Surigao City Campus

Bachelor of Science in Electrical Engineering

SURIGAO STATE COLLEGE OF TECHNOLOGY

SSCT

"For Nation's Greater Heights"

I.4.1 alternative sources of energy/renewable energy;

COLLEGE OF ENGINEERING AND INFORMATION TECHNOLOGY
City Campus
First Semester, Academic Year 2021-2022

Outcomes Based-Education (OBE) Syllabus in EE 422
RESEARCH PROJECT / CAPSTONE DESIGN PROJECT FOR EE
Course Credit: 1.0 unit (22 hrs)

Institutional Vision, Mission, and Goals

Vision:
An innovative and technologically-advanced State College in Caraga.

Mission:
To provide relevant,
a. high quality and sustainable instruction,
b. research, production and extension programs and
c. services within a culture of credible and responsive institutional governance.

Goals:
1. Foster application of the discipline and provide its learner with industry-based training and education particularly in engineering, technology and fisheries.
2. Conduct and utilize studies for the development of new products, systems and services relevant to Philippine life and of the global village.
3. Promote transfer of technology and spread useful technical skills, thus empowering its learners and their activities.

SSCT Core Values

Service-Oriented   Socially Responsive   Committed   Transformational

SSCT Quality Policy

Surigao State College of Technology provides quality instruction, research, extension programs and production services to satisfy its customers by responding to their needs and expectations and continually improving its quality management system.

Institutional Graduate Attributes (IGA) :

- Visionary Leader
- Effective Communicator
- Competent Technologist
- Self-Directed Lifelong Learner

Program Goals

:The *Electrical Engineering* program aims to design and apply the generation , transmission, and distribution of electrical energy to produce competent engineers that exhibit positive work ethics and flexibility in work conditions for nations greater heights.

Program Educational Objectives (PEO) and Relationship to Institutional Mission

Program Educational Objectives (PEO)	Mission		
	a	b	c
EE-PEO1. Demonstrate professionalism in electronics engineering and apply professional ethics thru communication and collaboration.	/	/	/
EE-PEO2. Use appropriate techniques, resources, and modern tools necessaryfor analysis, design, and modelling of complex electrical systems	/	/	/
EE-PEO3. Plan, lead, and implement designated tasks, interact with other engineering professionals, and take leadership roles in electrical engineering organization	/	/	/
EE-PEO4. Engage in lifelong learning able to discover new opportunities for continuing personal and professional development in electrical engineering	/	/	/

Program Outcomes (PO) and Relationship to Program Educational Objectives (PEO)

Program Outcomes (PO)	Program Educational Objectives (PEO)			
	1	2	3	4
EE-POa. Apply knowledge of mathematics and science to solve engineering Problems				
EE-POb. Design and conduct experiments, as well as to analyse and interpret Data				
EE-POc. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political,	/	/	/	/

ethical, health and safety, manufacturability, and sustainability, in accordance with standards				
EE-POd. Function on multidisciplinary teams				
EE-POe. Identify, formulate, and solve engineering problems				
EE-POf. Apply professional and ethical responsibility				
EE-POg. Communicate effectively				
EE-POh. Identify the impact of engineering solutions in a global, economic, environmental, and societal context	/	/	/	/
EE-POi. Recognition of the need for, and an ability to engage in life-long learning				
EE-POj. Apply knowledge of contemporary issues				
EE-POk. Use techniques, skills, and modern engineering tools necessary for engineering practice				
EE-POl. Apply knowledge of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments	/	/	/	/
EE-POm. Understand at least one specialized field of electronics engineering practice				

Course Description

This is the capstone course which utilizes the fundamentals of electrical engineering in the design of an electrical system. It includes the synthesis of processes, analysis of process conditions and the analytic, heuristic and optimum design of equipment and processes. Economic analysis is included to estimate the cost of equipment, capital investment, total product cost and profitability.

DACUM Main Duties (DMD)

EE-DMD1. Design, review, and redesign schematic diagrams, plan layout, and execution plan
EE-DMD2. Approve the system operation as per approved project specification
EE-DMD3. Oversee project implementation
EE-DMD4. Site survey
EE-DMD5. Coordinate with team members

Course Outcomes (CO) and Relationship to Program Outcomes (PO)

Program Outcome (PO) / Level	Course Outcomes (CO)	Assessment Task (CO-AT)	DACUM Links				
			1	2	3	4	5
EE-POc *Demonstrating* Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards;	*EE422-CO1*: Design an electronic system in accordance to environmental, safety standards and economic feasibility.	Students design an electronic system as their capstone project. This is a group project were they will analyze, design, develop, implement, and evaluate the electronic system project. Criteria – Environmental, safety standards, economic feasibility Total: 80 points	/			/	
EE-POh *Demonstrating* Identify the impact of engineering solutions in a global, economic, environmental, and societal context;	*EE422-CO2*: Identify societal problems that needs electronic engineering solution.	Students do a societal scanning of real-world problems that needs engineering solution. This is an individual project were the student will propose a solution using electronic engineering technology. Criteria – Realistic problem, Innovation, Technology Total: 80 points			/		
EE-POl *Demonstrating*	*EE422-CO3*: Apply engineering management in working with capstone	Students do a business plan for the capstone project. This is a group project were the		/			/

Apply knowledge of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments;	project as a leader or a member in a team.	student will apply engineering economy and technopreneurship for the project feasibility in business incubation. Criteria – Financial Plan, Return of Investment, Break-even analysis Total: 80 points					

Course Outcomes (CO) and Relationship to Intended Learning Outcomes (ILO)

Course Outcomes (CO)	Intended Learning Outcomes (ILO)
EE422-CO1: Design an electronic system in accordance to environmental and safety standards	*EE422-ILO4*: Design system models and simulations of systems operation. (EE422-CO1) *EE422-ILO5*: Design the evaluation process of the developed system. (EE422-CO1) *EE422-ILO7*: Design the research journal for presentation in research conference. (EE422-CO1)
EE422-CO2: Identify societal problems thatneeds electronic engineering solution.	*EE422-ILO1*: Identify real-world problems. (EE422-CO2)
EE422-CO3: Apply engineering management in working with capstone project as a leader or a member in a team.	*EE482-ILO2*: Apply project development process in capstone project. (ECE482-CO3) *EE422-ILO3*: Apply project management in implementation of capstone project. (EE422-CO3) *EE422-ILO6*: Apply engineering economy in the profitability of the project. (EE422-CO3)

Detailed Course Content

Intended Learning Outcomes (ILO)	Topics	Time Frame	Teaching and Learning Activities (TLA)	Assessment Tasks (ILO-AT)	Target	Resources	Values Integration	Remarks
EE422-ILO1: Identify real-world problems. (EE422-CO2)	**1. SCANNING OF REAL-WORLD PROBLEMS** *1.1 Selecting Research Problems* *1.2 Choosing the Project Study*	7.0 hrs	Paired critiquing on real-world problems *Synchronous* Learning Module 1 *Asynchronous*	Identification quiz on researchable real-world problems for capstone project	70% of the students shall have a rating of at least 3.0	Video clip on real-world problems	Core Value: *Committed* Sub-Value: *Persistent identification of real-world problems*	
EE422-ILO2: Apply project development process in capstone project. (EE422-CO3)	**2. ENGINEERING PROJECT DEVELOPMENT** *2.1 Problem Analysis* *2.2 System Design and Development* *2.3 Project Implementation* *2.4 System Evaluation*	7.0 hrs	Video viewing in youtube in engineering project development *Synchronous* Learning Module 2 *Asynchronous*	Graded oral presentation in engineering project development	70% of the students shall have a rating of at least 3.0	Website in engineering project development	Core Value: *Transformational* Sub-Value: *Adaptive project development*	
EE422-ILO3: Apply project management in implementation of capstone project. (EE422-CO3)	**3. PROJECT MANAGEMENT** *3.1 Project Initiation* *3.2 Project Planning* *3.3 Project Execution* *3.4 Project Monitoring and Controlling* *3.5 Project Closing*	8.0 hrs	Video viewing in youtube in project management *Synchronous* Learning Module 3 *Asynchronous*	Q & A about project management	70% of the students shall have a rating of at least 3.0	Website in project management	Core Value: *Service oriented* Sub-Value: *Commitment in project management*	

EE422-ILO4: Design system models and simulations of systems operation. (EE422-CO1)	**4. SYSTEM MODELLING** *4.1 Software Modelling* *4.2 Software Simulation*	7.0 hrs	Perform a system modelling and simulations of system operation *Synchronous* Learning Module 4 *Asynchronous*	Graded project presentation in system modelling for capstone project	70% of the students shall have a rating of at least 3.0	Video clip in system modelling	Core Value: *Transformational* Sub-Value: *Optimistic system modelling*	
PROPOSE PROJECT PRESENTATION – 1.0 Hr.								
EE422-ILO5: Design evaluation process of the developed system. (EE422-CO1)	**5. SYSTEM PERFORMANCE EVALUATION** *5.1 Technical Standards* *5.2 Environmental Issues* *5.3 Health and Safety* *5.4 Ethics*	7.0 hrs	Design an evaluation process of a developed system *Synchronous* Learning Module 5 *Asynchronous*	Graded project presentation in system performance evaluation related to capstone project	70% of the students shall have a rating of at least 3.0	Website in system performance evaluation	Core Value: *Socially responsive* Sub-Value: *Accountability in performance evaluation*	
EE422-ILO6: Apply engineering economy profitability of the capstone project. (EE422-CO3)	**6. ENGINEERING ECONOMY IN PROJECT PROFITABILITY** *6.1 Project Costing* *6.2 Break-Even Analysis* *6.3 Return of Investment*	7.0 hrs	Exhibitions in economic feasibility of the capstone project *Synchronous* Learning Module 6 *Asynchronous*	Q & A about the application of engineering economy in capstone project	70% of the students shall have a rating of at least 3.0	Website in engineering economy	Core Value: *Socially responsive* Sub-Value: *Empathy in project profitability*	
EE422-ILO7: Design the research journal for presentation in research conference. (EE422-CO1)	**7. ENGINEERING RESEARCH JOURNAL** *7.1 IEEE Citation* *7.2 IEEE Research Journal*	9.0 hrs	Participate in crafting the capstone project research journal *Synchronous* Learning Module 7	Graded project presentation in research journal for capstone project	70% of the students shall have a rating of at least 3.0	Website in IEEE research journal	Core Value: *Committed* Sub-Value: *Integrity in writing research*	

			Asynchronous				journal	
CAPSTONE PROPOSAL PRESENTATION – 1.0 Hr								

References:

Books

Bermudo, P. et. al (2010). *Research Writing Made Simple: A Modular Approach for Collegiate and Graduate Students.*. Mindshapers Co., Inc. Philippines
Narayan, R. (2014). *Research Methodology and Techniques in Computers.* Centrum Press. New Delhi.

Webpage

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D. Bromley. *System Evaluation.* Retrieve from: https://www.modustrading.com/WhatIsSystemEvaluation.html#:~:text=System%20evaluation%20is%20the%20process,Parameter%20selection.
D. Resnik. *What is Ethics in Research & Why is it Important.* Retrieve from: https://www.niehs.nih.gov/
Chron. *Product Cost.* Retrieve from: https://smallbusiness.chron.com/product-costing-vs-cost-accounting-37642.html#:~:text=Product%20costing%20is%20the%20accounting,costs%20and%20retail%20stocking%20fees.
Return of Investment . Retrieve from: https://www.investopedia.com/terms/r/returnoninvestment.asp
Investopedia. *Break-even Point.* Retrieve from: https://www.investopedia.com/terms/b/breakevenanalysis.asp
M. Kerr. *How to write a Market Analysis.* Retrieve from: https://articles.bplans.com/how-to-write-a-market-analysis/
Wikipedia. *Gantt Chart.* Retrieve from: https://en.wikipedia.org/wiki/Gantt_chart
Editage Insights. *Effective Table and Figure Presentation.* Retrieve from: https://www.editage.com/insights/tips-on-effective-use-of-tables-and-figures-in-research-papers?refer=scroll-to-1-article&refer-type=article
Enago Academy. *Table and Figure Presentation.* Retrieve from: https://www.enago.com/academy/how-to-use-tables-and-figures-to-effectively-organize-data-in-research-papers/
University of Victorias. *What is a Journal.* Retrieve from: https://www.uvic.ca/library/research/tips/journal/index.php
IEEE Research Journal Format. Retrieve from: https://www.coep.org.in/page_assets/491/IEEE_Template_4.pdf
MeaseyLabs. *Making a presentation from your research proposal.* Retrieve from: http://john.measey.com/Blog/2018/03/18/Making-a-presentation-from-your-research-proposal
Podiobox. *15 Minute Presentation Guide.* Retrieve from: https://www.podiobox.com/blog/post/15-minute-presentation-quick-guide
Business Insider. *7 brilliant ways to start any presentation.* Retrieve from: https://www.businessinsider.com/smart-ways-to-start-a-presentation-2016-6#-7
Inomics. *Dress Code for Economic Conferences: What to Wear and What to Avoid.* Retrieve from: https://inomics.com/advice/dress-code-for-economic-conferences-what-to-wear-and-what-to-avoid-48004#:~:text=Smart%20is%20better%20than%20casual&text=For%20women%2C%20skirts%20and%20dresses,dress%20up%20a%20plain%20outfit.
Brock University. *How to Create a Research Poster.* Retrieve from: https://researchguides.library.brocku.ca/poster

Course Policies:

1. Attendance shall be checked in every class session in the Google Meet. This is to monitor the absences incurred by the students in terms of the allowable number of absences for a course as stipulated in the Student Handbook.
2. During online classes, video camera shall be turned on all the time and microphone shall be turned off. The microphone shall be unmuted only if the student's name is called to participate in class discussion.
3. Major examinations in multiple-choice type shall be done online. For problem solving type, detailed solutions shall be written legibly in separate sheets of paper and shall be converted to pdf form prior to submission.
4. Cheating in major examinations which includes attempts to defraud, deceive, or mislead the instructor in arriving at an honest assessment shall entail zero score.
5. Plagiarism which is a form of cheating that involves presenting the ideas or work of another as one's own work shall entail zero score.
6. Projects shall be submitted on or before the deadline. Students who submit unsatisfactory projects shall be given the chance to improve their works on the condition that they resubmit the revised outputs on the date set by the instructor. Non-submission of a project on the deadline shall entail zero score.
7. An INC grade shall be given to students who fail to submit the course requirements of at least 95% of the projects and quizzes or failure to take the major examinations.

Revision History:

Revision No.	Revised by	Date of Revision	Date of Implementation	Highlight of Revision
1	Engr Vicente Z. Delante	August 2021	September 2021	Followed OBTL Format as per CMO #101 S. 2017
				DACUM Workshop vis-à-vis CMO No. 101 S. 2017

Prepared by:

ENGR. Vicente Z. Delante
Asst. Prof. 111

Date: 8/16/21

Checked and reviewed by:

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Date: 8/16/21

Noted by:

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, CEIT

Date: 8-17-21

Recommended by:

RONITA E. TALINGTING, PhD
Campus Director

Date: 8-12-21

Approved by:

EMMYLOU A. BORJA, EdD
VP for Academic Affairs

Date: 8-13-2021

1.4.1

APPROVAL SHEET

This Project Study entitled "**PHOTOVOLTAIC SOLAR TRACKING CHARGING STATION"** prepared by **Norween L. Osias, Guilbert E. Partos Jr., Renante D. Tampong** 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 3, 2022.

ENGR. ROBERT R. BACARRO, MECE, MBA
Chairman

ENGR. FEDERICO A. AVES
Member

ENGR. JERRY I. TELERON, PhD, PCpE
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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

June 10, 2022

1.4.1

APPROVAL SHEET

This Project Study entitled **"PERFORMANCE ANALYSIS OF SALTWATER ELECTROLYTIC CELL BATTERY USING ZINC-COPPER AND ALUMINUM-COPPER ELECTRODES"** prepared by **Howell A. Arcala, Joseph S. Serrano, Ralphie Monter and Gaspar Dale Cinco,** 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
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PANEL OF EXAMINERS

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

June 10, 2022

1-4-1

APPROVAL SHEET

This Project Study entitled **"Designing A Mini Hydroelectric Power Generator"** prepared by **Franc Jerald A. Acquiatan, Dinmark A. Mag-usara, Marc Dave V. Dagohoy** and **Precyl John P. Olario,** 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
Co-Author/Adviser

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PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 7, 2022.

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

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

Date: June 8, 2022

[-4.1

APPROVAL SHEET

This Project Study entitled **"Hybrid Power Source for an Automated Poultry Incubator"** prepared by **Marc Francis A. Arlan, John Ivan S. Alcesso, Rogelio A. Bagotsay Jr., Klent Joseph N. Rojo** 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
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PANEL OF EXAMINERS

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

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

Date: June 10, 2022

1.4.1

APPROVAL SHEET

This Project Study entitled **"Design of the Induction Motor of a Water-Turbine Generator"** prepared by **Andrew Dave Nale, James Wilsid Lazarte, Almer Silvosa and Ace Arnold Seroy** 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
Co-Author

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PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 04, 2022.

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Date: June 13, 2022

Ϳ.4.1

WEB-BASED MONITORING OF SOLAR & WIND ENERGY IN SURIGAO DEL NORTE

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Abstract: This web-based monitoring of solar and wind energy is a system that monitors data collected and it checks the feasibility of solar and wind energy in Surigao del Norte[1]. The study utilized the minicomputer raspberry pi as the central processing unit of the design[2]. The development of the project study consists of six stages, which are the analysis, design, development, implementation, evaluation, and communication[3]. The result shows the development of web-based monitoring of solar panel and wind turbine energy design system[5]. Through the use of python, the program of the system is developed. The result of line graph analysis of the harvested data proves the feasibility of the study at Brgy. Daywan Claver, Surigao del Norte[6].

