the actual speed is given by

$$N = \frac{Ns * H^{1.25}}{\sqrt{Hp}} \qquad [5]$$

Where: Hp is the theoretical horsepower of water turbine

Conceptual Framework

The project study focuses on the goal of producing 800 watts power by enhancing the blade design and its channel to the hydroelectric whirlpool turbine.

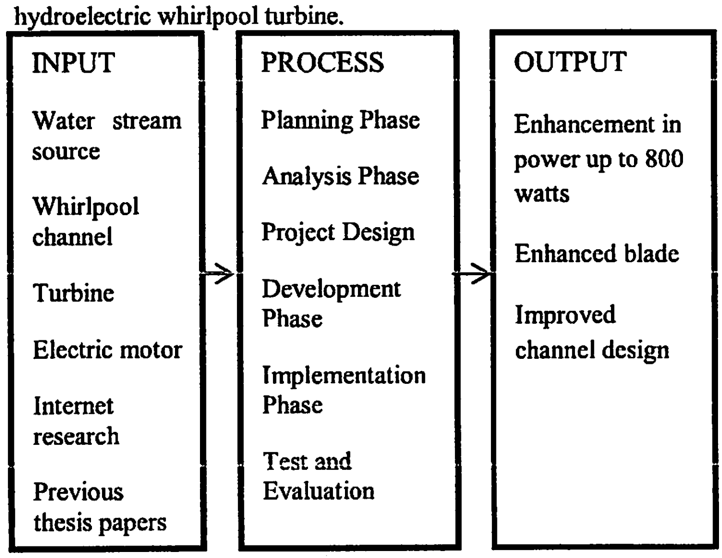

Figure 1. ***Flowchart of the Project***

The Input-Process-Output Diagram in Figure 1 indicates how the project is being processed. The input is where the researcher considered some importance process to ensure the availability of the source, water source, internet source, design source.

The conceptual framework of the study starts from the input of the hydroelectric whirlpool turbine. The second box shows the process involved to automate the hydroelectric system. Planning, analysis, design, implementation, and maintenance phases were followed systematically to prevent significant errors and problems in the future.

Objectives

The general objective of the study is to enhance the power, change the blade and channel design for the better and efficient output of a hydraulic whirlpool turbine that will provide sustainability and reliability. The specific objectives are:

1. To investigate the flows rate of the stream.
2. To identify the characteristic of turbines.
3. To enhance the power output, blade and channel design.

2. METHODS

Project Design

The research design is the overall plan of how to develop and implement the project in practice. The researcher defines the research design as a plan that describes how, when, where data are to be collected and analyzed [23]. A developmental research design is used in this study. It is defined as the systematic study of designing, developing and evaluating the project that must meet the criteria of internal consistency and effectiveness. It was used in determining the performance of the system in terms of accuracy, efficiency, and durability.

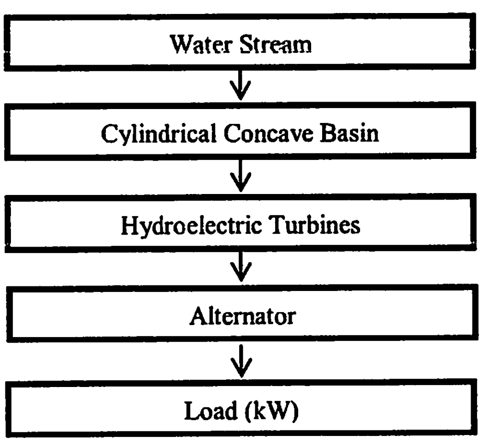

Figure 2. ***Block Diagram of the Hydroelectric Whirlpool Turbines***

Water stream. It must be set up properly for the testing and operation. The power of the water stream is the way to make the blade rotate.

Cylindrical Concave Basin. Is responsible for the flow of water to the whirlpool and gives force to the blade to rotate more because of its design.

Hydroelectric Turbine. The turbine will now rotate because of the force that is driven from the whirlpool that makes the blade rotate so that the alternator motor will operate and gives desired power on the researcher.

Alternator. This component converts mechanical energy to electrical energy in the form of alternating current so that the desired power will be reached.

Load (kW). It is an electrical component or portion of a circuit that consumes electric power. This is opposed to a power source, such as a battery or generator, which produces power.

Project Development

The researchers will make a plan of the overall activities and the equipment to be used in the project, and study the enhancement of the design with systematic approach. The enhancement can be visualized with the flowchart below.The study of the project is very crucial for it is case to case study or consideration of the fact of such area of the study in the field, materials, design of the system, project development, implementation and the test evaluation.

The researchers consider failures in this study for which gives the researchers more encouragement to enhance the system or the design to be able to meet the requirements of this study. Figure 3 tells the work flow of the researchers.

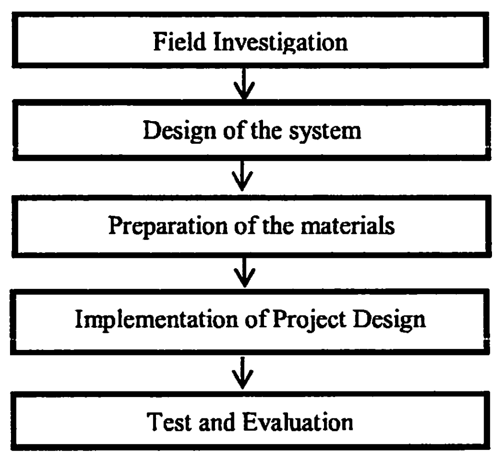

Figure 3. ***Work flow of Detailed Project Design***

Field Investigation. The researchers ask permission to the Barangay Local Government Unit of Panikian to conduct a research study within their place. The researchers gathered important data on water stream current, the flow of water areas, prone in flood area and the other related activities within the area.

Design of the system. The researches focuses on the enhancement of the blade and the channel basin so that the power will be enhance. The researchers ask guidance for mechanical work because it is hard for us to take this study without the knowledge of a mechanical engineer for the best the system for the blade and channel design.

Preparation of Materials. From the beginning of the study, the researchers already gathered the important materials to be use in the said area such as the cement and sand/gravel for constructing the cylindrical concave basin, after that the researchers prepared the set up of hydroelectric turbine in the area.

Implementation of Project Design. Implementation simply means carrying out the activities described in your work plan. Furthermore, the researcher conducted physical behavior test of the water by applying the floating method to be able to know the power of the water stream. Load calculation is needed, to know how much power the stream can provide.

Test and Evaluation. One of the most important measures to be implemented is the test and evaluation of the project because in this way the researchers will find out the best output with its maximum results.

Project Implementation

To ensure the suitability and sustainability of location, the researchers enhance the project design with the gathered data being collected and with a systematic study of the designing, developing and implementation phase. The researchers prepare all the materials needed for the implementation of the project study, but first and foremost the researchers construct first the channel basin for the hydro electric turbine. It is not easy to implement with this kind of study for it needs to have patience because the researchers will wait first for the basin to dry up and it takes 24 hrs before we implement the project.

Project Evaluation

The project study will be evaluated with the resukts obtained throughout the process. These are the following to be evaluated in the project study:

1. Performance: Is the design of the blade and channel basin can enhance the power of previous study?
2. Durability: Can the blade and the channel basin won't be the damage during a strong typhoon?

Project Setting

The researchers configure the location to be implemented, and the proposed implementation is in the vicinity located a few kilometers from the highway in Barangay Panikian,Carrascal, Surigaodel Sur. This location was chosen due to the availability of the water source and close to the recipient of this project that will be implemented. The main water source is from a river. A water irrigation for a rice field was taken from the river and that small stream was used as our source for this project.

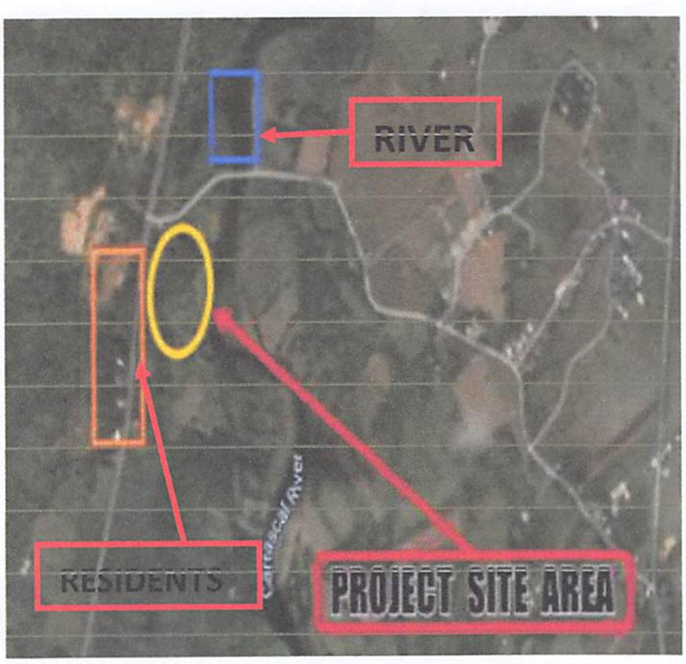

Figure 4. *Location Map Satelite View*

Participants of the Study

Table 1 is the illustration of the involved contributors in the study in which it quantified the total number of the participants.