Keywords: Web-based, Solar Energy, Wind Energy, Raspberry pi, Hybrid

1. INTRODUCTION

Today the drastic development of technology is widely known. Renewable energy utilization such as solar and wind power, currently become an alternative source of energy, especially in remote areas that are not reached in grid lines.. Numerous nations around the world have to make endeavors to diminish fossil fuel reliance. Nevertheless, it said by the worldwide Vitality Agency's world Vitality Viewpoint 2013 that fossil fuel utilization will still overwhelm the control division in 2035. In endeavors, governments have contributed parts of their budgets to empower the utilization of clean and renewable control sources such as biomass, geothermal, hydropower, sun-based, wind, tidal, and wave. Nowadays, these renewable vitality advances are the speediest developing vitality advances (especially wind and sun-based) and are fetched competitive in an assortment of lattice, off-grid, and farther applications worldwide. [1]

The utilize of control created by renewable sources, has expanded in later a long time. In any case, not all of the green vitality downsides have been overcome. Photovoltaic boards deliver no vitality amid no nearness of light and wind turbines cannot produce control when there's no wind or with an excess of it. That's the reason why this sort of Half-breed framework (HSs) has been made and used. Their applications can be either framework-associated or off-grid. Indeed, these frameworks have been proposed since 1998 [1], their employments and scopes have advanced as well. These days, with Web of Things (IoT) utilization, expanding, the sum of electronic and convenient gadgets associated with the electric organize is around 26 million, agreeing to these electronic devices can be at nearly any portion of the planet, at that point, diverse elective era frameworks have ended up nccessary.[2]

A hybrid energy framework is characterized as the component combination of two or more sorts of control era frameworks. For this investigation, the sun-oriented vitality framework is coordinated with the wind turbine framework to make a crossover renewable vitality framework. Since the control yield of this renewable vitality eventually depends on climatic conditions such as temperature, sun-powered irradiance, wind speed, etc., the insecurity of the framework yield is compensated by including a reasonable vitality capacity framework to the half-breed vitality framework. The control independence is enormously dependent on the idealized adjustment that exists between control request and produced control.[3]

As of now, it is seen a creating framework with a single power source non-conventional vitality does not supply the electricity required in a room of normal utilization house and a part slightest one building. Renewable vitality sources as solar, wind, geothermal, tidal, hydro, etc. are boundless by nature. So, renewable vitality sources can be utilized to supply constant loads. There are several innovative developments in plan, development, and usage for generating electrical vitality by utilizing non-conventional sources as sun-powered, wind, hydro, biomass, bio powers, and geothermal. The limitations of worldwide assets for fossil and atomic fuel have necessitated a pressing look for elective sources of energy.[4]

They propose a framework, which can foresee whether a particular put is reasonable for setting up the sun-based control plant and/or wind control plant. They outlined and actualized a moo-fetched and solid instrumented framework for inaccessible wireless estimations of climate, with the assistance of different sensors. The show is effectively deployable by keeping it on the beat of a building or being light in weight, it can be drifted with a balloon. The gadget is made as a standalone information procurement unit, from which information is sent employing GSM-based communication to the ground station. Many control sparing instruments are actualized to provide the most extreme battery life for the sensor module[5].

1.1 Related Literature

When people sail against the wind, they have been using wind. For more than two thousand years, wind turbines have been equipped with pumps and grain equipment. Wind energy is widely available and is not limited to fast-moving streams or wind farms that require fuel sources in the future. Air pumps have exhausted the pol field in the Netherlands. In arid regions such as the Midwestern United States or inland Australia, wind pumps provide water for livestock and steam engines. With the development of electrical energy, wind energy has found new applications in lighting buildings, rather than being a concentrated energy source. Throughout the 20th century, Parallel Road developed small wind power plants suitable for farms or houses, as well as large utility-scale wind turbines that can be connected to the grid for remote energy use. Today, wind turbines operate in a wide range, from small factories that charge batteries in isolated homes to almost gigawatt offshore wind farms that power the national grid.[6]

Photovoltaic energy is defined as the use of sunlight to generate electricity. Sunlight shines on photovoltaic cells or mirrors and generates electricity. In the second half of the 20th century, although Edmond Becquerel observed the impact of photovoltaic technology in 1839. The development of photovoltaic cell technology developed rapidly. In 4877, Cambridge scientist Adams published his first research report in Photovoltaic Report. Charles Fritts even converted it into a solar cell with an efficiency of less than 1% in 1883, but it is similar to modern silicon solar cells. . Chapin, Fuller, and Person built the first modern silicon solar cell. Manufactured in 1954, the efficiency of solar cells was realized through the Pn 6 junction system. The initial commercial manufacturing cost was very high, and the efficiency was relatively low, accounting for about 5-10%. In addition, solar cells are mainly made of crystalline materials such as crystalline silicon (c-Si).[3]

A hybrid system is a combination of two power sources that supply power to the load. In other words, it can be defined as "the combined use of two or more renewable energy sources to provide higher system efficiency and greater balance in the energy system." The hybrid power system has good reliability, efficiency, lower emissions, and lower cost. It is best to start with a hybrid system (HES). The hybrid power system is an engineering design of hybrid or paired power components, such as the. In the power supply, it is very common to arrange various power supplies to run in parallel (equivalent). Therefore, hybridization is defined as the cross formation of reagent pairs that work together to achieve the goal. Therefore, the hybrid is manually synchronizing or automatically synchronizing two or more power generation resources or components to supply power to the grid, thereby forming a hybrid power system. The hybrid power system is an infrastructure design that integrates multiple or more power converters for energy storage, power conditioner, and power management system. Generally, Hybrid Renewable Energy System (HRES) is an extension of HES, which uses a combination of multiple resources (such as hybrid or hybrid renewable energy) to provide a power system.[7]

Monitoring and assessment offer assistance to make strides in execution and results. The general reason for assessment is estimation and evaluation of execution meet results and yields also called comes about. Customarily, observing and assessment focusses on the appraisal of inputs and usage process. Nowadays center has moved to survey commitments of different exercises to a given advancement result with such variables as yields, cooperation, approach, methods, brokering or coordination Venture administration employments information picked up through checking and assessment to improve methodologies, programs, and exercises.[8]

The researchers was well advanced in meeting that challenge, while also testing the practical limits of doing so from wind and solar variable renewable energy. The relatively dilute nature of wind and solar mean that harnessing them is very materials-intensive – many times that from energy-dense sources. Integrating the two renewable resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes a more reliable and economical run.[9]

1.2 Theoretical Framework

Control estimation over a terminal stack is ordinarily made by assessing with a voltmeter or a computerized multimeter (DMM), the voltage, V(t) over its terminals, and by assessing the current I(t) going into the stack. The gotten electrical signals, V(t) and I(t) are either constant values if a consistent DC source is utilized or can be time subordinate on the off chance that the control source is time-varying. Information securing and broadcast framework was coordinated into the microgrid. The framework measures: add up to PV current IPV, add up to wind turbine current I_{WT}, preoccupation stack current I_{DL}, battery terminal voltage V_B, inverter RMS current I_{AC}, inverter RMS voltage V_{AC}, and inverter power factor ψ. Inverter yield recurrence is

$$P_{rated} = \frac{1}{2}\rho\eta_v \pi R^2 v_{rated}^3$$

$$P_v = \begin{cases} 0 & v < v_{cut\_in} \\ P_{rated}\left(\frac{v}{v_{rated}}\right)^3 & v_{cut\_in} \le v \le v_{rated} \\ P_{rated} & v_{rated} \le v \le v_{cut\_out} \\ 0 & v > v_{cut\_out} \end{cases}$$

additionally measured but it isn't relevant in this article. The battery current I_B isn't specifically measured, but it can be computed through the application of Kirchhoff's current law, once all the currents within the branches associated with the Dc transport are known. The current into the inverter from the Dc transport I_{DC} is additionally not measured, but it can be sensibly assessed from the measured inverter output amounts as takes after. To begin with, the AC control yield of the inverter P_{AC} is computed.

$$P_{AC} = V_{AC} I_{AC} \psi$$

Hence, a purely resistive load or a DC source would lead to a PF of zero. [10]

The common scientific show for the sun-based cell has been studied over the past three decades. The circuit of the solar cell shown, which comprises a photocurrent, diode, parallel resistor (spillage current), and an arrangement resistor. Agreeing to both the PV cell circuit and Kirchhoff's circuit laws, the photovoltaic current can be displayed as takes after.

$$I_{pv} = I_{gc} - I_o\left[\exp^{\frac{e v_d}{F K T_c}} - 1\right] - \frac{v_d}{R_p}$$

Where I_{gc} is the light generated current, Io is the dark saturation current dependent on the cell temperature, e is the electric charge = 1.6 x 10-19 Coulombs, K is Boltzmann's constant = 1.38 x 10-23 J/K, F is the cell idealizing factor, Tc is the cell's absolute temperature, vd is the diode voltage, and Rp is the parallel resistance. The photocurrent (Igc) mainly depends on solar irradiation and cell temperature [11].

The vitality generation of a wind turbine depends on the wind speed and is depicted by the control curve. The Vcut_in wind speed v_{cut_in} is the wind speed at which the wind turbine begins to produce control. The bend takes after the theoretical presumption of Pvfv3 until the evaluated yield is reached. The evaluated control yield depicts the most extreme control yield of a wind turbine and counting the discuss density r, the proficiency and the range of rotor edges with span R. The corresponding wind speed V_{rated} is the greatest level of the wind turbine as a control generator, constrained by its introduced capacity (Prated). For higher wind speeds the control yield can as it were be as high as the evaluated created control. On the off chance that the wind speed increases further the wind turbine may well be harmed due to tall drive effects on the rotor edges. The wind turbines are exchanged off at a certain wind speed to anticipate such impacts. This so-called cut-out wind speed V_{cut}_out is approximately 25 m/s[11].

The relationship between wind and sun-based control can be assessed in the same topographical point or several locations. Within the first case, the comes about might be valuable for evaluating the conceivable performance of exceptionally near or indeed coordinates sun powered and wind energy production frameworks, particularly well known for little scale self-consumption. In fact, for a few a long time it is conceivable to discover on the showcase little wind turbines, structures with PV boards already integrated. In this case sun oriented and wind vitality bolstering the system should be as much complementary as conceivable in arrange to guarantee a smooth and ceaselessly productive power generation. More formally, given the hourly series of wind energy values Wh(x,y,t) and solar energy values Sh(x,y,t) where the x and y coordinates define the geographical location and t ¼ 1, ., 8760 the nth hour of the year 2005, the same-point hourly wind-solar power correlation coefficient is computed as:

$$R_h(x,y) = \frac{\sigma_{hWS}}{\sqrt{\sigma_{hW}\,\sigma_{hS}}}$$

where:

$$\sigma_{hWS} = \sum_{t=1}^{8760} (W_h(x,y,t) - \bar{W}(x,y))(S_h(x,y,t) - \bar{S}(x,y))$$

$$\sigma_{hW} = \sum_{t=1}^{8760} (W_h(x,y,t) - \bar{W}(x,y))^2$$

$$\sigma_{hS} = \sum_{t=1}^{8760} (S_h(x,y,t) - \bar{S}(x,y))^2$$

Wðx; yÞ and Sðx; yÞand are the average values of Wh(x,y,t) and Sh(x,y,t) for the year 2005.[12]

Cloud concealing was performed to segregate between clear and cloudy zones. In common, cloud optical and physical properties incorporate a brighter reflectance and colder temperature than any common objects on arrival. In like manner, routine edge cloud veil algorithms drew upon COMS MI unearthly groups to separate cloudy regions through their higher reflectance and colder temperature. e. The edge values for the COMS MI obvious and IR unearthly groups were observationally determined and reflected the Korean Peninsula's climatic characteristics. For pixels considered 'cloudy,' the sun-powered radiation constricted by the clouds was recreated employing a cloud calculate, whereas, for clear zones, the solar radiation from air parameterization was utilized. At last, the assessed surface sun-based radiation was compared with ground pyranometer perceptions in South Korea.[13]

$$S = I\left(\frac{d_M}{d}\right)^2 \cos(\theta)$$

$$S_I = S(\tau_O \tau_R - \alpha_W)\tau_A$$

$$S_R = S\tau_O(0.5(1 - \tau_R))\tau_A$$

$$S_A = S(\tau_O \tau_R - \alpha_W)F_C \omega_0 (1 - \tau_A)$$

1.3 Conceptual Framework

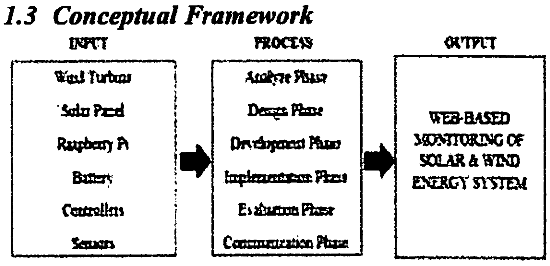

Figure 1. ***The flow of conceptual framework of the study***

The overview of the conceptual framework of the study is composed of three blocks, first wind turbine, solar panel, raspberry pi, battery, sensors will serve as the input to develop the design, second analyze, design, development, implementation evaluation & communication phase will serve as process. The output is to develop a web-based monitoring of solar & wind energy system.

1.4 Objectives

The general objective of this project study is to monitor and provide an accurate data power generation system. The following specific objective:

1. Development of Web-based Monitoring of Solar and Wind energy in Surigao del Norte.
2. Program development for the monitoring system.
3. Line graph representation of Wind & Solar energy harvested.

2. METHODS

2.1 Research Design

A cross-sectional study is a type of research design, provide a snapshot of analysis so there is always possibility that a study could have differing results if another time-frame chosen. The purpose of this study to collect data to determine the feasibility of solar and wind energy in the area.

2.2 Project Design

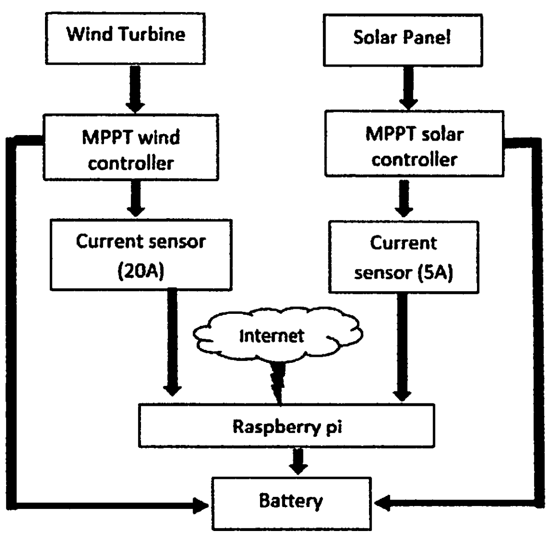

Figure 2. ***Block diagram of the project design.***

Fig. 2 shows the first two blocks represent the input, through the wind the turbine will spin and solar panels create energy from the sun that will produce different currents. Every two sources have a controller to limit the current flowing at the same time that will charge the battery. Sensors will measure the current from the controllers connected to the raspberry pi. The raspberry pi is the central processing u executes a program, calculate the voltage and wattage produce, store data, and display the GUI (graphical user interface).

2.3 Project Development

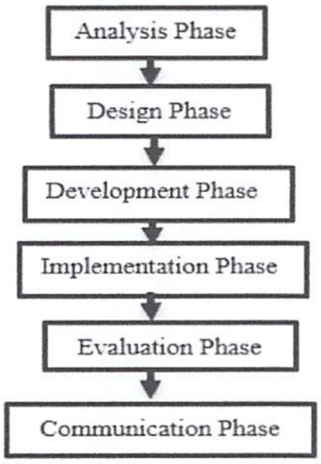

Figure 3. ***The flow of Project Development.***

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 the implementation phase, we apply various designs to achieve a well-develop and operational system.

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

Last, communication phase the researchers assure the functionality, efficiency, and standard of the proposed product to hit the satisfaction of the customers.

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. The location and coordinate with the local officials with the permission of the lot owner for the legitimacy and formality to conduct the study. The device if it is in good condition to ensure effectiveness and avoid the error of the project. Daily check reports and maintain the accuracy of the devices and functionality in general. The possible technical problem and maintain the cleanliness of the area.

2.5 Project Setting

Figure 4. ***Located at Sitio Sabang, Tayaga, Claver, Surigao del Norte***

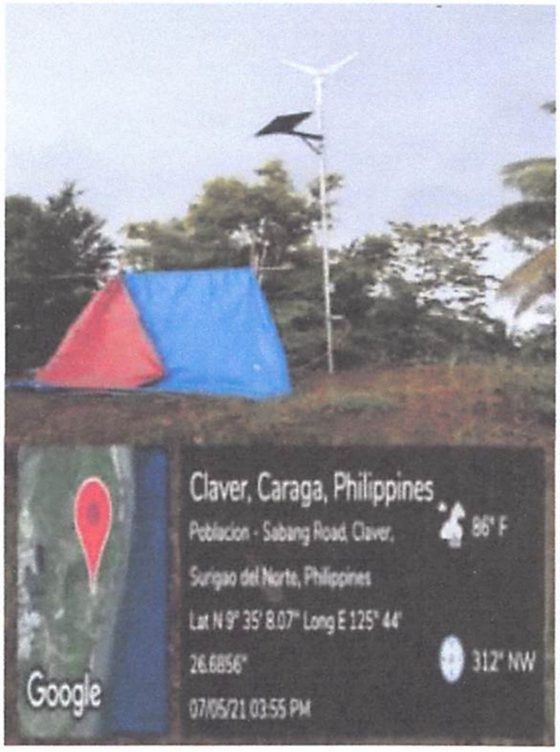

Figure 5. ***Located at Daywan, Claver, Surigao del Norte***

Participants of the Study

Table 1. ***List of participants and their involvement in the study.***

Participants	$f(n = 7)$	% Involvement
Electrical Engineer	2	50%
Computer Engineer	2	40%
EVALUATORS	3	10%
TOTAL	7	100%

Selecting two (2) Electrical Engineer for the implementation of solar and wind energy system which corresponds to 50% involvement as shown in table 1, two (2) Computer Engineers 40% involved in the software of the system, and three (3) evaluators with 10% involvement from College of Engineering & Information Technology faculty.

2.7 Instruments

Lists of instruments were obtained from this project study:

1. questionnaires and interviews,
2. computer
3. connection (internet)

The objectives of the questionnaires are to provide feedback if it is applicable in the specified proposed area. The interview's objective was to collect information on how reliability, function, and feasibility of the project study. The computer is a tool that will utilize thru the internet of various studies, inventions that will make the study successful.

2.8 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.

2.9 Data Collection Procedure

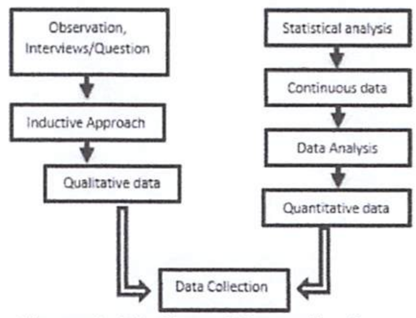

Figure 6: ***The flow of data collection***

General overview and flow of diagram gathered quantitative and qualitative data. First, observation 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.

2.10 Statistical Tools

The following statistical tool was applied in this project study is Mean. It is applied in this study by the practitioners and stakeholders it will determine the perception of the evaluator regarding the project presented.

3. RESULTS AND DISCUSSIONS

A brief overview of the results achieves in the project study. The discussion of the development of the study, the flowchart of the codes applied on the system & the line graph representation solar and energy produced of two different locations with a duration of 5 days respectively.