The participants of the study were the selected people living near the river and practitioners such as electrical and mechanical engineers. The researchers also seek knowledge from persons with high understanding in terms of mechanical and electrical aspects in developing and testing this project.

Table 1. ***Participants Involved in the Project Study***

Participants	f(n=6)	%
Brgy. Captain	1	25
Irregation President	1	25
Electrical Engineer	1	25
Mechanical Engineer	1	25
Person residing in the area	1	25

Instrumentation

The researchers use modern equipment to identify the result of the project output. For the test measurements, the researchers use different tools that provide them the relevant results in testing and measuring the system. For measuring lengths, the researchers used a tape measure. For measuring time, the researchers used a smart phone to measure lengths of time. For measuring revolutions, the researchers used a digital tachometer. This device can measure the relative revolution of the turbine and alternator. For the measurements of the voltage and current, the researchers used a digital multimeter. For the measurement of the angle of elevation of the penstock, the researchers used a protractor.

Ethical Consideration

Based on the laws, the developments of the project do not violate any environmental issues. The researchers take utmost care of not doing any harm to the people and the surrounding environment from the development of this project.

The researchers ensure that the implemented project is overall environment-friendly and does not provide ill effects to the recipients and to the nature. Moreover, this project is about harnessing the energy developed by water and has no pollution to the environment.

Data Collection Procedures

The researchers visit and investigate the vicinity of the place for the availability of the water and the location suitable for the implementation. The researchers also conduct an interview with the residents residing the near the location about the behavior of the stream source and the weather throughout the year.

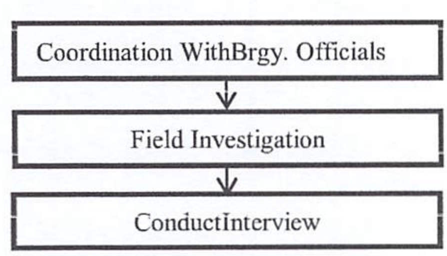

Figure 5. *Data Collection Procedure*

Coordination with Brgy. Officials. The researchers approach the Local Government Unit OfBrgy. Panikian, Carrascal, Surigaodel Sur to ask permission to let the researchers go to the area and study the location, to be authorized to make a project study.

Field Investigation. The researchers study the field if it is suitable for the project to be implemented, and measuring, and testing the area if the water stream power is enough to rotate the turbine.

Conduct Interview. The researchers conduct interview to the people residing close to the area if that location is prone to floods, and landslide and also if that area is a play zone area of for kids. As a result of interviews, the location is suitable for the implementation of project.

3. RESULTS AND DISCUSSION

3.1 Flow Rate of the Stream

Table 2 shows the measurements of the flow rate of the water using a timer with the length of the flow of 1 meter by using a Ping-Pong ball being swept with the current.

Table 2. ***Measurement of the flow rate of the water using a Ping-Pong ball***

Trial	Length(m)	Time(s)	Velocity (m/s)
Trial 1	1	0.9	1.1
Trial 2	1	1.00	1.0
Trial 3	1	0.9	1.11
Trial 4	1	0.8	1.25
Trial 5	1	1.01	0.99
AVERAGE		**0.92**	**1.09**

Table 2 shows the measurements of the flow rate of the water using a timer with the length of the flow of 1 meter by using a Ping-Pong ball being swept with the current.

The measurement is made by measuring the time it takes a floating object to travel a specified distance downstream and in this case researchers marked 1 meter distance and counted 5 trials then computed the average time. The researchers also measure the width and the height of the river using a meter stick. These are the calculation in order to quantify the available power if the water stream.

Height= 0.92m

Width = 0.51m

Distance = 1m

Average Velocity = Distance/Time=1m/1.09s= 0.92m/s

Area = W x H = (0.51)(0.92) = 0.4692 m^2

Volume Flow = Area x Velocity =(0.92)(0.4692)=0.4317 m^3/s

Power = YQh = (9810)(0.4317)(0.92) = **3.896KW**

Table 3 shows the measurements of discharge of the water basin that was measured with a timer through the use of 4-liter container that fetched the water at the outlet.

Table 3. ***Discharge of the basin measured in seconds with the four-liter container***

Trial	Volume(l)	Time(s)	Discharge(l)
Trial 1	4	1.01	2.75
Trial 2	4	1.03	2.58
Trial 3	4	1.01	2.66
Trial 4	4	1	2.58
Trial 5	4	1.50	2.66
AVERAGE		**1.11**	**2.65**

3.2 Characteristics of the Turbines

Model turbines are tested under different conditions of head, discharge, speed, power, efficiency. Results are plotted in the form of curves and are known as performance characteristic curves.

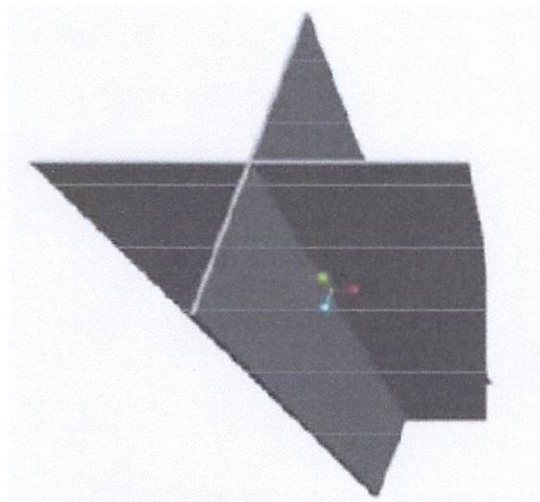

Figure 5. Rectangular Blade Turbine

The simple blade is rotated by the movement of the water in the horizontal plane. The rectangular blade consists of a rectangular bladed fixed to the shaft. The number of blades varies with the design, but studies have shown that performance improves with a lower number of blades.

Figure 6. Rectangular Curve Blade Turbine

The curved blade is also rectangular but curved to capture the force of the water better. The angled blade also captures energy from the vertical movement of the water.

For the design of the hydroelectric turbines to be efficient, the blade of the turbine and the basin should be observed.

Calculation of theoretical power is given by

$$P = Q\gamma h \quad [1]$$

Where: γ is specific weight of the water, N/s^3

Q is volumetric discharge of the water, m^3/s.

h is the effective head of the water, m.

Q = 2.65L or 0.00256 m^3/s

γ = 9807 N/s^3

h = 0.5m

P = (0.00256)(9807)(0.5)

= 12.994275W

3.3 Enhancement of Power, Blade, and Channel Design in Hydroelectric Whirlpool Turbines

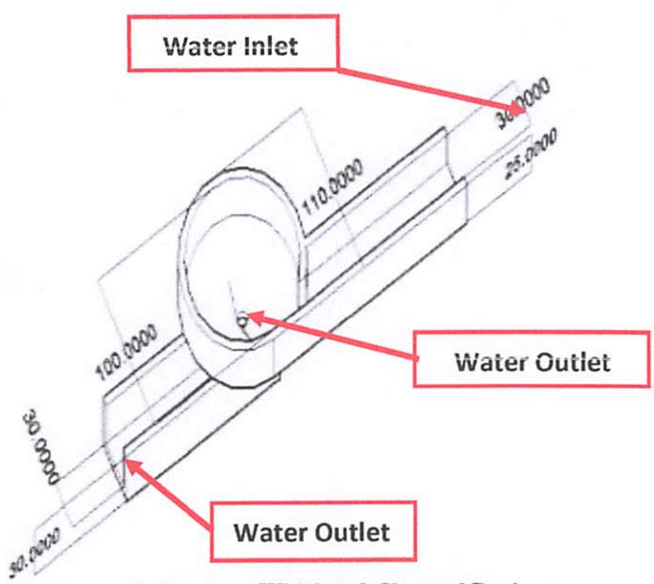

Figure 7. ***Previous Whirlpool Channel Design***

Figure 7 show the previous researchers design of whirlpool channel with its results below in table 4.

Table 4 shows the measurements of discharge of the water basin that was measured with a timer through the use of 4-liter container that fetched the water at the outlet.

Table 4. Discharge of the basin measured in seconds with the four-liter container of the previous study.

Trial	Volume(liters)	Time(seconds)	Liters/Second
Trial 1	4	1.95	2.05
Trial 2	4	2.36	1.69
Trial 3	4	2.26	1.77
Trial 4	4	2.36	1.69
Trial 5	4	2.30	1.74
AVERAGE		**2.25**	**1.78**