3.1 *Development of Web-based monitoring of solar and wind energy system*

Table 3. ***Solar panel specifications (Electrical)***

Maximum Power	50W
Maximum System Voltage	600V DC(UL)
Open-Circuit Voltage (Voc)	22.7V
Optimum Operating Voltage (Vmp)	18.5V
Optimum Operating Current (Imp)	2.7A
Short-Circuit Current (Isc)	2.84A

Table 4. ***Solar panel specifications (Mechanical)***

Weight	9.9lbs
Dimensions	24.8 x 21.3 x 1.4 inches
Type	Monocrystalline

Table 5. ***Wind Turbine specifications***

Product description	300W Model
Rated Power	300W at 12m/s(27mph)
Maximum power	330W at 13.5m/s(30mph)
Start-up wind speed	2.0 m/s(4.5mph)
Survival wind speed	50m/s(112mph)
Voltage Output	12V DC option
Blade Diameter	1.35m (4ft. 4.2in)
Number of blades	3
Weight	10kg
Overspeed Protection	Electronic stalling to slow rotation
Blade Material	Nylon Fiber
Body Material	Diecast aluminum alloy, powder-coated for weather & corrosion protection
Turbine generator type	Brushless low friction 3-phase permanent magnet AC synchronous
Mounting	Simple clamp mounting onto a 48mm external diameter steel pole
Operating temperature	40 to 80 deg. Centigrade

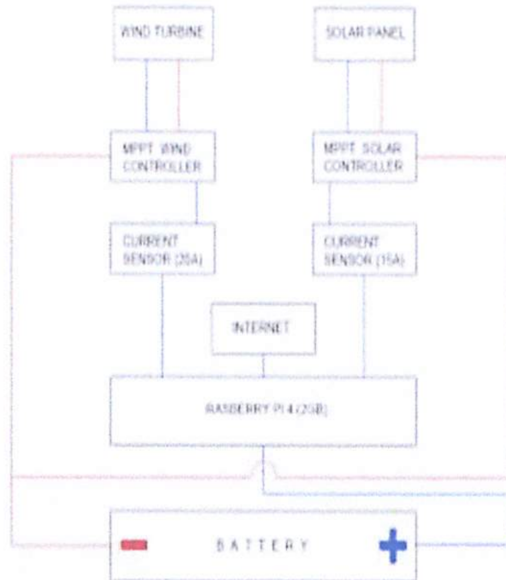

Figure 7. ***Component diagram and configuration of the project design.***

In fig. 7 shows the components diagram of the project design. The wind turbine and solar panel serves as the sources of the system. The MPPT solar and wind charge controller will limit the current produced by the two sources. The sensor will measure the current from the controllers. The raspberry pi and sensors are internally connected in which the raspberry pi is the central processing device of the system. Using the internet it will display the graphical user interface (GUI) of the monitored power produced by the wind turbine and solar panel.

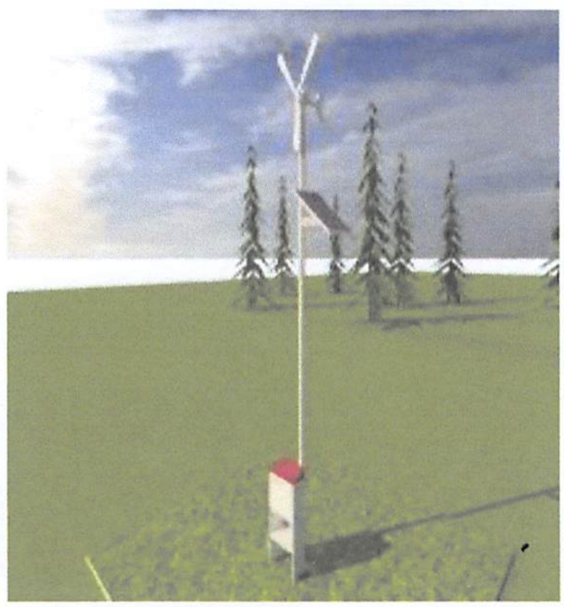

Figure 8. ***Measurements of Stand pole used to install solar panel & wind turbine***

This distance of the solar from the ground is 4m and the wind turbine 5m. To make the pole able to stand strong putting support by using slam (tier wire & bars).

3.2 Program Development of the system

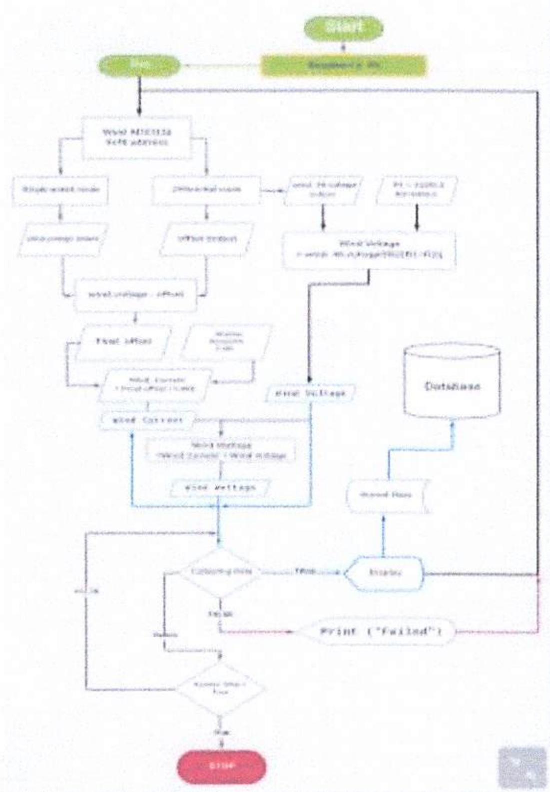

Figure 9. ***Flowchart of the solar energy system***

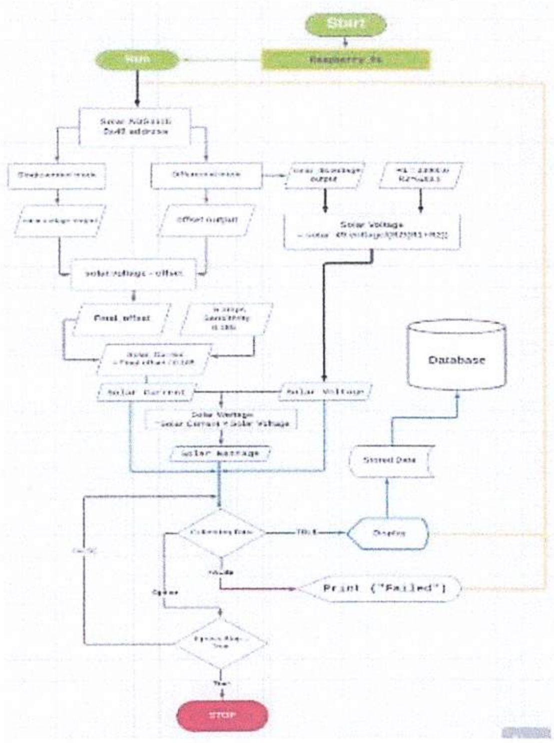

Figure 10. ***Flowchart of the wind energy system***

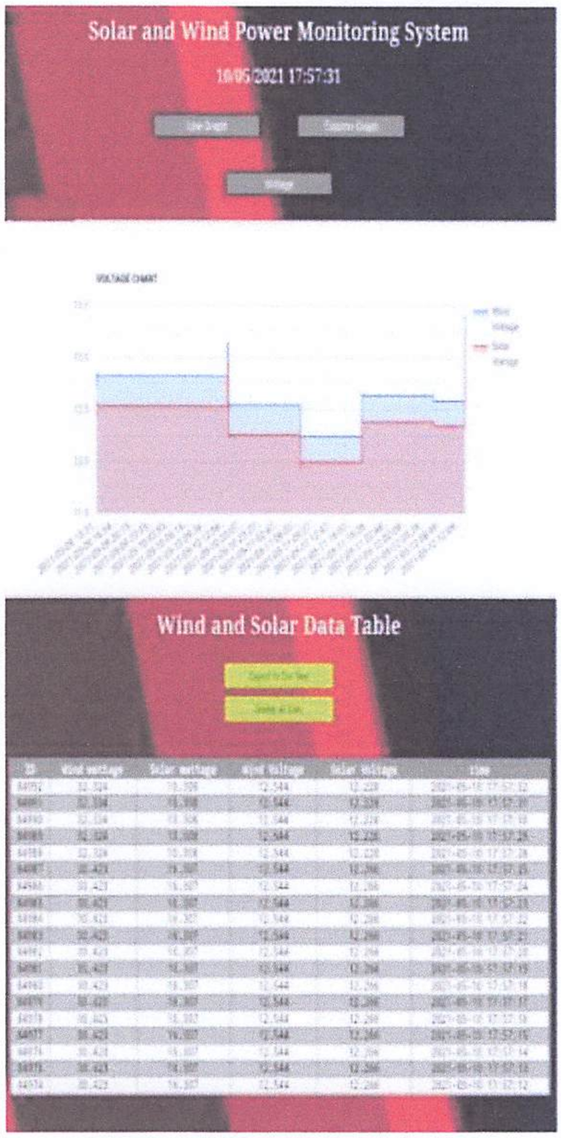

Figure 11. ***GUI (graphical user interface)***

Python programming applied on the system. Fig. 9, 10 shows the flowchart of software monitoring which consists of several parts and its functions so that the possible error that occurs will easily troubleshoot. Codes that will be able to measure, calculate, and store data. Fig.11 shows the display of GUI (graphical user interface) so that it can easily analyze the data.

3.3 Line Graph Analysis of the Harvested Data

The total duration of monitoring is ten (10) days, in two different locations, the first five days of real-time monitoring are on location 1. The following figures: Line graph average/hr. wattage, current, and voltage from day 1 to day 5 of solar and wind energy.

Figure 12. ***In Sitio Sabang, Tayaga, Claver, Surigao del Norte, Day 1 - Day 5, Wind and Solar average/hr. wattage monitoring.***

In Sitio Sabang, Tayaga, Claver, Surigao del Norte wind turbine produces a maximum average/hr. power of 84 watts and a minimum of 7 watts, while the solar panel made a maximum average/hr. power of 20 watts and a minimum of 5 watts from day 1 to day 5. There is a point in the graph very low in production of power as shown in figure 12.

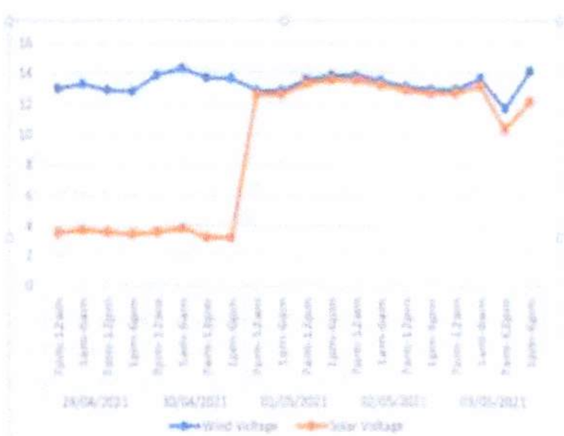

Figure 13. ***In Sitio Sabang, Tayaga, Claver, Surigao del Norte, Day 1 – Day 5 Wind and Solar Average/hr. voltage monitoring***

In figure13. From day 1 to day 2, the solar energy and wind turbine have a difference of 8V. Consequently, the average/hr. voltage two energy sources are almost the same, sustaining a value of 12V from day 3 to day 5. Notice the graph of the voltage is increased.

Figure 14. In Sitio Sabang, Tayaga, Claver, Surigao del Norte, Day 1 – Day 5, Wind and Solar Average/hr. current monitoring.

In this graph, the wind turbine produces an average/hr. the current of a maximum of 7A and a minimum of 0.5A. The solar panel also made a maximum of 4A and a minimum of 0.4A. Also, in general, the graph on this image has huge fluctuation and low current as shown in figure 14.

In Daywan, Claver, Surigao del Norte, the second five days duration of real-time monitoring, the following figures: Line graph average/hr. wattage, current, and voltage from day 1 to day 5.

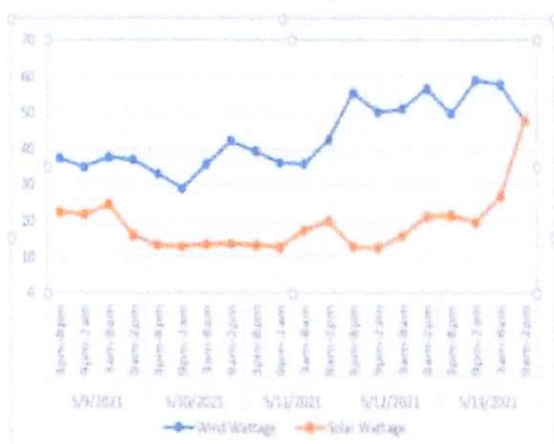

Figure 15. ***Located at Daywan, Claver, Surigao del Norte, Day 1 - Day 5, Wind and solar average/hr. wattage monitoring.***

The wind turbine has a dominant production of power compared to solar. The wind turbine average/hr. power made the maximum of 58W and minimum of 12W. Solar panels produce a maximum and minimum power of 47W and 11W as shown in figure 15. The graph also in this figure has a minimal fluctuation and increasing.

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DEVELOPMENT AND IMPLEMENTATION OF HYDROELECTRIC WHIRLPOOL TURBINES

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ABSTRACT: This study is to design and implement a cylindrical concave basin structure which has the ability to form whirlpool streams. This high velocity of water whirlpool can be used as an alternative energy resource. A water turbine constructed on the water turbulence or whirlpool principle is capable of utilizing very small sources even for untapped water, and it is highly suitable for the closed-circuit production of electrical energy. The rotating fluid in the basin serves as the driving force to the hydroelectric generator.

Keywords: whirlpool turbines, cylindrical concave basin, fluid dynamics computation, penstock, vortex

1. INTRODUCTION

As energy costs continue to rise, the CO2 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 are a lot of alternative solution through a renewable source of energy it will help meet the demand without negative consequences in the environment.

The aim of the study is to design and implement hydroelectric whirlpool turbines to generate electricity using water through its blades. Its sustainability mainly depends on the velocity of water passes through the blades. In this study, the whirlpool turbine blades are designed in with the aim to increase the efficiency of the turbine. Also discusses the various ways to optimize the whirlpool basin in its design process.

Related Literature

Over the years 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, this 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 and would typically be used to power 1-2 houses. 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. Here have 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. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level.

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 of [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 modern life increased the development of new devices to use 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.

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 affecting 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. Also, by analyzing the effect of the conical bottom [17], by using the commercial code ANSYS Fluent, found that the terminal form of the cylinder where the gravitational vortex is formed must be conical, being the diameter of the discharge hole very important to get the maximum output power.

Water vortex is a phenomenon where water flow in a swirl motion, always described by cylindrical coordinate, with tangential, radial, and axial axis. In 1858, Rankine already published his study on water vortex by introduced 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.

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

$$Ns = \frac{5050}{h+32} + 19 \qquad [4]$$

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

To design the basin the calculation of the dimensions of the penstock is taken with the predetermined variables. The assumed power output will be 500 watts. And the efficiency of the system is assumed 65 %.From table 8, the specific weight of the water is given by 9810 Newton per cubic meter. The velocity of the water at the location through a series of testing was in the average of 1.449 meter per second. The assumed effective head of the water is 0.5 meter

For the calculation of dimensions.

From eq [3]

$$Pin = \frac{Pout}{\eta}$$

$$Pin = \frac{500W}{.60}$$

$$Pin = 833.33\ Watts$$

From eq [1]

$$Pin = Q\gamma h$$

$$833.33\ \text{W} = Q * 9180\ N/m^3 * 0.5\ \text{m}$$

$$Q = 0.17\ \text{m}^3/\text{s}$$

From eq [2]

$$Q = AV$$

$$0.17\ m^3/s = A * 1.449\ m/s$$

$$A = 0.12\ m^2$$

Taking the root of the area, we will get a square dimension of the penstock of 0.30 meter by 0.30 meter. This dimension will be taken with consideration the actual level of the water stream on the location of the basin.

To create a whirlpool at the basin, it is needed to generate a sufficient amount of volume of water stored at the basin. Also, it is needed to have the right amount of diameter outlet so that the vortex will create enough torque to rotate the turbine. Base on the study of gravitation vortex power plant, the smallest allowable diameter of the outlet is 0.10 meter, in order that the water at the vortex will not be very low. [24]. The diameter of the basin is 1 meter and a height of 0.15 meter to hold an average volume of 0.12 cubic meter.

For the calculation of the specific speed of the turbine.

From eq [3]

$$Ns = \frac{5050}{h + 32} + 19$$

$$Ns = \frac{5050}{1.64+32} + 19$$

$$Ns = 169\ \text{rpm}$$

For the calculation of the actual speed of the turbine.

From eq [4]

$$N = \frac{Ns * h^{1.25}}{\sqrt{Hp}}$$

$$N = \frac{169 * 1.64^{1.25}}{\sqrt{\frac{833.33}{746}}}$$

$$N = 296.75\ \text{rpm}$$

Conceptual Framework

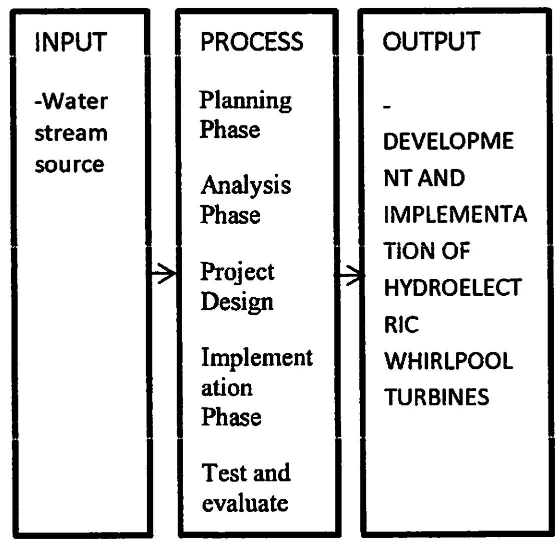

Figure 1. ***Flowchart of the Project***

As shown in Figure 1, the conceptual framework of the study which starts from the input to the hydroelectric whirlpool turbines. 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 design and implement a hydraulic whirlpool turbine that will provide efficiency, sustainability and reliability. The specific objectives are:

1. To design the system with the pre-established parameters.
2. To develop the hydroelectric turbine that will generate output according to its pre-establish parameters
3. To implement the design.
4. To test and evaluate the performance of the hydroelectric turbines using measuring parameters.

2. METHODS

Project Design

The research design is the overall plan of how to develop and implement the project in practice. Parahoo 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.

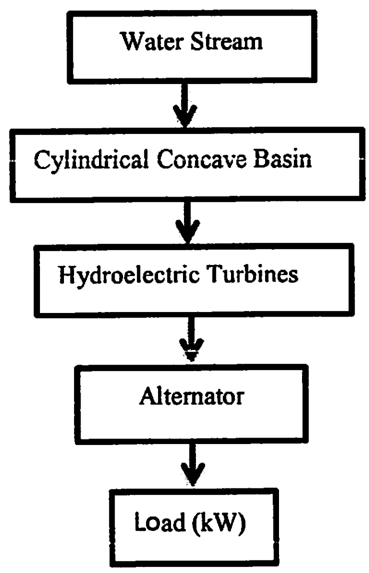

Figure 2. ***Block Diagram of the Hydroelectric Whirlpool Turbines***

As shown in Figure 2, this is the flow of harnessing the water energy into electrical energy as an output. It starts at the source the water stream which will flow in the cylindrical concave basin which helps to create a whirlpool. Through whirlpool the blades in the turbine will rotate proportionally to the speed of the water. Lastly, the turbine will generate electricity in order to supply the load.