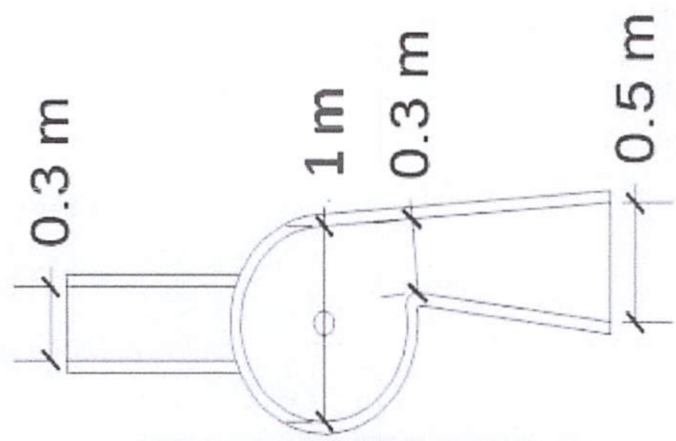

Figure 8. ***New Cylindrical Whirlpool Design***

New cylindrical whirlpool design has the abilty to make the current of the stream travel fast than the previous design because the new design has an entrance of 0.5m and before the water go to the vortex it measured with 0.3m which gives pressure to the current stream and you will see the result in table 3 that the basin improved by its design.

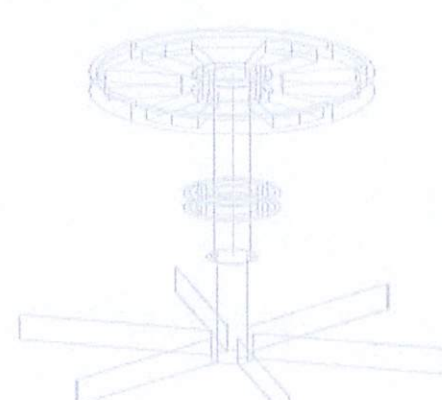

Figure 9. Previous *Turbine Design*

Previous turbine design has 6 blades without c urvatures and causes a greater distortion in the vortex

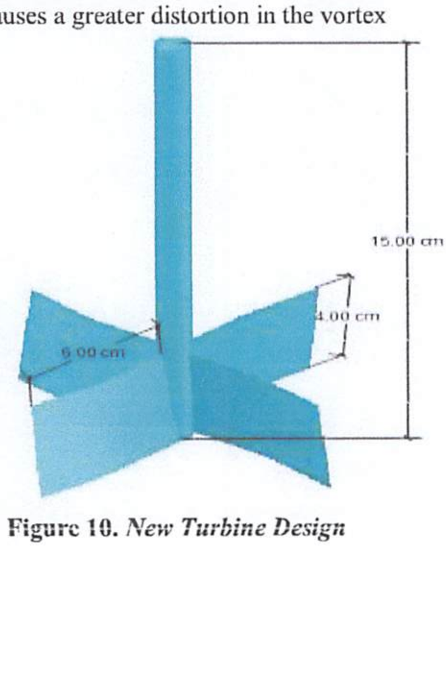

Figure 10. ***New Turbine Design***

Having four propellers in the turbine with curvature can improve the velocity and the efficiency in it because it can catch more water in the basin. The number of blades varies with the design, but studies have shown that performance improves with a lower number of blades. The curved blade is also rectangular but curved to capture the force of the water better.

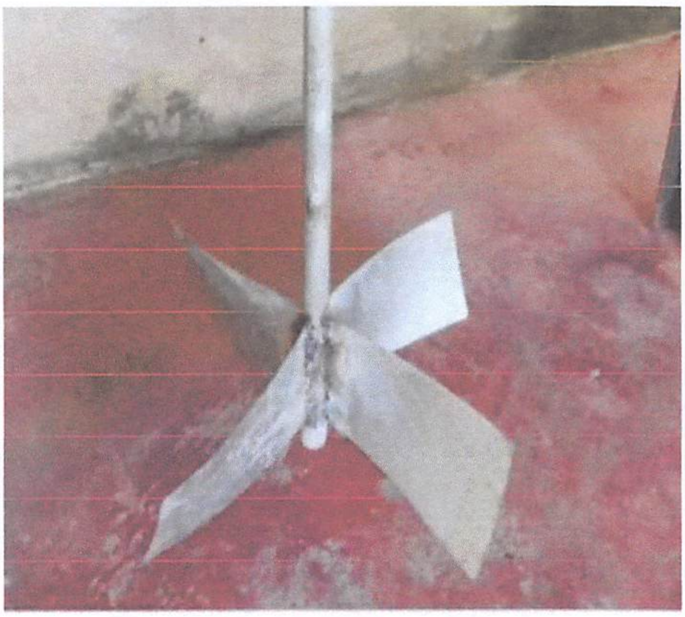

Figure 11. ***Actual Design of the Turbine Blade***

The turbine blade used is as a prime mover for the alternator. It rotates when there is a driven force from the whirlpool that gives power to the alternator to create energy. Figure 7 shows the actual design of whirlpool turbine with 4 blades with the length of 12cm, height 4cm and wheel diameter of 6cm.

Trial	Time(second)	RPM
1	60	98.1
2	60	95.9
3	60	96.6
4	60	94.3
5	60	97.6
AVERAGE		96.5

Table 5. Measurement of revolution per minute of the turbine using a digital tachometer for the new design.

Trial	Time(second)	RPM
1	60	78.1
2	60	77.9
3	60	79.1
4	60	80.1
5	60	81.3
AVERAGE		79.3

Table 6. This is previous measurement of revolution per minute of the turbine using a digital tachometer .

Figure 12. ***Design of the Cylindrical Concave Basin***

Actual design of the water basin used to develop the whirlpool is show in Figure 8. The diameter of the basin is 1m meter with a circumference of 3.14m. The length and width of the cross sectional areas of the entrance are 17 cm and 15cm, respectively. The water from the source is fed up to the basin. From this, the whirlpool is then created

Figure 13. Previous Alternator

Figure 13 shows the alternator used, it has a built-in rectifier and voltage regulator, this alternator has an output of 12v DC and a maximum ampacity of 55A.

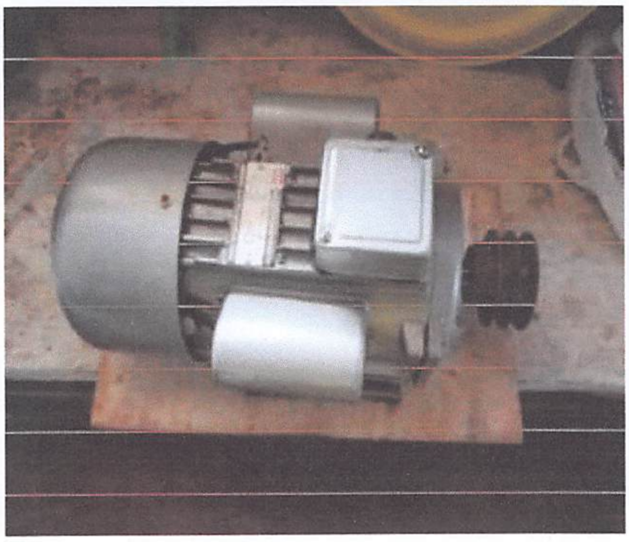

Figure 14 . ***Alternator***

Figure 9 shows an electrical generator that converts mechanical energy to electrical energy in the form of alternating current.The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-Pulley at the end of the crankshaft by a V belt. The type of alternator that the researchers purchase contains diodes that convert AC to DC, and IC regulator that keeps the generated voltage constant even when the engine speed changes.

Table 7. ***Specification of Generator***

Model of alternator	LR160-741 (HITACHI)
Model of IC regulator	SA-A (HITACHI)
Battery Voltage	24V
Nominal Output	24V/90A
Direction of Rotation	Clockwise
Weight	6.2kg
Rated Speed	5000 min^{-1}
Operating Speed	1,050-18,000 min^{3}
Regulated Voltage	14.4+0.3V at 20C

Table 7 shows the specification that the researchers used. It is a good generator because of its specification that has a built in regulator and IC regulator for soft operation.

Figure 10. ***Belt***

The researchers use belt since it is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. This is a way to give a source of motion, to transmit power efficiently or to track relative movement. The size of belt is 182.88 cm.

Figure 11. ***Battery***

Battery is important to regulate and make the output voltage stable for the load. This is necessary in order to prevent the circuit from malfunction or any problem that may arise with regards to the supply voltage. Researchers decided to use battery because nature is unpredictable. Even though the residents nearby the water stream claimed that the water stream will flow steadily amidst extreme heat of the sun, researchers still used battery to protect the circuits ahead. This battery is a 24V dc voltage with a maximum of 80 ampacity.

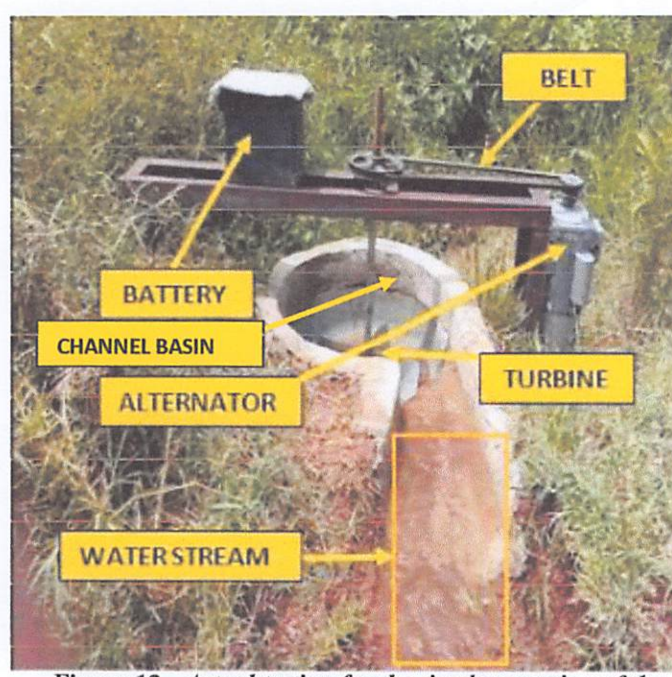

Figure 12. ***Actual testing for the implementation of the project***

The figure above shows the actual testing implementation of the hydroelectric turbines. Water already wipe out through whirlpool of the basin.