Materials

The primary materials used in the research project are the following:

1. **Alternator** is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current.
2. **Bearing** is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts.
3. **Driving belt** a part of an internal combustion engine that synchronizes the rotation of the crankshaft and the camshaft(s) so that the engine's valves open and close at the proper times during each cylinder's intake and exhaust strokes.
4. **Iron pipe** used as a pressure pipe for transmission of water, gas and sewage, and as a water drainage pipe.
5. **Sheet metal** a metal formed by an industrial process into thin, flat pieces. Sheet metal is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes.
6. **Digital Tachometer** is a device used to measure revolution per minute of an object.
7. **Penstock** is a passage that conveys the water flowing from the reservoir to the power generation unit (which is made up of turbines, generators and control/monitoring devices). The water in the penstock possesses kinetic energy due to its motion and potential energy due to its height. The amount of water flowing through the penstock is usually controlled by a valve (control gate).

Project Development

The researchers will make a plan of the overall activities and the equipment to be used in the project, and study the development of the design with systematic approach. The development can be visualized with the flowchart below.

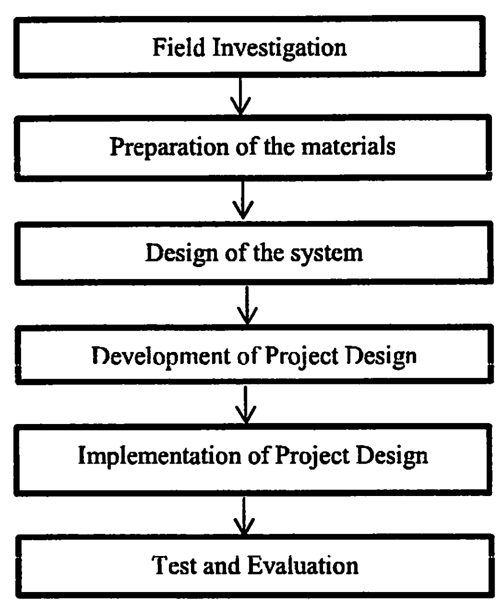

Figure 3. ***Work flow of Detailed Project Design***

Figure 2 shows the flow of work of detailed design. Gather data relevant to the project design and location through Field investigation. With the data collected the researchers prepare the materials to be used. Then, detailed layout design of the project is prepared and also the development of the design. Finally, the implementation of the project design is prepared

Project Implementation

The researchers develop the project design with the gathered data being collected and systematic study of the designing, developing and implementation.

Project Evaluation

The researchers conduct an interview with the residents about the location of the project that will be implemented to access the location, and to determine the impact of the implementation of the project especially to the recipients of the generated electricity.

Project Setting

The researchers configure the location to be implemented, and the proposed implementation will be in the vicinity located a few kilometers from the highway. In Brgy. Sudmon, San Francisco, Southern Leyte. 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.

Participants of the Study

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

Instrumentation

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

Ethical Consideration

Based on the laws, the development of the project did 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 the recipients and 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 conduct a survey near in the vicinity of the place for the availability of the water and the location suitable to be implemented. 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.

3. RESULTS AND DISCUSSIONS

3.1 Design of the hydroelectric whirlpool turbines

One of the key factors in determining overall turbine performance relates to the velocity profile at the runner exit and the flow interacts with the Initial calculations for the hydroelectric turbine at the selected design condition. The result of the turbines having six propellers in the initial velocity to the final velocity the tests were done to figure out the efficiency of the turbines.

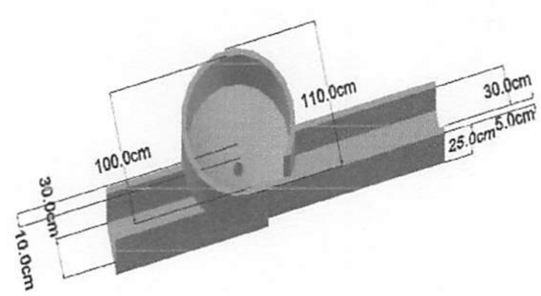

Figure 4. ***Design of the Cylindrical Concave Basin***

Figure 4 shows the 3d design of the water basin used to develop the whirlpool. The length and width of the cross-sectional area of the entrance is 17 cm and 20cm.The water from the source is fed up to the basin. From this, the whirlpool is then created. The water flows 1 meter per 0.69 seconds making the velocity of 1.449 meter per seconds.

Figure 5 shows the 2d and 3d design of the turbine used as a prime mover for the alternator.

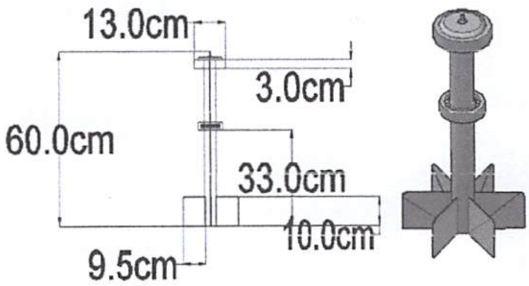

Figure 5. ***Design of the Turbine Blade***

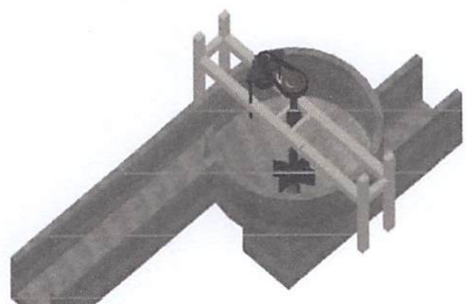

Figure 6. ***3D Design of the hydroelectric turbines***

Figure 6 shows the position of the alternator with the water basin.

Figure 7. ***Alternator***

Figure 7 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.

3.2 Development of the Hydroelectric Whirlpool Turbines

Figure 10. ***Whirlpool Turbine***

Figure 10 shows the actual design of whirlpool turbine with 6 blades with the length of 10cm, height 74 cm and wheel diameter of 12.5cm.

3.3 Implementation of the Hydroelectric Whirlpool Turbines

Figure 13. ***Actual implementation of the project***

The figure above shows the actual implementation of the hydroelectric turbines. Every component (alternator, turbine blade, 12v battery, and the indication Led light bulb) is already attached to the motor, and the construction of the concrete basin.

3.4 Test and Evaluation of the Hydroelectric Whirlpool Turbines

Table 1. ***Discharge of the basin measured in seconds with the four-liter container***

Trial	Volume(liters)	Time(seconds)	Liter/s
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

Tria 15	4	2.30	1.73
AVERAGE			**1.78 L/s**

Table 1 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 2. ***Measurement of the flow rate of the water using a Ping-Pong ball***

Trial	Length(meter)	Time(seconds)	m/s
Trial 1	1	1.20	0.83
Trial 2	1	0.90	1.11
Trial 3	1	1.03	0.97
Trial 4	1	1.08	0.93
Trial 5	1	1.37	0.73
AVERAGE			**0.91 m/s**

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 3. ***Measurement of revolution per minute of the turbine using a digital tachometer at no load***

Trial	Time(seconds)	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 3 shows the measurements of the rpm of the turbine at no load with the use of a digital tachometer that was observed within one minute. In order to measure the speed of the turbine an indicator tape is attached in the turbine wheel.

The result shows that the speed of the rpm was greater before it has a load connected into it.

Table 4. ***Measurement of revolution per minute of the turbine using a digital tachometer with load***

Trial	Time(seconds)	RPM
1	60	34.2
2	60	31.7
3	60	35.1
4	60	34.6
5	60	33.5
AVERAGE		**33.82**

Table 4 shows the measurement of the rpm of the turbine taken with a load connected on it using a digital tachometer that was observed within one minute. The result shows that there is a significant decrease in the speed of the water turbine now with a load connected to it.

Table 5. ***Measurement of the revolution per minute of the alternator***

Trial	Time(seconds)	RPM
1	60	61.9
2	60	62.8
3	60	63.6
4	60	65.5
5	60	67.3
AVERAGE		**64.22**

Table 5 shows the measurements of the rpm of the generator using a digital tachometer that was observed within one minute. The results show that the speed of the alternator is greater than the speed of the turbine

Table 6. ***Measurement of output voltage of alternator without load***

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

Table 6 shows the measurements of the output voltage of the alternator. These measurements are taken without a load connection. The result shows that the output voltage is within the range of the desired output of the pre-establish parameters.

Table 7. ***Measurement of the current with the use of three 30 watts lamp***

Trial	Time(seconds)	Current
1	60	0.01

2	60	0.01
3	60	0.01
4	60	0.01
5	60	0.01
AVERAGE		**0.01 A**

Table 7 shows us that the current taken by the load was not fluctuating.

Table 8. ***Water Properties***

Velocity(m/s)	Specific weight (N/m^3)	Head of water (m)
1.449m/s	9810 N/m^3	0.5m

Table 8 shows the result of the speed of the water. In order to get the velocity of water, the researcher conducts an experiment using a tape measure with the length of 1meter and put the balloon in water stream when using the timer, it shows the time and distance it travels along in the water.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

From the test and measurements, the researchers conducted, following conclusions are drawn:

1. The design of the system with pre-establish parameters found to be coordinated with the output of the hydroelectric turbine. The design was established with the theoretical calculations based on the pre-determined values and variables.
2. Based on the results, the researchers are able to developed hydroelectric turbine that generates torque through the whirlpool created by the water.
3. The researchers are able to implement the project design in the desired location.
4. Using test instruments, the researchers are able to get the measurements of the results of the implemented project.

Recommendation

Based on the findings the recommendations are also drawn:

1. The volume of water discharge must remain the same so that the voltage will not drop.
2. The basin of the hydroelectric turbine can be redesign to enlarge the volume of water so that it can generate more than the amount of the output.
3. The motor must be larger in power output in order to produce more electricity.
4. Turbine fabrication should be carried out using better materials for weight reduction and increase in structural strength.
5. The measurements indicated that the best position for the placement of turbine is the bottommost position
6. The value of velocity head increases with the increase in depth. Hence greater efficiency was noted at the bottommost position
7. Similarly, the values of efficiency were greater for turbines with smaller number of blades.
8. There was a significant distortion of vortex even with smaller loads in case of the turbine configuration with greater number of blades.
9. Increase in the radius of the blades decreases the efficiency of turbines. This is because of friction at the inner surface of the basins.

5. ACKNOWLEDGEMENTS

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(1)

A CASE STUDY OF FOOTSTEP POWER GENERATION CHARGER

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Abstract: A footstep power generation charger is design to harness the wasted energy produced by footstep to power low-power electronic devices. The study utilized the Arduino nano microcontroller which is the brain of the system. It performs logic and processing computation. Online research, preparation of materials, development of the design, implementation of the project, test and evaluation are the five steps in producing a research design. A voltage amplifier is used to improve the current and charging process in this design, which uses a parallel connection. The result of the study shows the accuracy of the output voltage is eighty percent and the output current of ninety-five percent (attached to the circuit). The system is found to be quite acceptable in terms of performance, serviceability, and construction cost.

Keywords: Piezoelectric, Pressure, Circuit booster, Area energy capability, Footstep base

1. INTRODUCTION

Electricity has become a lifeline for human population. Its demand is increasing day by day. The present innovation aims to provide a means of producing electrical power from this ever-increasing human population that does not adversely affect the environment. This technology is based on a theory called the piezoelectric effect, in which pressure and strain are applied to some materials that have the potential to build up an electrical charge.[1]

Power assumes a critical part being developed of the country. Power is characterized as set of physical wonder connected with the stream of charge. There are two sorts of power to be specific Static power, that can be held steady and Dynamic electricity which can spill out of one potential to another. With the upgrading population and foundation of the forthcoming organizations and production lines there have been an awesome interest for the need of power so as to run the machines and types of gear.[2]
Man has needed energy at an increasing rate for his sustenance and well-being ever since he came on the earth. Due to this lot of energy resource have been exhausted and wasted. Proposal for the utilization of waste energy with foot power human locomotion is very much relevant and is very important for highly populated countries in INDIA and CHINA, where the roads, railway stations, bus stands and temples are overcrowded and millions of people moving around the clock. By using such principle, the energy can be utilized in the whole area where the mechanical energy is being converted to electrical energy. [3]

Such concept is implemented in various part of the world where there are heavy traffic of pedestrians such as in train stations, airports, shopping malls and footballs stadiums. The produced electrical energy can be used directly for lighting purposes or stored for later use.[4]
The goal was attained by setting up an experimental model at a specific location in Surigao City and analyzed the data acquired. In this research, a simple and low-cost technique was given for improving the performance and efficiency of kinetic energy to electrical energy conversion by positioning a transducer-based footstep power that serves as a generator on a specific location. [5]

1.1 Related Literature

The production of electric power from the foot step movement of the peoples and the pressure exerted during walking which is fritter away, is the main theme of this paper. The mechanical power transformation into electrical power as the pressure exerted by the footstep and by using transducers is basically called as "Foot step power generation system". Power is produced by the power generating floor and it is basically the production of electrical energy from kinetic energy. As today electricity demand is increasing and it is unable to overcome this global issue by using the traditional power generating sources. [5]

Piezoelectric ceramics belong to the group of ferroelectric materials. Ferroelectric materials are crystals which are polar without an electric field being applied. The piezoelectric effect is common in piezo ceramics like PbTiO3, PbZrO3, PVDF and PZT. The main component of the project is the piezoelectric material. The proper choice of the piezo material is of prime importance. For this, an analysis on the 2 most commonly available piezoelectric material - PZT and PVDF, to determine the most suitable material was done. [6]

A piezoelectric sensor is a device that uses the piezoelectric effect to detect changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. A piezoelectric disc generates voltage when deformed. [7]

The results of this study show that with the sidewalk layout in such a way as to obtain, a voltage of 6.8 V and a power of 0.000319 Watts are produced for each 1 stage footing when provided 441 N style, As the force gets heavier in giving to piezoelectric, the voltage will continue to increase, in this design the author uses 4 pieces of piezoelectric arranged parallel in one-piece. media, with an average of 3207 steps per minute necessary to be an energy source.[8]

The electronics are fully powered by the energy harvested from walking or running, producing 10-20 μJ of energy per step that is then consumed by collecting and storing data from the force sensor. The general shoe system shows that through piezoelectric energy-harvesting, wearable sensor electronics can be adequately powered.[9] The electronics, sensing technologies, data transmission, and data processing methodologies of such wearable systems are all principally dependent on the target application. Hence, the article describes key application scenarios utilizing footwear-based systems with critical discussion on their merits.[10]

The project's uniqueness is that it presents the capability of the specified area in terms of generating pressure and producing electricity. Aside from the design and methodology that we have developed, there are just a handful similar studies that have already been completed. However, we are focusing on the area's capability since no matter how great the design and equipment are constructed, it is serviceable if there is no reliable source of energy.

1.2 Theoretical Framework

The piezoelectric effect requires materials with a specific asymmetry in the crystal structure. This includes some natural crystals, such as quartz or tourmaline. In addition, especially formulated ceramics can be created with a suitable polarization to make them piezoelectric. These ceramics have higher sensitivities than natural crystals. A useful output can be generated with as little as 0.1% deformation. [11]

The power generated by the vibration of the piezoelectric is shown to be a maximum of 2mW, and provide enough energy to charge a 40mAh button cell battery in one hour. piezoelectric materials form transducers that are able to interchange electrical energy and mechanical motion or force.[12]

The power generated by piezoelectric due to human work performed by the pressure of footsteps can be estimated as follows: [13]

-The force exerted by a person of 80 kg weight is 80 * 9.8 = 784 N/person.

- The energy produced by walking one step on a tile for a displacement of 0.01 m is =784 * 0.01= 7.84 J/step.

-If the length of the tiles is 75m and the span between steps is 1.0m, the energy produced by walking along the tile will be 75*7.84=0.588kJ/tile.

- Since 1kwh equivalent to 3600kJ, then the energy produced is 0.588/3600=1.63*10-4 kwh/tile per person.

-Assuming that there are 500 students in the faculty and they walk twice per day along the tile, then the total expected energy produced per tile is 1.63*10-4*2*500=1.63kwh.

1.3 Conceptual Framework

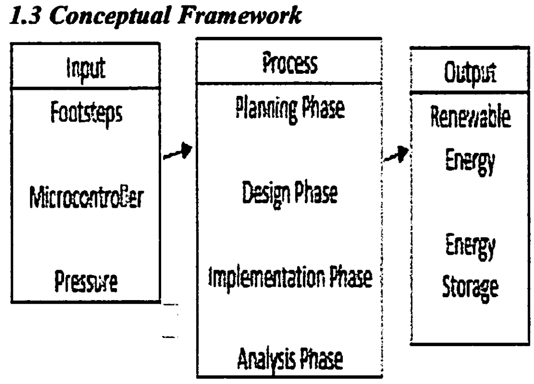


Figure 1. ***IPO diagram of the Project***

The study's conceptual framework is divided into three steps, as indicated in Figure 1. It begins with the pressure of footfall and progresses to a tile with 30 piezo disks attached.

The second is where a small amount of AC energy is generated, which is where the testing and analysis takes place. Finally, storage refers to how much energy was stored over a period of time.

1.4 Objectives

The project's overall goal is to see if using a footstep energy source is a better option than using other renewable energy sources.

The following are the specific objectives:

1. To document the design of the Footstep Power Generation Charger.
2. To test and analyze the system
3. To determine the economic feasibility of the design.

2. METHODS

2.1 Research Design

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.

2.2 Project Design

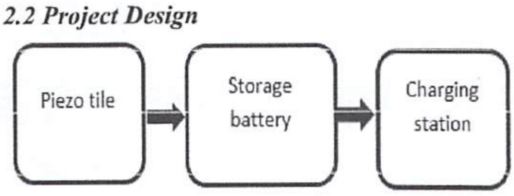


Figure 2. ***Block Diagram of the System***

As shown in Figure 2, a piezo disk which is capable in producing electric charge when deform or applied a pressure is called piezo tile. The energy produces by the tile that varies to different weight of people will directly store in the battery. A load where anything that is below 5 volts is perfectly charge using this device.

2.3 Project Development

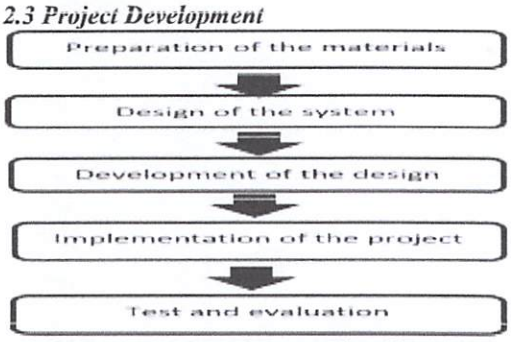


Figure 3. ***Project Development Flow Chart of the Project***

Figure 3 shows the flow of work design. Preparation of a material that can withstand any weight force, second is to design a system that utilizes a small current to a bigger battery. Third block is where the parallel connection is used to increase the current and a circuit booster to charge a bigger battery. Fourth is the implementation of the project design in two areas that prepared for evaluation that is seen in the last block.