Figure 13. Previous Actual Project Design

The figure above shows the actual testing of the previous implementation of the hydroelectric turbines. The previous researchers uses only wooden foundation while the present researchers uses metal as foundation.

Table 8. Measurement of output voltage of alternator without load in the previous study.

Trial	Time(second)	Voltage
1	60	13.6
2	60	12.9
3	60	12.5
4	60	13.1
5	60	12.8
AVERAGE		**12.98**

Table 9. Measurement of output voltage of alternator without load in present study.

Trial	Time(second)	Voltage
1	60	17.8
2	60	18.3
3	60	18.6
4	60	17.6
5	60	18.5
AVERAGE		**18.16**

Table 8 and 9 shows the measurements of the output voltage of the alternator in the previous and present study. These measurements are taken without a load connection. The results show us that the output voltage in the present study is improved.

Financial Feasibility of the Project

Table 10 shows the unit cost of the project, the researchers make sure that all items that have been purchased is standard with its quality.The total expenses of the researchers spend for this project costs ₱10,847

Table 10. ***Unit Cost of the Project***

PARTICULAR	QUANTITY	COST/ UNIT	AMOUNT
Generator	1 pc.	3,500.	3,500
V Belt Shaft	1 pc.	120	120
Battery	1 pc.	2,500	2,500
Wires	2 meters	55	110
V Belt	1 pc.	142	142
Flat Iron Angle Bar	2 pc	550	1100
Cement	1pc.	220	220
Sand/Gravel	3 sacks	40	180
Basin Sink	1pc.	250	250
Welding	1 welder	1500	1,500
Transportation	3	400	1,200
TOTAL AMOUNT			**₱10,847**

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the findings the following conclusions are drawn:

1. It is concluded that with a flow rate of 1.09 m/s using ping pong ball and it produces a power of the stream with 3.896kW.
2. Furthermore it is concluded that with these two kinds of designs - the rectangular blade which is the previous design and rectangular curve blade which is the present design shows that rectangular curve blade is the best design to the study.
3. Lastly it is concluded that the design of the whirlpool was enhanced in terms of the discharge of water from its outlet with a measurement of 2.65 liters per 1.11 seconds compared to the previous design which has a measurement of 2.25 liters per 1.78 seconds.

Recommendation

Based on the findings the recommendations are also drawn:

1. It is recommended that the design of whirlpool to be enhance further using a conical basin design.
2. It is also recommended to use other design of blade such as kaplan water turbine design to generate more power.
3. Lastly it is also recommended to use motor generator to generate more power.

5. ACKNOWLEDGEMENTS

This project study has been successful through the help and support of many people. The researchers would like to express their genuine gratitude and appreciation to all the people behind the completion of this study. First and foremost, to the Almighty God for the wisdom, strength, optimism, good health and guidance He unconditionally gave to the researchers. Without Him, this project study will not be realized. To the researchers' beloved parents and family, for the financial, emotional, and spiritual support, they have provided to the group. To the co-author, Engr. Conrado Delosa, who encouraged us to this study and his knowledge, expertise that assisted to the researcher.. To Engr. Robert R. Bacarro for giving his time and effort to review, discuss and even conducting a seminar that helps us the researchers to do the study well even if he has the responsibility in the college as college dean. To Engr. Aldrich B. Calinawan for giving us time to discuss and gave insights about the blade designs and the channel design of hydroelectric whirlpool turbine. To Mr. Demster Fijo for giving his time and effort in creating our auto cad designs for the basin and turbine. Lastly to the Barangay Local Government Unit for letting the researchers to use the area of the project studies.

3. REFERENCES

[1] IIEE.ORG (2019), Hydroelectric analysis, [Online]. Viewed 2019 January 10.

[2] Zotloterer. (2013). Retrieved March 2019, from Zotloterer : Available: http//.wwwzotloterer.com.