2.4 Project Implementation

The proposed project will be implemented in two locations: Unicity Surigao and Metro Surigao. It will undergo 3 phases. The first phase is set-up, which involves hardware and software configuration. The second phase is monitoring the energy generated by the device. The maintenance phase is the final step. This entails improving and adjusting the project's program for the users.

2.5 Project Setting

Figure 4. ***Unicity, located at San Nicolas street, Surigao City***

Place one piqued our interest for the study since it is in the center of the city, where people traffic is frequent.

Figure 5. ***Metro Surigao located in Rizal Borromeo street, Surigao City***

Because there is a minute delay between transferring to the next area, place two is close to where the first is implemented, which makes it easier to transfer the device.

2.6 Participants of the Study

Table 1. ***List of participants and their involvement in the study.***

Participants	f(n=4)	% Involvement
Electrical Engineer	1	32
Electronics Engineer	2	42
Civilian	1	26
TOTAL	4	100%

Table 1 shows approaching an electrical engineer for battery charging and storing technique. Two electronics engineers for circuit components and a local mechanic for the hardware design.

2.7 Instruments

Laptop/PC – this helps in collecting data and build ideas through internet.

Tester – helps in measuring the voltages, amperage and output power of the device.

2.8 Research Ethics

First of all, honesty is one of the research ethics used by the researchers in this report. The researchers did not fabricate, falsify or distort details. Researchers did not disappoint our peers, research sponsors, or the public, and the researchers honestly collected the data. As what is written in the goals, the researchers kept their commitments and agreements. Based on the law, the development of the project did not violate nor caused any environmental issues.

2.9 Data Collection Procedure

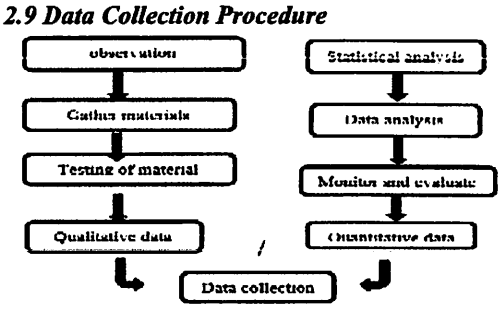


Figure 6. ***Block diagram for qualitative and quantitative data collection***

Figure 5 shows a general overview and flow of the diagram gathered quantitative and qualitative data. First row, observation is chosen to ensure that the evidence obtained enable the researchers to effectively address the research problem and using an average value in performing statistical analysis. Second row is where the gathered material ensures a low-cost material for the easy to replace proposes when the testing begins. The data analysis yields a number of individuals each hour, which is then converted into a percentage based from the total capacity of people in the defined location. Then turn to expected power using the average power in one step that is 2.25mW. Third row performs the different weight of people ask to step the device which provides a different output voltage and current. monitoring with the use of Arduino Microcontroller which helps in evaluation of data. Finally, that's where the data was organized into categories.

2.10 Statistical Tools

The statistical methods used mean. Mean refers to the mean or average that the central trend of the data in question is extracted from. The square root of the sum of the square deviation is the standard deviation of the mean divided by the number of ratings.

Mean, in mathematics, a quantity that has a value intermediate between those of the extreme members of some set. Several kinds of mean exist, and the method of calculating a mean depends upon the relationship known or assumed to govern the other members.

2.11 Financial Analysis

Bolts and nuts, wood board that used as a tile or the device's foundation plate, tapes, foams, and other low-cost materials were utilized to construct the gadget, which cost only 2000 pesos to construct due to the availability of some components found around the house. Only the main component, the piezoelectric, and the monitoring components are generally required to be purchased.

3. RESULTS AND DISCUSSIONS

3.1 Design of the Footstep Generation Charger

In this study, the piezoelectric is assembled using a parallel circuit as shown in

Figure 7. The parallel circuit serves to raise the piezoelectric output current. Figure 8 shows that the output from the energy harvester is used to charge two AA batteries. After the batteries are full, they are connected to the boost step-up circuit so that the voltage goes up to 12 volts and used Zener diode to limit it to 5.5v so that it can safely charge the 3.7v battery. The study used a microcontroller to control the flow of power flowing from the piezoelectric to the 3.7-volt battery. The voltage sensor is used to determine the voltage stored in two AA batteries, the same as the current sensor. In figure 9, it is presented in the picture that the circuit used an inductor with a ratio of 150 is to 20 winding serves as a current folder which 11.25volts is expected to generate. The output of this circuit is used to charge the 3.7-volt battery and possible to charge12-volt battery. The harvesting circuit has a range output voltage (1.5 volts to 2.9 volts) and used in two applications when pressure is applied on the wood layers:

1. To light up the current indication LED at the 1.7 level
2. To simulate energy storage by connecting it to a small storage battery.

Figure 7. ***Pictorial Diagram of the Piezoelectric circuit***

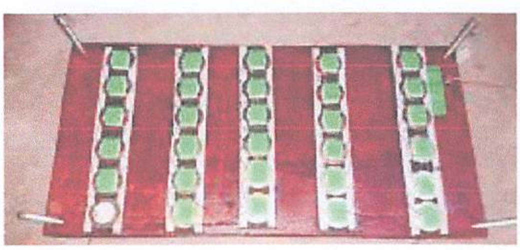


Figure 9. ***Schematic Diagram Circuit Booster***

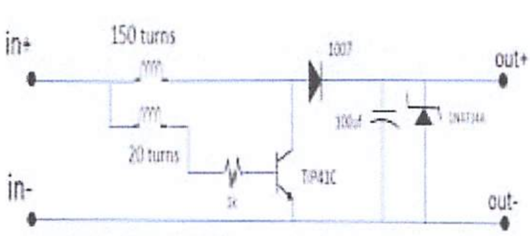
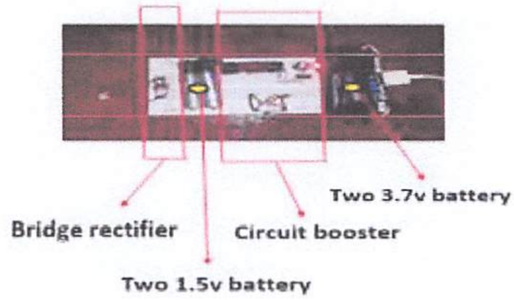


Figure 7. ***Pictorial Diagram of the Circuit Booster***



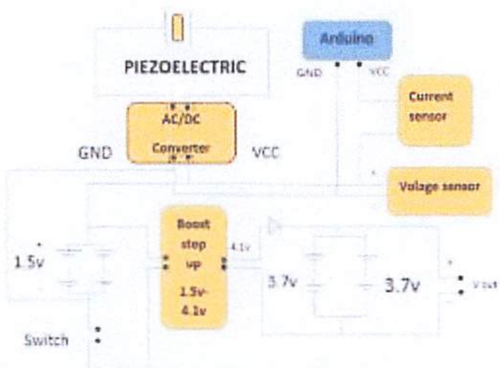


Figure 8. ***Schematic Diagram of the piezoelectric circuit***

3.2Analysis of Test Results

Table 2 ***test Output voltage versus weight***

Subject	*Weight (kg)*	*Output voltage*			*Average (V)*
		Trial 1	*Trail 2*	*Trail 3*	
1	80	9.7	8.1	1.9	7
2	70	1.9	5.9	3.2	4
3	65	7.1	9	7.7	8
4	60	1.9	4.7	2.2	3
5	55	8	1.4	3.9	5
6	50	5.4	4.1	4.9	4.5

Several people were asked and cooperated by standing on the experimental model. In the table, it can be seen that from three tests using heavy pressure of the different weight of people, the piezoelectric output voltage varies from 1.4 Volts to 9.7 Volts (not connected to the circuit). Although the weight was increasing, different pressures generate different piezoelectric voltages. Average voltage ranges from 4 to 8 volts.

Table 3 ***test Output current versus weight***

Subject	*Weight (kg)*	*Output current (ua)*			*Average (V)*
		Trial 1	*Trai 12*	*Trai 13*	
1	80	*4.1*	*8.1*	2.9	*5*
2	*70*	*1.2*	*5.9*	*3.2*	*5*
3	65	*3.4*	*3*	*5.7*	*4*
4	60	*7.9*	*4.7*	*1.9*	*4*
5	55	*3*	*0.8*	*3.9*	*2*
6	50	*2.4*	*3.1*	*4.9*	*3*

In the table 3, it can be seen that from three tests using heavy pressure of the different weight of people, the piezoelectric output current varies from 0.9 Volts to 8.1 microamps (not connected to the circuit). Although the weight was increasing, different pressures generate different piezoelectric voltages. Average ampere ranges from 2 to 5 microamps.

3.3 Economic Feasibility of the Design

The built experimental model and its analysis have laid out the ground to see the feasibility of installing piezoelectric tiles at metro Surigao and unicity. The case study was carried as follows:

A. having an average output (connected from the circuit) of 1.5-volts and 1.5-microamp/step we have 1500mV times 0.0015mA = 2.25mW/step/person. This value was used in the study case

B. A survey of two establishments was done 12hours from 6am to 12pm and 12 to 6pm. A sample of such survey and results are shown in table 4 and 6.

C. This type of energy can be considered as a limited energy source, since its output depends on the availability of footsteps. Hence the expected power output was evaluated as shown in column (5) of table 4 and 6.

D. The obtained results were be extrapolated to find the expected power output if tiles are located at the gates entrance of metro Surigao and unicity where the average traffic can be taken as 4000 people in 12 hours.

For example, the expected power generated (p) during the period (12:00-1:00pm) can be evaluated as follows: - For a tile with 200 steps, Then P= [(39.5*10^-3)/126] *200*4000 = 251 W. Table 6 and 7 shows the feasible expected power during the period (6:00am-12:00pm) and (12:00pm-6:00).

Table 4. ***Sample of collected data and analyze in METRO Surigao***

Time(hour) (1)	Person (2)	(%)((2)/sum of (2)) (3)	Power for one tile (mW)(2)(2.25mW) (4)	Expected power (mW)(3)(4) (5)
6:00-7:00	56	0.08575803982	126	10.8
7:00-8:00	98	0.1500765697	220.5	33.1
8:00-9:00	105	0.1607963247	236.25	38
9:00-10:00	175	0.26779938744	393.75	105.45
10:00-11:00	123	0.1883614089	276.75	52.13
11:00-12:00	154	0.2358346095	346.5	81.72
Total	653			

Table 5. ***The feasible expected power at the METRO Surigao.***

Time (hour)	Power (watt)
6:00-7:00	154
7:00-8:00	270
8:00-9:00	290
9:00-10:00	482
10:00-11:00	339
11:00-12:00	425
Sum	**1960**

Table 6. *Sample of collected data and analyze in UNICITY Surigao*

Time(hour) (1)	Person (2)	(%)((2)/sum of (2)) (3)	Power for one tile (mW)(2)(2.25mW) (4)	Expected power (mW) (3)(4) (5)
12:00-1:00	126	0.1392265193	283.5	39.5
1:00-2:00	146	0.1613259669	328.5	53
2:00-3.00	182	0.2011049724	409.5	82.4
3.00-4:00	175	0.1933701657	393.75	76.14
4:00-5:00	119	0.1314917127	267.75	35.21
5:00-6:00	157	0.173480663	353.25	61.3
Total	905			

Table 7. *The feasible expected power at the UNICITY Surigao*

Time (hour)	Power (watt)
12:00-1:00	251
1:00-2:00	290
2:00-3:00	362
3:00-4:00	348
4:00-5:00	237
5:00-6:00	312
Sum	**1600**

Table 8. *Direct material and service cost.*

Description of Materials	QTY	Cost (PHP)
Bolts/nuts	4	45
spring	1	50
washer	12	36
Wood tile 50x25	2	300
Current sensors (5A, 30A)	1	160
Voltage sensor	1	120
Arduino nano	1	215
Battery aa 1.5volts and 3.7v	4	350
Electronic Components		300
Wires	4m	50
Piezoelectric transducer	30	300
tester	1	360
Soldering iron and led	1	200
Electrical tapes	1	30

services	
Transportation	1000
GRAND TOTAL	**4,516**

CONCLUSIONS

Based on survey data and footstep powered design, a 50x25cm wood tile is used with up and down spring mechanism. The device performs with the efficiency of 85 percent equal to 2.25mwW/step applying a person weight of 80kg.

Because the output that the device generates is dependent on how much pressure it provides, device testing is done with various weights. Based from the data obtained, a weight range of 50 to 80 kg performed 80 percent voltage and 95 percent current efficiency (attached in the circuit), which is sufficient to power low-powered devices. It also required approximately 2 steps to charge two AA 1.5-Volt batteries and 15 steps to charge two 3.7-volt batteries respectively

The study was made to find the expected power generation if commercial tiles are installed in the establishments which has around 4,000 people. The obtained results show that if the produced power is stored it will amount to an energy of 1960 Wh in just 6 hours with constant steps. This energy can be used to light up street lamps during the night and for charging purposes. For example, using a 20 W LED lamp over 10 hours periods.

According to the statistics, the foot step power generating charger is only suitable for use in populous areas, not in areas with a smaller population, because the device works best with a consistent source of energy.

RECOMMENDATIONS

From the design that we have made, we recommend

1. larger tile span for safety purposes around (27 by 14 in)
2. Add more piezoelectric for the addition of energy output around 80-100 Pcs is good.
3. 35mm piezo disk diameter is a durable material than 27 mm disk.
4. Series and parallel connection are a better output.

5. ACKNOWLEDGEMENTS

The researchers would like to thank the Almighty God for the enlightenment of our minds in making the study possible. To the parents of the researchers, for their unconditional support and love to make the study successful. To our adviser, Engr. Vrian Jay V Ylaya, for his imperishable dedication in guiding and supporting the researcher to make the study well. Also, the former dean, Engr. Robert R. Bacarro, for lengthening his guidance to improve our knowledge in project study. To our classmates for sharing their priceless time and idea. Thank you to all the people behind this study for their unfathomed effort and patience.

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WIND POWER DATA LOGGER USING WEIBULL AND RAYLEIGH ANALYSIS

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Abstract: The data loggers used to automate the process of gathering data for wind speed assessment, by using wind power data logger powered by Linux based raspberry pi 4 and anemometer to measure wind speed and stored the data to the system with some features GUI that show the graphs for the wind speed through an LCD. The study used Weibull and Rayleigh distribution analysis for the data. There are about five stages in developing this research project, which are the analysis phase, design phase, development phase, implementation phase, and communication phase. The study shows that the build device Linux-based raspberry pi 4 data logger can give accurate readings for wind speed. the device data-log the wind speed on the island of Masapelid barangay pateñio and gathered the data through a CSV file. the project analyzes the data using the Weibull and Rayleigh distribution method and concludes that wind power generation in the area is possible compared to the Philippine wind power classification.

Keywords: Renewable, datalogger, Wind, raspberry pi, SBC, Weibull, Rayleigh, GUI, graph

1. INTRODUCTION

Wind power system is used in rural areas where frequent power outage is common. Wind power energy is applicable for off-grid and on-grid system which gives energy between the grid and wind power. The system switches between wind and power grid if one of the power sources is interrupted [1]. Single board computer is one of the most powerful small computers that capable of making programming ideas from scratch. Raspberry pi is a Linux-based single-board computer used by technical app developers used for data processing and graphical visualization, it contributes more flexibly and can be work better with microcontrollers[2]. Most microcontrollers are used in data logging applications like data logging for solar PV and can used also for wind[3]. Data logging systems are also used for online and wireless platforms like IoT and other wireless connectivity like 3G, Bluetooth, Modems through online and wireless real-time monitoring. Home solar system monitoring is used in web and mobile-based to monitor small solar systems [4]. One of the most commonly used data logging is a microcontroller based on Arduino because of its cost-effective data logging performance along with the use of sensors, like reading voltage, current, and power, with Arduino cheap data logging feasible for recording data for low-cost design[5].

The project helps assess the feasibility of wind power generation by gathering data about wind performance to give a more efficient and effective future implementation of renewable power generation.

As the grid line is continuously providing energy for consumer, there are some issues in the areas with a power outage or brownouts, Implementing off-grid wind power and implementing on and off-grid system however it is weather dependent[6][7], and the system is not sure if it is possible to implement the system in the area.

The project proposed a datalogger for wind speed to conduct an assessment ensuring effectiveness for future implementation of a wind power system. By using SBC or Single Board Computer, visual graphics like graphs and data allow monitoring capabilities for offline mode. Raspberry pi and sensor configuration is the best combination for computing and processing where GUI is displayed and the data from the sensor communicate with GPIO of the SBC, This project can work offline and XGA (1024x768) resolution LCD the graphs and outputs a RAW file CSV.

Based on the observation of the area the wind is consistent. the researchers caught interest in this project because it fits properly in the field of electrical engineering and this giving idea of what is possible improvement about this project to enhance the feasibility of wind renewable power generation.

1.1 Related Literature

In Faya-Largeau, Chad the analysis for wind speed and wind energy potential used the Weibull distribution methods to achieve cost-effective wind turbine in the Saharan zone[8][9]. Just like an assessment for the data is a must to have a reference for comparison whether the system is effective or not, just like in PANGAN-AN island, a case study conducted an assessment of renewable energy systems for rural electrification provide the best possible option to improve energy access because of some locations are lacking electricity. However, it claims that there are several factors of implementing the system including technology, economics, and the community[10].

Wind speed power production and wind speed relationship define a power curve where it shows the illustration of power output curves through mph or m/s versus the power in kW[11]. Wind characteristics are the basis to determine wind energy source suitable in a particular area[12]. Weibull distribution is the best method to determine if the area is suitable for Wind and also Solar global irradiance from the sun and estimate the annual energy power generation of a PV plant[8][13].

Dataloggers are used in monitoring PV solar to measure and record data like temperature, voltage, current, humidity, and irradiance that can be accessed through an internet website or via mobile phone. This allows the users to communicate with the datalogger online and monitor the data. Arduino-based are commonly used in data logger design for an affordable cost and display the data readings through digital LCD and stored in SD card[14].

Smart data logger used in meteorological parameters, a weather station that collects wind speed, temperature, PV generation output data that allow monitoring by the user through online, it claims that the smart logger effectiveness, the system claims to be an accurate, robust and precise and minimal cost[15].

In another work, the automatic weather station was designed for real-time weather monitoring where data is transmitted through wireless communication, uploaded data via FTP and stored to the web server and allows user to monitor the data with an android device, It claims that the system is flexible in the parameter of weather real-time monitoring and functional user interface design[16].

The rationale of the project is having wind speed for data reading using SBC such as raspberry pi 4B as the main processing and running Linux-based system that can work offline and can provide graphical visual graph output displayed through XGA LCD and give raw data CSV.

1.2 Theoretical Framework

Converting anemometer data from analog to digital is needed to be able to communicate between the sensor and the computer. Anemometer has a power supply needed to be able to operate and also a range of voltage from minimum to maximum wind speed.

Base on the datasheet for the anemometer wind speed calculation there is a voltage minimum of about 0.77V and a maximum voltage of 2V for the anemometer speed ranging from 0 m/s to 32.4 m/s.

$$V_S = \Delta V/d \qquad (1)$$

$$W_s = V_s * S_{max} \qquad (2)$$

By using the formula (1) where V_S is the Voltage speed correspond to the change of Voltage ΔV divided to the distance unit in meter. Then we can calculate now for the windspeed W_S (2) by multiplying the Voltage speed V_s and maximum Speed S_{max}.

In wind power generation, the wind speed that starts to generate power is 6.7 mph or equivalent to 3 m/s, the nominal or rated wind speed for turbines is 26 mph to 30 mph or 12 m/s to 13m/s. This is the rate for large-scale wind turbines if the wind speed exceeds 55mph or 25 m/s the turbine cut out the speed to avoid damage[11].

Wind turbines work by converting the kinetic energy in the wind first into rotational kinetic energy in the turbine and then to electrical energy that can be supplied. The energy available for conversion mainly depends on the wind speed and the swept area of the turbine.

$$P_{avail} = \frac{1}{2} \rho A v^3 C_p \quad ; \quad A = \pi^2 \qquad (3)$$

Where:
ρ = Air density
V= Wind speed
C_p = Power Coefficient

Based on the formula given the power can be calculated [17].

1.3 Conceptual Framework

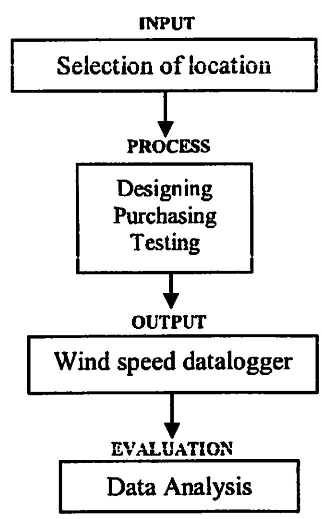

Figure 1. IPO of the study

Figure 1 starts with the input wherein the researchers determine the location where the project should be tested to gathered data. After that, the researchers proceed to the process stage, where designing purchasing, and testing takes place. This stage is challenging because this is where trials and errors are mostly present. Making the goal output to build a datalogger for wind. Evaluating the data for data analysis.

1.4 Objectives

This study aims to build a datalogger for wind speed to assess and collect data for the feasibility of wind power generation.

The specific objectives are:

1. Build wind speed data logger using Linux-based GUI.
2. Data-log the area for 1 week.
3. Make an analysis of the data.

2. METHODS

2.1 Research design

The cross-sectional research design used the project revising already existed technology and apply a variety of methods that rely on previous research with uniqueness. We also test our project and apply theory in the actual test.

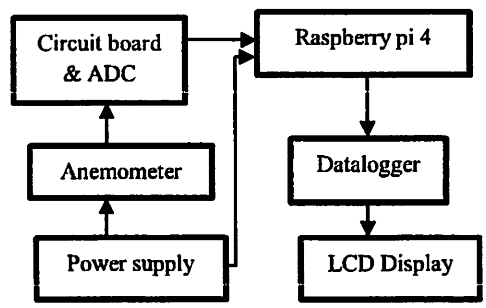

Figure 2. The Block Diagram of the Proposed Project

The block diagram Figure 2 measures the wind speed with the use of an anemometer for sensing where it connected to the circuit through I2C for conversion from an analog signal to digital to be able to be processed with a Raspberry Pi 4 connected to the PSU(power supply unit) or charge adapter to power the Raspberry Pi 4 which is 5 volts 3amps then all the data readings displayed in our 7 inch LCD visualizing graphs next is to our datalogger which is still in the raspberry pi command to output raw data.

2.3 Project Development

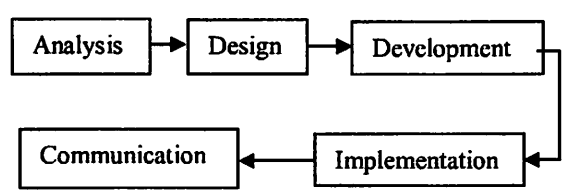

Figure 3. Development Process of the Study

The analysis phase where the materials of our project availability should be feasible and the chosen technology use has been researched and studied thoroughly to use on the project to achieve expected results.

Design phase at this stage we design a block diagram about how our project works and then later convert it to a schematic diagram.

Development phase where all the requirements needed in our project are arranged such as schedule, materials and tools, and instructions of our project.

Implementation phase where the instructions of our project are identifying how the project is made until it is completed.

Communication phase where the final output of our project is present and research journal for validation from the research panel.

2.4 Project Implementation

Check for the availability of the components local or online find all the requirements to the project and make the budget computation of the cost.

Purchase the required components check for the price inflation to have good deals of purchasing and check for sales of the components to have discounts.

Build the project based on the planned design and ask for recommendations from experts about the project to ensure the project's effectiveness.

Location selection and ask permission to the local residence importantly in the barangay leader officials of the pick location to ensure the accessibility of the area.

Securing the device to avoid damage and checking for the stability of the mechanism or sensors in the project to ensure that the project builds sturdiness.

Making daily reports for the data gathered in the device to monitor the process and troubleshoot for data reading interruptions.

Observe surroundings for possible natural accident causes harm of the device and apply cleanliness to the environment.

2.5 Project Setting

Figure 4. Brgy, Pateñio Island of Masapelid

The place is located on the island of Masapelid, Barangay Patiño, Municipality of Tagana-an. image of the island on Google Maps is as presented. This place is situated at approximately 9°42'22.1 N, 125°37'39.0 E. This island is facing the Pacific, making them the first to face the storms and typhoons if ever there is one. Barangay Patiño is just one of the places the distribution of grid lines is difficult, due to the geography of the island, the line of electricity is sometimes being interrupted and causes blackout for days, and also during storms and typhoons. This project will help for the assessment of the possible implementation of wind power generation.

2.6 Participants of the Study

The participants are the group of people or individuals that the researchers plan to become part of conducting the study.

Table 1. Profile of the participants

Participants	F(n=33)	% of involvement
Electrical Engineer	2	6.1%
Electronics Engineer	2	6.1%
Surneco	3	9.1%
Safety Offices	1	3%
Household holder	25	75.76%
Total:	33	

Table 1 shows the participants of the study. These include 2 Electrical engineers for the electrical privileges and an Electronics Engineer who will evaluate the difficulty and electronic advice of the installations of the project. 3 representatives of surneco assessing and evaluating the performance of the system and 25 household holders. Convenience Sampling, which is a type of non-probability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the study.

2.7 Instruments

The materials used by the researchers for developing the wind sensor data logger.

Anemometer the instrument used for reading wind speed data and provide data to the raspberry pi.

2.8 Research Ethics

Ethics applied in this project study are as follows:

1. Honesty, for honest scientific communication, honest report data results from methods and procedures.
2. Objectivity, for they strive to avoid bias in experimental design, data analysis, data interpretation, peer review, and other aspects of research where objectivity is expected or required.
3. Intellectual property, for the honoring of patents, copyrights, and other forms of intellectual property.
4. Openness, for the sharing of data results, ideas, tools, and resources and to be open for criticism.

2.9 Data Collection Procedure

Quantitative Data Collection

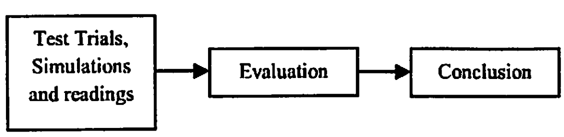

Figure 5. Quantitative data collection

Quantitative data are based on the project readings with the use of instruments conducting a test to gather results of the project, after that we evaluate the gathered data in the test readings of the instrument then construct a conclusion.

2.10 Statistical Tools

Weibull Distribution method

Different probability distributions have been used for describing and analyzing wind data. Among all distribution functions, Rayleigh and Weibull probability distributions are the most accurate and adequate ones in analyzing wind. To use the Weibull probability distribution, it is necessary to calculate two parameters, the shape parameter (k) and the scale parameter (c). there are several methods to estimate Weibull parameters such as the graphical, the moment, the standard deviation, the maximum likelihood, the energy pattern factor, and the power density method. According to the Standard deviation method, the Weibull parameters (c and k) were calculated using the following equations [18]:

$$k=\left(\frac{\sigma}{V_{avg}}\right)^{-1.086} \quad (1 \le k \le 10) \quad (4)$$

$$c = \frac{V_{avg}}{\Gamma\left(1+\frac{1}{k}\right)} \quad (5)$$

where V_{avg} is the average wind speed (m/s), σ is the standard deviation of the wind speed data and Γ is the gamma function.

Mean wind power density

By using the Weibull probability density function, the density of power of the wind (by unit surface) can be obtained by using the following equation[19][20]:

$$WPD = P(V) = \frac{P(V)}{A} = \frac{1}{2}\rho\varsigma^3 C_p \quad (6)$$

Where ρ is the density of air and A is the swept area of the rotor. C_p is the power coefficient. The actual amount would be less since all available energy is not extractable[21].

The two significant parameters of k and c are closely related to the mean value of the wind speed v_m as[22]:

$$v_m = \varsigma\Gamma\left(1+\frac{1}{k}\right) \quad (7)$$

As the scale and shape parameters have been calculated, two meaningful wind speeds for wind energy estimation, the most probable wind speed and the wind speed carrying maximum energy can be obtained. The most probable wind speed denotes the most frequent wind speed for a given probability and the wind speed carrying maximum energy represents the wind speed that carries the maximum amount of energy and is expressed as follows[22]:

$$v_{MP} = \varsigma\left(\frac{\kappa-1}{\kappa}\right)^{\frac{1}{\kappa}} \quad (8)$$

$$v_{Max\,E} = \varsigma\left(\frac{\kappa+2}{\kappa}\right)^{\frac{1}{\kappa}} \quad (9)$$

Rayleigh distribution is a simplified case of the Weibull Distribution where the dimensionless shape factor of the distribution is fixed ($k = 2$)[18].

Mean refers to the mean or average that is used to derive the central tendency of the data in question, "the mean can be characterized as a socialist, a fulcrum, a solution to the least-squares criterion, a set of ideal coordinates of the origin in n-dimensional space" [19].

Standard Deviation is a statistic that describes the amount of variation in a measured process characteristic or a measure that is used to quantify the amount of variation or dispersion of a set of data values. "Specifically, it computes how much an individual measurement should be expected to deviate from the mean on average" [20].

3. RESULTS AND DISCUSSIONS

3.1 Wind speed data logger

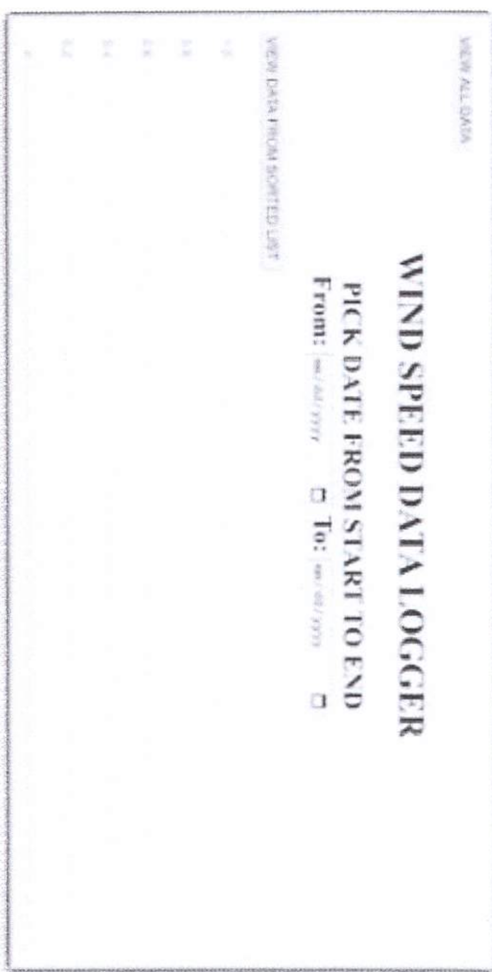

Figure 6. User interface

The system user interface with graph shown in the figure 6 for the actual wind speed where the user can view all data or pick a date to gather the data given the time and date. The data from the database compile and display the graph for wind speed.

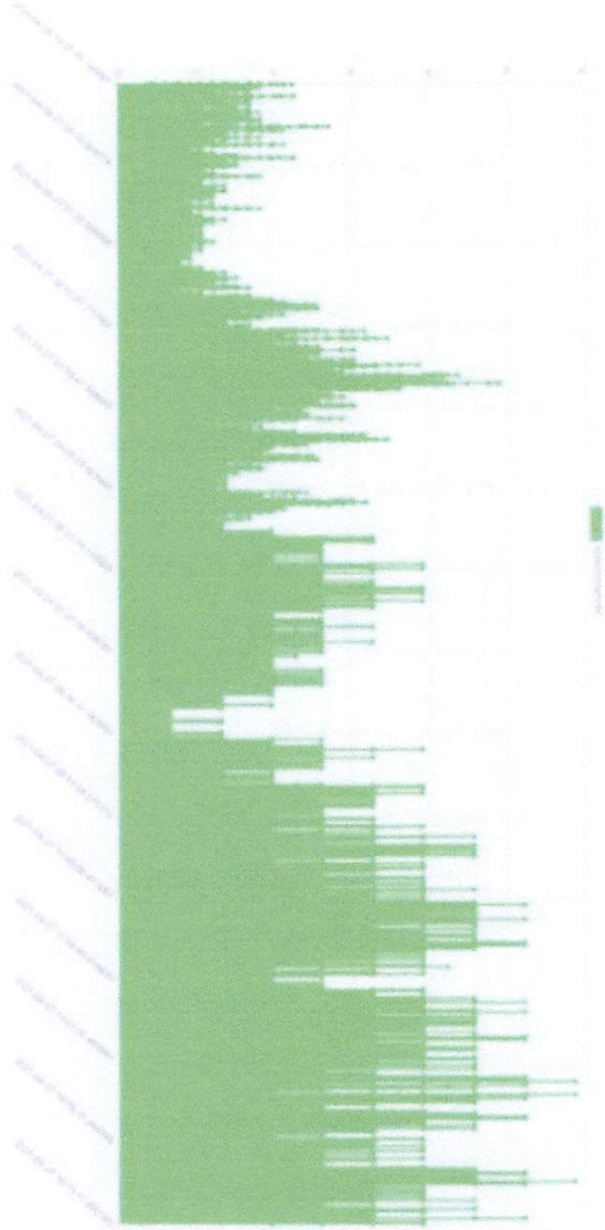

Figure 7. GUI wind speed graph

Figure 7 shows the wind speed graph where the x-axis is the date and time and the y-axis is the wind speed in meter per second.

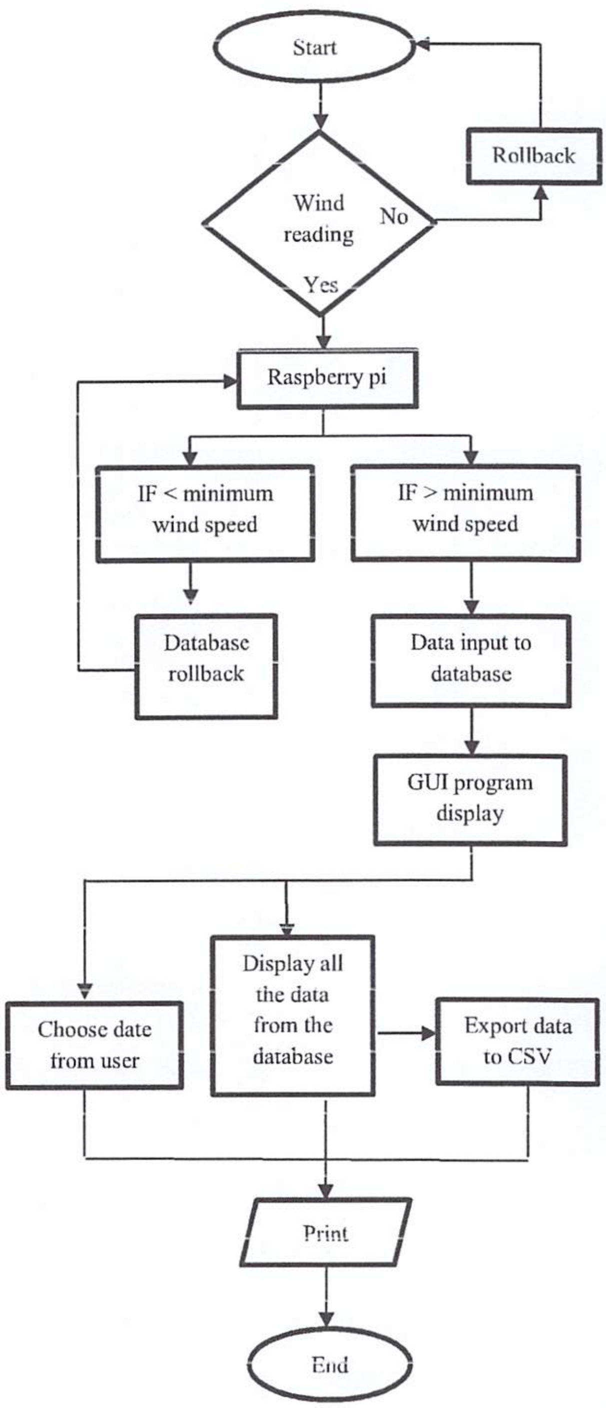

Figure 8. Flowchart

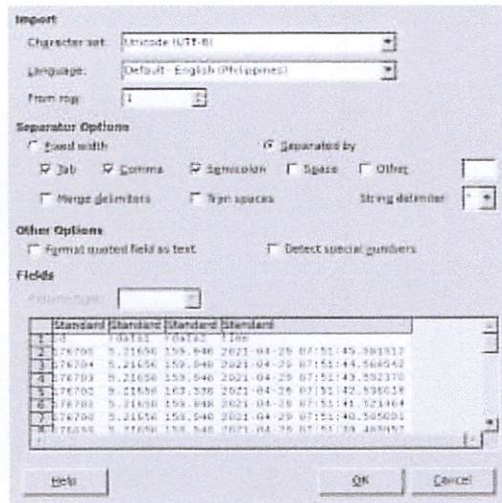

Figure 9. CSV file

The graph for the data recorded for wind speed is shown in the figure 7 The green graph of the data can be export through the CSV or an excel type for the data figure 9 file to compile all the recorded wind speed to be able to manage and monitor the data. As the graphical presentation viewed above the time interval for the reading of the data is every second.