[3] Chaulagain, R. K. (2012). Development and Testing of Gravitational Water Vortex Turbine. IOE. Retrieved March , 2019

[4] Faulkner, S. (1991). A simplified low head propeller turbine for micro-hydroelectric power. [Online], Viewed 2019 March 12. Available: http//www.dfew.org/Faulkner/turbine

[5] F. Manzini and P. Macías, "NuevasEnergíasRenovables: Unaalternativaenergéticasustentable", Centro deinvestigaciónenenergía / Universidad NacionalAutónoma de México, Ciudad de México, México, Tech. Rep., Aug. 2004

[6] S. Wanchat, R. Suntivarakorn, S. Wanchat, K. Tonmit and P. Kayanyiem, "A Parametric Study of a Gravitation Vortex Power Plant", *Advanced Materials Research*, vols. 805-806, pp. 811-817, 2013

[7] D. Basset, "A historical survey of low-head hydropower generators and recent laboratory based work at University of Salford", Ph.D. dissertation, Dept. Civil Eng., Univ. of Salford, Manchester, UK, 1989

[8] D. Basset, "A historical survey of low-head hydropower generators and recent laboratory based work at University of Salford", Ph.D. dissertation, Dept. Civil Eng., Univ. of Salford, Manchester, UK, 1989

[9] V. Lobo, "Design of a vortex induced based marine hydro-kinetic energy systems", M.S. thesis, Missouri University of Science and Technology, Missouri, USA, 2012.

[10] C. Chang, "Hydrokinetic energy harnessing by enhancement of flow induced motion using passive turbulence control", Ph.D. dissertation, Univ. of Michigan, Michigan, USA, 2010.

[11] J. Senior, "Hydrostatic Pressure Converters for the Exploitation of Very Low Head Hydropower Potential", Ph.D. dissertation, Univ. of Southampton, Southampton, UK, 2009.

[12] O. Yaakob, Y. Ahmed, A. Elbatran and H. Shabara, "A review on Micro Hydro Gravitational Vortex Power and Turbine Systems", *JurnalTeknologi*, vol. 69, no. 7, pp. 1-7, 2014.

[13] S. Dhakal, S. Nakarmi, P. Pun, A. Thapa and T. Bajracharya, "Development and Testing of Runner and Conical Basin for gravitational for gravitational Water Vortex Power Plant", *Journal of Institute of Engineering*, vol. 10, no. 1, pp. 140-148, 2014.

[14] S. Mulligan and P. Hull, "Design and optimisation of a water vortex hydropower plant", Undergraduate thesis, Inst. of Tech. Sligo, Sligo, Ireland, 2010.

[15] H. Shabara, O. Yaakob, Y. Ahmed and A. Elbatran, "CFD Simulation of Water Gravitation Vortex Pool Flow for Mini Hydropower Plants", *JurnalTeknologi*, vol. 74, no. 5, pp. 77-81, 2015.

16] C. Power, A. McNabola and P. Coughlan, "A Parametric Experimental Investigation of the Operating Conditions of Gravitational Vortex Hydropower (GVHP)", *Journal of Clean Energy Technologies*, vol. 4, no. 2, pp. 112-119, 2016.

[17] England: C. Griffen Co., 1858. W. J. M. Rankine, *Manual of applied mechanic*, London,

[18] A. J. Odgaard, "Free-surface air core vortex," *Journal of HydraulicEngineering*, vol. 112, no. 7, pp. 610-620, 1986.

[19] J. E. Hite Jr. and W. C. Mih, "Velocity of Air-Core Vortices at Hydraulic Intakes," *Journal of Hydraulic Engineerring*, vol. 120, no. 3, pp. 284-297, 1994.

[20] C. Yun-liang, W. Chao, Y. Mao, and J. Xiao-ming, "Hydraulic Characteristics of Vertical Vortex at Hydraulic Intakes," *Journal ofHydrodynamics*, vol. 19, no. 2, pp. 143-149, 2007.

[21] J.-P. Torre, D. F. Fletcher, T. Lasuye, and C. Xuered, "CFD Modelling of partially baffled agitated vessels with free surfaces," presented at Fifth International Conference on CFD in the Process Industries, CSIRO, Melbourne, Australia, 2006.

[22] A. Busciglio, F. Grisafi, F. Scargiali, and A. Brucato, "On vortex shape in unbaffled stirred vessels as mesured by digital image analysis," presented at 14TH European Conference on Mixing, Warszawa, 2012.

[23] K. Parahoo. "Nursing research: principles process and issues". Basingstoke: Macmillan; 1997. [Online]. *Research*vols. 805-806 (2013) pp 811-817, 2013

[24] Viewed: 2019 October 22 https://www.technologyandus.com/whirlpool-turbine-an-innovation-to-inlight-the-rural-areas/