3.2 Hardware design

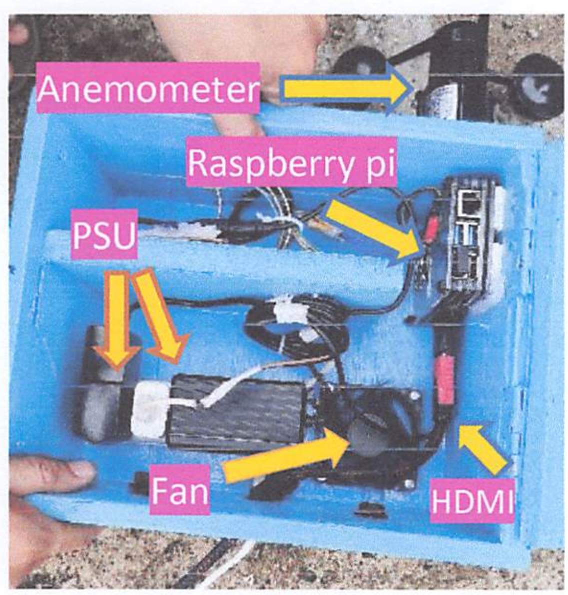

Figure 10. Project interior

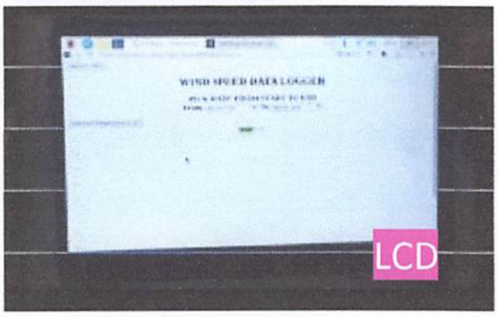

Figure 11. Display output

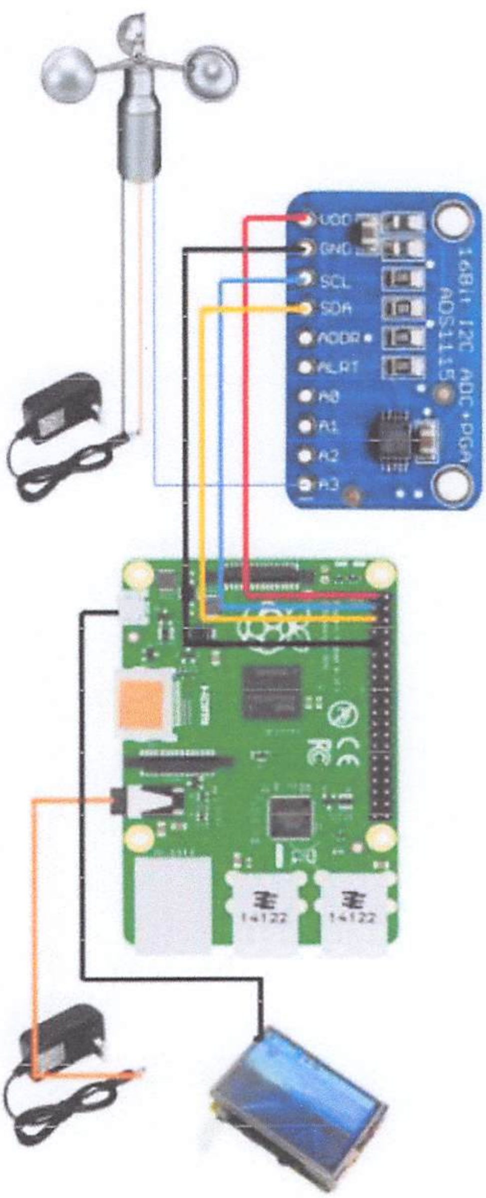

Figure. 12 Component's diagram

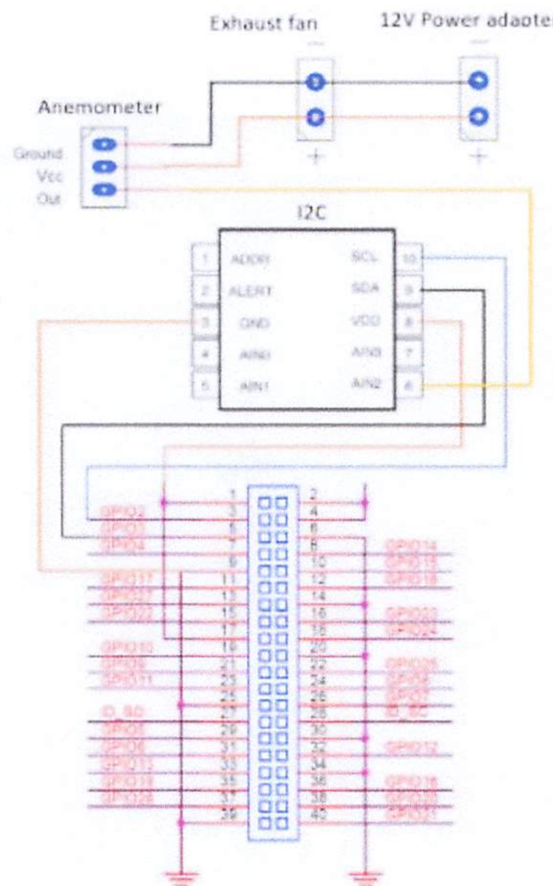

Figure 13. Schematic diagram

3.3 Recorded Datalog

Wind speed characteristics

Average wind speed and maximum wind speed per day for a week are shown in Figure 9**.** It is measured in m/s. Data shows that mean wind speed ranges 4.03 m/s – 7.07 m/s. Maximum wind speed measures 12.77 m/s, as shown in Table 2.

Table 2. Mean and Maximum wind speed

Days	Mean wind speed	Max wind speed
Day 1	7.07	11.76
Day 2	7.01	12.77
Day 3	4.03	7.91
Day 4	6.62	7.80
Day 5	6.77	8.07
Day 6	6.90	9.46
Day 7	6.83	8.46

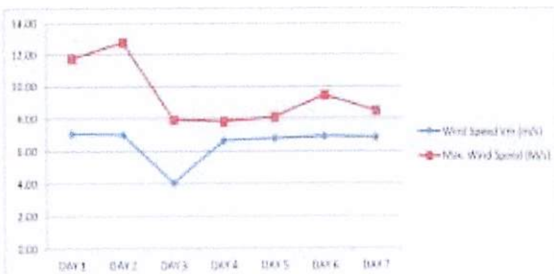

Figure 14. Graph of Mean and Maximum Wind Speed

3.4 Wind power data analysis

Analysis of Weibull and Rayleigh Parameters and densities.

$V_{max\,E}$ or the speed of the maximum energy-carrying wind speed and V_{mp} or the speed of the most probable wind speed are shown in figure 15. The understanding of the V_{mp} and $V_{max\,E}$ leads to the possibility to know if the site is possible for the installation of the wind turbine. Data shows that $V_{max\,E}$ ranges from 6.20 m/s to 11.81 m/s. V_{mp} ranges from 4.50 m/s to 6.10 m/s as shown in Table 3.

Table 3. V_{maxE} and V_{mp}

Days	$V_{max\,E}$	V_{mp}
Day 1	8.62	5.07
Day 2	9.86	5.70
Day 3	8.57	6.10
Day 4	7.42	5.59
Day 5	8.14	5.49
Day 6	8.60	5.51
Day 7	6.20	4.50

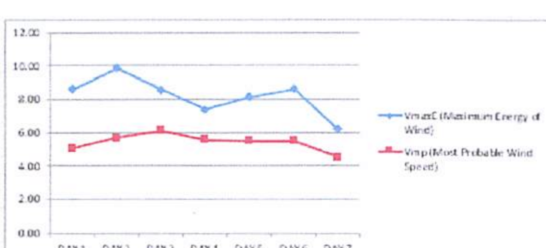

Figure 15. Graph of V_{maxE} and V_{mp}

Table 4. Wind power classification

Class	Resource Potential Utility	Rural	Wind Power Density (W/m²) @ 30 m	Wind Speed (m/s) @ 30 m
1	Marginal	Moderate	100-200	4.4 - 5.6
2	Moderate	Good	200-300	5.6 – 6.4
3	Good	Excellent	300-400	6.4 – 7.0
4	Excellent	Excellent	400-600	7.0 – 8.0
5	Excellent	Excellent	600-800	8.0 – 8.8
6	Excellent	Excellent	800-1200	8.8 – 10.1

Table 5. Weibull & Rayleigh wind power density

Day	K (shape Factor)	C (scale factor)	WPD Weibull (w/m^2)	WPD Rayleigh (w/m^2)	WPD Actual (w/m^2)
1	1.80	7.52	389.22	435.46	306.38
2	1.85	7.89	432.68	398.13	328.81
3	1.50	6.64	344.72	238.59	302.82
4	2.04	6.55	223.89	228.43	291.19
5	1.43	7.45	243.78	258.60	199.10
6	1.90	7.77	268.74	293.50	211.71
7	2.00	7.71	286.58	286.32	205.37

The wind power classification is shown in Table 4. data source given from "Philippines wind energy Resource Atlas Development" stated that "the wind speed average is not the best indicator of the resource" instead it uses the wind-power-density term expressed in watts per square meter (w/m^2)[12]. It shows the class ranging from 1 to 6 then the class separate to utility and rural resources potential, it shows the table for power wind power density and wind speed, Comparing to the 1-week data collected in the device in table 5 the data show that the wind power density (w/m^2) can be classified between 2 (good) and 3 (excellent) in rural and for utility.

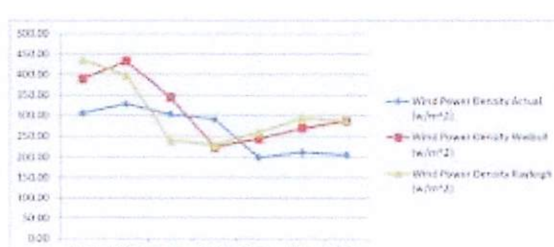

Figure 16. Graph of wind power density Weibull, Rayleigh, and actual

Table 5 presents the daily values of the shape parameter k, the scale parameter c, and the wind power density available on Masapelid Island. The shape and the scale factor were obtained using Eq. 4 and 5, Wind power Densities were obtained using

Eq 6. Thus, the result of the shape factor and scale factor are respectively in the range of 1.43 - 2.04 and 6.64 – 7.89. Equation 5 was used to calculate the wind power density. The wind power density was calculated in Weibull, Rayleigh, and the actual power. The wind power density of Weibull varies from 223.89 w/m^2 – 432.68 w/m^2, wind power density Rayleigh varies from 228.43 w/m^2 – 435.46 w/m^2 and wind power density actual varies from 199.10 w/m^2 – 328.81 w/m^2. Maximum wind power density is recorded on Day 1, obtaining 435.46 w/m^2 by the Rayleigh Distribution method. The minimum wind power is recorded on day 5, obtaining 199.10 w/m^2 as shown in Figure 16.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

GUI based on Linux was build and works properly using python programming language and the device capable of giving accurate readings for wind speed continuously.

Wind data logger device was used to record data for one week and the device was capable of continuous runtime and recorded easily the one-week data in the area.

Data analysis has been make using Rayleigh and Weibull for wind power density provided in the actual data shown in table 2 the value can be classified as good, and excellent compared to the wind power classification provided by the Philippines wind energy Resource Atlas Development, therefore Brgy, Pateño island of maspelid is capable of the system.

Recommendations

Base on the findings and conclusions presented, the following recommendations are suggested.

1. Due to a power outage, the device can be interrupted by recording data, so the researchers recommend adding a power backup or battery to make it standalone to avoid data interruption.
2. the data analysis for the Weibull and rayleigh distribution calculation has been done manually, the researchers recommend including the Weibull and rayleigh distribution methods and formula in the program for more reliable and fast calculation.

5. ACKNOWLEDGEMENTS

The completion of this project study could not have been possible without the participation and assistance of so many people. Their contributions are sincerely appreciated and greatly acknowledged. The group would like to express their deep appreciation and indebtedness to the following: to our Lord God almighty, the author of knowledge and wisdom, thank you for the countless love. to our Dean of the College of Engineering in SSCT, Engr. Robert R. Bacarro, and also to our adviser Engr. Vrian jay Ylaya for the guidance and to our mentors Engr. Jemielou M. Fideles and Engr. Ghandi B. Galila, to make our project study possible and successful. to the parents of the researchers, for the undying support, guidance, patience, and love, thank you. We owe you our future for guiding us this far. Our victory is yours as well. We thank you!

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HYDRAULIC ANALYSIS OF MACOPA IRRIGATION FOR HYDROPOWER SYSTEM

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Abstract: This study aims to analyze the potential of the water flow in Macopa, San Francisco, Surigao del Norte irrigation and to utilize the energy with the construction of a pico-hydro power plant. The study was carried out by measuring the speed and velocity of the water flow and calculating the hydraulic power that may be generated by the irrigation flow. If it is feasible, a hydropower plant can be constructed. Construction begins with actual discharge analysis, turbine selection, type of generator used, and impact of generator output toward loading were tested in the field to be able to produce electrical energy that can be used for streetlights in Macopa communities concerning secure generator system, environmentally friendly, easy to operate and affordable. The results show that irrigation flow can be achieved as a water resource for the construction of a hydroelectric power plant.

Keywords: Irrigation, Hydropower, Turbine, Generator, Renewable

1. INTRODUCTION

Water power has been an energy source for hundreds of years. Initial developments used water wheels to drive millstones and water pumps and later plant machinery. In the past century, a new system was invented to use the energy of water, the water turbine, to generate electricity. It started on a small scale, with power plants producing small quantities of electricity for their needs; and turned into a large infrastructure producing large quantities of electricity to sell it. [1].

In line with the social, economic, and economic development of the economy as well as information, electricity has become one of the main needs for the community, including the remote communities. In the middle of 2016, the level of household electrification in the Philippines stood at 89.6 percent, leaving 2.36 million households without electricity and many other areas with a limited service of only four to six hours per day [2]. This is due to several factors such as the limited ability of the State Electricity Company to provide and distribute electrical energy to all communities in the country, especially in remote rural areas.

The power shortage situation in Surigao del Norte was caused by generation insufficiency brought about by shutdown/non-availability of generating units [3]. Power distributor's management implores for public understanding since this power crisis is beyond its control and is experienced in Surigao del Norte and the Philippines as a whole.

The Province of Surigao del Norte has many rivers and some of the rivers can store lots of water in the dam. However, there is irrigation in the existing dam here in Surigao del Norte that is suitable for the hydropower plant. This project study can be used as an alternative source of energy in some of the barangays and municipalities in Surigao del Norte.

It is important to pursue this study because electricity is one of the most important needs in Surigao del Norte and even in the world in this generation and also in the future. If this study will be successful, it can minimize the power shortage because of this alternative source of energy. In addition, the study will help the researcher understand how the hydroelectric plant operates.

Related Literature

Hydropower technology is fairly mature, but new challenges continue to emerge. First, given current trends in decarbonization in the electricity sector [6], the amount of electricity produced by variable renewable energy sources (RES) has steadily increased [5]. Effective and efficient treatment of VRE production intermittent is a growing field of research [4].

Under the name, Dammed Hydroelectric power plants derive electricity from the potential energy of dam water through the use of a turbine and generator. The height at which this water is discharged from the dam supplies the energy needed to run the hydraulic turbine. That creates electricity. To keep a steady stream of electricity some of the water from the head of the dam is stored in a reservoir which can be used to elevate the water level whenever necessary [9].

Hydropower is the most advanced clean, renewable energy technology available. It helps to curb climate change as hydroelectric plants produce very small amounts of greenhouse gases [8]. Although it is widely used throughout the world, only one-third of the economic hydroelectric potential has been used so far [7].

To meet the electricity needs of villages that have not been powered with electricity, building a pico-hydro power plant can be a solution. Based on potential and feasibility surveys, pico-hydro power generation is highly feasible to develop [5]. Pico-hydro power plants require the flow of water as a source of energy, which can be sourced from river flows, municipal wastewater streams, and irrigation flows [9].

The turbine system is central to the plant and transforms water into mechanical energy. The selection of which turbine(s) to use depends in large part on the characteristics of the installation site, for example, the available net head and anticipated dynamics of the river discharge, and is therefore arguably one of the most difficult decisions in the design of a hydropower plant [12].

Before the implementation of these pico-hydro power plants in the field, ongoing research was first done to improve the performance of a pico-hydro power plant, such as by developing flow steering in the turbine, and by increasing the shaft fatigue life of the cross-flow turbine. Before the construction of this pico-hydro power plant, several things should be done, namely the potential surveys and development feasibility, and analysis of the operation, performance, and economy of the power plant to be built.

1.1 Theoretical Framework

In this study, the speed of the water pounding the blade (V) is calculated with this formula:

$$V = \sqrt{2.g.h} \qquad (1)$$

Where g is the gravitational flow of water and h is the head of the irrigation. The amount of hydraulic power (Ph) Pico-hydro power plant using a waterwheel on irrigated irrigation can be known based on the following equation:

$$Ph = 9.81.Q.h + 1/2.Q.V^2 \qquad (2)$$

where Q is the actual discharge of the water.

This Pico-hydro power plant uses a waterwheel to utilize water in irrigation, using an under-shot water mill type that has a maximum efficiency of 80-85% and no longer requires a rapid pipe. The speed of the circumference of the mill can be calculated through the equation:

$$U1 = \frac{V1 \cos \alpha 1}{2} \qquad (3)$$

Where V is the speed of the water founding by the blade.

Reaction hydraulic turbines absorb a portion of the kinetic and potential water energy as mechanical energy. This power transfer occurs in the turbine blades and is given by the well-known Euler's equation for a steady flow of an ideal fluid along a streamline. It is the relation between velocity, pressure, and density of a moving fluid. This equation is achieved by applying the law of conservation of the angular pulse to the liquid inside the turbine [12].

This study aims to design a pico-hydro power plant using a simple waterwheel by utilizing a water source from Macopa irrigation, which tends to be used only for agriculture. The waterwheel used in this study is based on the water flow system, which is the under-shot water wheel. The flowing water height is 2.7034 m and the water capacity is 1.40 m3/s up to 1.68 m3/s. The potential water source from the existing irrigation in the area is very possible to be converted into a source of electrical energy by using the Pico-hydro Power Plant.

1.3 Conceptual Framework

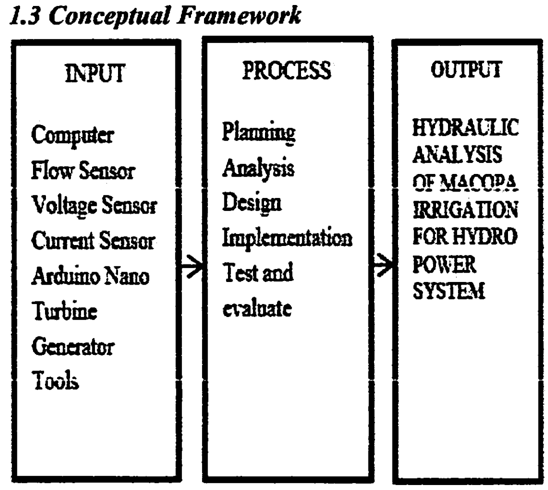

Figure 1. ***Flowchart of the study (IPO Diagram)***

As shown in Figure 1, the conceptual framework of the study starts from the input which is the first block. Using a computer, the voltage and current were programmed through the Arduino Nano to generate the data logging. The turbine and the generator were installed using tools.

Second is the process which has done first with planning to achieve an efficient and effective output. Analyzing all parameters that involve in this study. The design process deals with appropriate design for the location and other factors to consider. This was followed by further tests and evaluations to have a reliable, operational, and efficient output for the project study.

The output of this project study is the Hydraulic analysis of Macopa irrigation for hydropower systems which is done after the process is completed. Where the produced output would become the alternative source of energy.

1.4 Objectives

The General objective of this project study is to find out if the Macopa irrigation is feasible for the pico-hydropower system, considering seasonal variation in power generation to meet the area's demand during all seasons. The specific objectives are the following:

1.) To test the flow of water, to determine the capacity, and to produce power
2.) To implement the design of Pico-hydropower system
3.) To test the output using lighting load

2. METHODS

2.1 Research Design

The research design applied to this project study is Observational design. Which can conclude with the results of collected data of a particular system's behavior. In cases where the researchers have no control over the experiment in collecting the data to determine the feasibility of water flow for hydropower systems.

2.2 Project Design

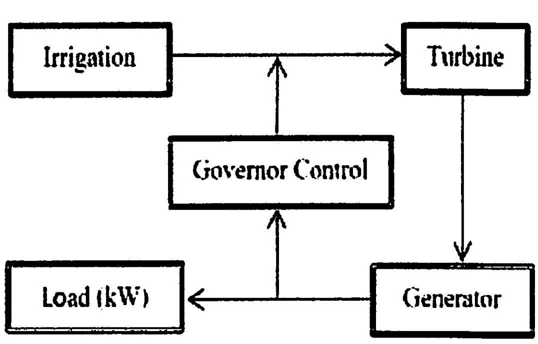

Figure 2. ***Block Diagram of the Pico- hydropower plant***

As shown in Figure 2, the water starts at the water storage that flows in the irrigation and spins the turbine which drives the generator. When the generator produces more than the desired output, the governor's control will control the flow of water in the irrigation.

2.3 Project Development

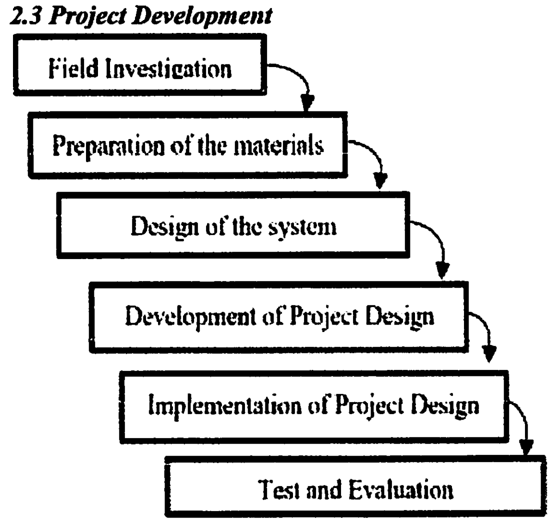

Figure 3. ***Workflow of Detailed Project Design***

Figure 3 shows the flow of work of detailed project design. To develop this project study, it is necessary to gather data relevant to the project design and location through field investigation. With the data collected, the researchers must prepare the materials to be used and the detailed layout design of the project with accurate and precise calculations is ready to implement in the particular location. Then, the development of the prototype hydropower plant design will be implemented as well as the evaluation of the performance and acceptability of the project.

2.4 Project Implementation

To implement this project is to study first the area by measuring the existing irrigation and the discharge of the water flow. The second is installing the production solution. This is the piece everyone remembers. The solution needs to be moved from development to test. The third is converting the data. Changing data from one format to another needs to take place once the solution is implemented. Fourth is Performing the final verification in production. The researchers should have prepared to test the production solution to ensure everything is working as expected. The desired output of this pico-hydropower plant is 0.5kW to 3kW. And the last is monitoring the solution. Usually, the project team will spend some period monitoring the implemented solution. If there are problems that come up immediately after implementation, the project team should address and fix them.

2.5 Project Setting

Figure 4. ***Google satellite and cellphone image of the location of the proposed study***

Figure 4 shows the configuration of the area analyzed and implemented, the pico-hydropower plant located at Macopa, San Francisco, Surigao del Norte.

2.6 Participants of the Study

Table 1. ***List of the participants***

Participants	f(n=7)	% involvement
Electrical Engineer	2	28.57%
SURNECO	2	28.57%
EVALUATORS	3	42.86%
TOTAL	7	100%

Table 1 shows a voluntary sample is made up of people who self-select into the survey. Often, these folks have a strong interest in the main topic of the survey. A convenience sample is made up of people who are easy to reach. With multistage sampling, selecting a sample by using combinations of different sampling methods.

2.7 Instruments

List of instruments that obtain to this project study:

1. Flow Sensor
2. Voltage/Current Sensor
3. Arduino Nano
4. Computer

These lists of instruments ar used to perform research and disseminate the information needed for project development.

2.8 Research Ethics

Know and obey relevant laws and institutional and governmental policies. Do not fabricate, falsify, or misrepresent data. Don't deceive colleagues, research sponsors, or the public. Strive honesty in all scientific communications. Honestly report data, results, methods and procedures, and publication status. Avoid careless errors and negligence; carefully and critically examine your work and the work of your peers. Strive to avoid bias in experimental design, data analysis, data interpretation, peer review, personnel decisions, grant writing, expert testimony, and other aspects of research where objectivity is expected or required. Share data, results, ideas, tools, resources. Be open to criticism and new ideas.

2.8 Data Collection Procedure

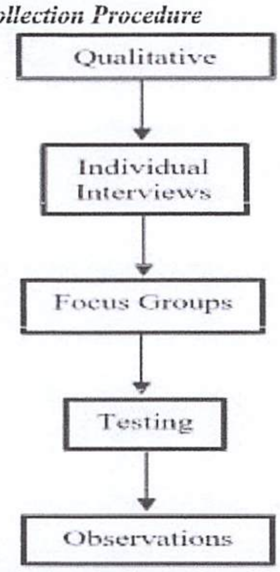

Figure 5. ***Gathering Qualitative Data Block Diagram***

To gather Qualitative data, Interview some individuals with the use of an evaluation tool. Have more time to discuss with the team and observe every opinion and Ideas of the group. Then doing some execution and trials.

2.10 Statistical Tools

The statistical tools that are used in this project study are the mean and coefficient of variation. Mean refers to the mean or average that is used to derive the central tendency of the data in question. These are very useful tools in this study for more opinions and ideas that we gather.

2.11 Financial Analysis

Table 2. ***Direct Materials and Service Cost***

Description of Materials	QTY	COST(PHP)
Synchronous Generator	1	6,000
Angular bar	11	4,015
Pillow Block	4	1,280
1x2x16 Pully	1	1,440
1x2x18 Pully	1	1,450
1x2x3 Pully	1	222
1x8x8 Wood Planks	4	1,634
1 kl. Welding rod	4	360
Flow Sensor	1	1,300
Voltage/Current Sensor, Arduino Nano		1,700
2 pcs F - Belt	2	726
Bolt and Nut w/ washer	80	720
10 m wire AWG #14	1	700
SERVICES		
Transportation		3,000
Fabrication		4,000
TOTAL		**28,547**

3. RESULTS AND DISCUSSIONS

This research investigated hydraulic analysis in Macopa irrigation for hydropower plant development. The results of this study are explained further.

3.1 Potential of Water Flow Energy in Irrigation

Head (h) = **2.7034 m**
Debit Air (Q) = **0.168 m3/s**
The speed of the water pounding the blade (V):

$$V = \sqrt{2.g.h} = \sqrt{2(9.81)(2.7034)}$$
$$= \mathbf{7.283\ m/s}$$

Figure 7. ***Measurement of water potential in irrigation flow***

Based on data head(h) and discharge(Q) that has been obtained then the ydraulic power, as follows:

$$Ph = (9.81).Q. + 1/2.Q.V^2\ (kW)$$
$$= (9.81)(0.168(2.7034) + (1/2)(0.168)(7.283)^2$$
$$= \mathbf{8.91\ kW}$$

Table 3. ***Energy Potential***

TIME (Per Hour)	WATER SPEED AND VELOCITY (m^3/hour)
15:00:03	1488
16:00:10	1472
17:00:16	1464
18:00:23	1552
19:00:29	1560
20:00:36	1552
21:00:42	1512
22:00:56	1440
23:00:02	1432
24:00:08	1512
1:00:15	1536
2:00:21	1528
3:00:27	1552
4:00:34	1528
5:00:40	1520
6:00:47	1488
7:00:53	1488
8:00:00	1552
9:00:06	1560
10:00:13	1520
11:00:19	1456
12:00:26	1472
13:00:32	1552
14:00:39	1560
15:00:03	1504

Figure 8. ***Duration of water speed in the irrigation flow***

Based on the graph of the data gathered, the speed of the water was consistent and has a potential for the Pico-hydropower system. The pick ranges from 1560 to 1432 m^3/h as shown in figure 8 and it shows that the speed of the water was not constant. An Arduino Nano programming had been used to gather the data within 24 hours. The x-axis and y-axis represent the time and the speed of water respectively.

3.2 Implementation of the Pico-hydro Power Plant

The speed of the circumference of the mill can be calculated through the equation:

$$U1 = \frac{V1\ cos\ \alpha 1}{2} = \frac{7.283\ \cos(8)}{2} = \mathbf{3.606\ m/s}$$

Turn of the mill:

$$N = \frac{60.U1}{\pi.D1} = \frac{60(3.606)}{\pi(0.9144)} = 75 \times 85\%(ME)$$

$$= \mathbf{64\ rpm \sim 62\ rpm}$$

The blades used for this waterwheel form as shown in FIG. 9. Many blades are used as many as 16 pieces. With a radius of 3 ft and 2.1 ft wide using an angular iron plate with 3/16 mm thick and ½ x 8 x 25 inches wood planks 16 pieces.

Figure 9. ***Waterwheel pico-hydropower plant***

Mechanical transmission system using multiple pulley model to increase the rotation to be distributed to a generator (see figure 10).

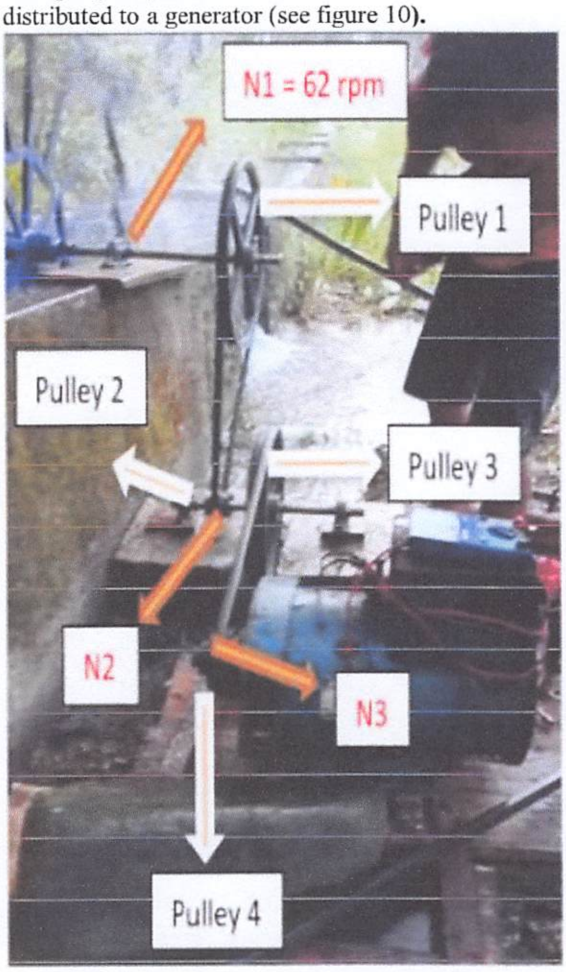

Figure 10. ***Mechanical Transmission System***

r Pulley 1 = 9 inches = 0.2286 m
r Pulley 2 = 1 inches = 0.0254 m
r Pulley 3 = 8 inches = 0.2032 m
r Pulley 4 = 2 inches = 0.0508 m

The rotation at n1 is equal to the rotation of the mill which is 62 rpm.

$$N2 = \frac{r\ pulley\ 1.n1}{r\ pully\ 2} = \frac{0.2286(62)}{0.0254}$$

$$= \mathbf{558\ rpm}$$

Next rotation n2 is transmitted by pulley to generator ratio (n3), Increasing the round can count through the following equation:

Mechanical efficiency of 83.33%

= N2(83.33%) = (558) (83.33%)
= 465 rpm

$$N3 = \frac{r\ pulley\ 3\ .n2}{r\ pully\ 4} = \frac{0.2032(465)}{0.0508}$$

$$= 1860\ \text{rpm}$$

From the results of mechanical transmission system using multiple pulley model, then got the spin on the generator of 1860 rpm. Mechanical efficiency 85 %, then obtained:

N3 = 1860 x 85% = **1581 rpm**

Table 4. ***Potential Energy as Output of Generator***

TIME (Per Hour)	VOLTAGE (Volts)	AMPERE (Amps)	POWER (Watts)
14:33:00	165.95	0.03	5.66
15:33:03	158.26	0.03	5.16
16:33:10	164.53	0.03	5.57
17:33:16	164.21	0.03	5.55
18:33:23	165.79	0.03	5.65
19:33:29	162.35	0.03	5.42
20:33:36	158.43	0.03	5.17
21:33:42	159.56	0.03	5.24
22:33:56	162.69	0.03	5.44
23:33:02	162.29	0.02	5.42
24:33:08	159.43	0.03	5.23
1:33:15	132.93	0.03	3.65
2:33:21	159.4	0.03	5.23
3:33:27	137.36	0.03	3.9
4:33:34	164.05	0.03	5.53
5:33:40	168.38	0.03	5.83
6:33:47	168.66	0.03	5.85
7:33:53	164.99	0.03	5.6
8:33:00	166.06	0.03	5.67
9:33:06	159.5	0.03	5.23
10:33:13	159.39	0.03	5.23
11:33:19	166.69	0.03	5.71
12:33:26	167.65	0.03	5.78
13:33:32	169.16	0.03	5.88
14:33:39	171.55	0.04	6.05

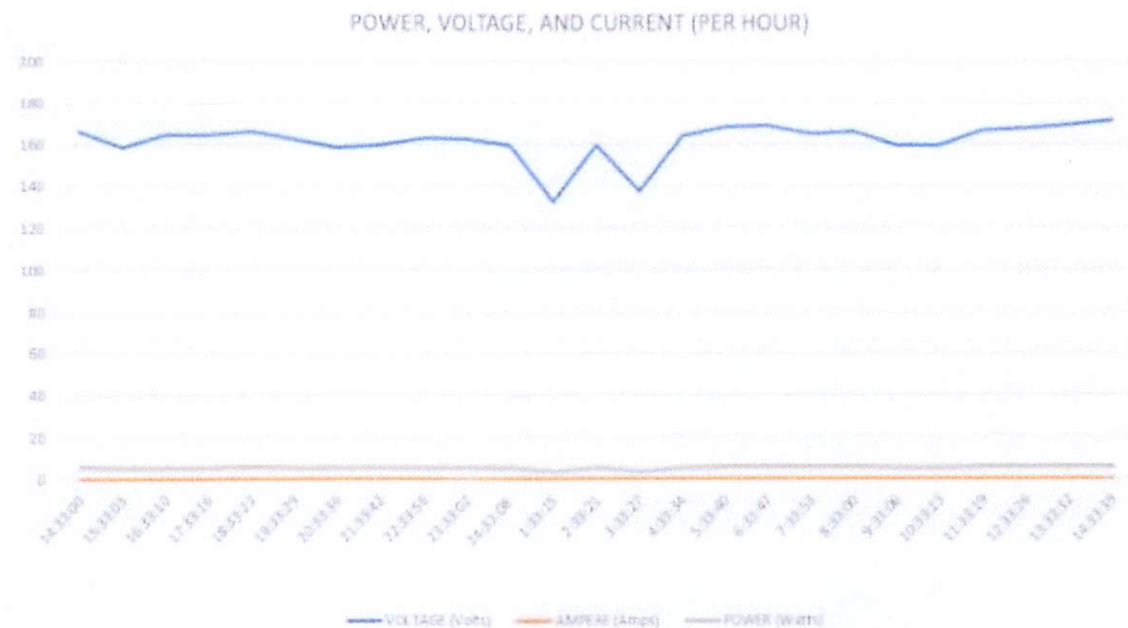

Figure 11. ***Duration of Energy as an output of Generator***

Figure 11 shows the graph of the voltage, current, and power output. The data was gathered 24 hours using Arduino Nano Programming. Based on the graph of the data gathered, the voltage and current were consistent. The voltage pick ranges from 132.93 to 171.55 V and the current pick ranges from 0.03 to 0.04 amperes based on the load that was used for monitoring. The graph was observed that there was a very low peak voltage and current due to connecting of high-powered load like a laptop, water heater, electric fan, etc.

3.3 Test Result with Load

This project was designed to provide energy for the streetlights in the Macopa community and the results prove that the system can carry the desired load.

Number of lights = 40
Type of load = 18 W CFL
Lighting hours = 12
Total load = 40 x 18 W = 720 W

Energy Consumption per day:
720 x 12 = 8.64 kW

Figure 12. ***Development of pico-hydropower system***

The development of this project was done as the image shown in figure 12. The preparation of materials, implementation of the project design, and testing were evaluated to achieve the desired output of the Hydraulic Analysis of Macopa Irrigation for Hydropower system.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Based on survey data and pico-hydro power plant design using under-shot type waterwheel. From the survey that has been done got the data in the form of water debit 0.168 m3 / s and head 2.7034 m, so known big hydraulic power (Ph) with the efficiency of 85% equal to 8.91 kW.

In the calculation of the water velocity relationship design fell with the diameter of the mill, it is obtained the speed of the mill around 62 rpm. To increase the rotation to be distributed to the generator, the feeding system used a multiple pulley transmission model, with 85% mechanical efficiency obtained by rotation distributed to the generator of 1581 rpm. From the results of the increase of rotation by using the transmission system multi-pulley model, then get the generator specification that will be used, that is Rated Power (w) = 3000 Watts, rated voltage (v) = 115V/230V, rated rotating speed (rpm) = 1800 rpm.

Based on data of potential water from irrigation of Brgy. Macopa, San Francisco, Surigao del Norte the suitable type of power plant used is pico-hydro power plant using under-shot type waterwheel. From the observation, all loads could sustain by the pico-hydro power plant with the load specification has been used.

4.2 Recommendations

The researchers would like to recommend the following for hydraulic analysis of Macopa irrigation for hydropower system:

1. Install more waterwheels and generators in the irrigation to produce more energy.
2. Improvement of revolution per minute through the best design of pulleys.
3. Maintenance and control in Macopa irrigation for pico-hydropower system.

5. ACKNOWLEDGEMENTS

The researchers would like to acknowledge the accomplishment of this project study was the work and sacrifice of several people to whom the researchers owe gratitude: First of all, praises and thanks to the God Almighty for the wisdom, guidance, and blessings, He had showered upon the researchers to achieve the goals/concept of this paper. To parents, for their unconditional love, understanding, and support, both moral and financial all along with the writing of this document. To Engr. Robert R. Bacarro, MECE, MBA, for giving a chance to the researchers to experience making this project study, this is of great help to the student not just in this subject but also the knowledge as an Electrical Engineering student. This document opens a further door for improvement that will be meaningful in line with future work.

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