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Mechanical Twelve-Blade with Double Catch Design Pelton Wheel Gravity Generator For Multi-Renewable Energy Harvester For Street Lighting

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ABSTRACT:- This paper presents the design and implementation of mechanical twelve-blade with double catch design pelton wheel gravity generator for multi-renewable energy harvester for street lighting in Barangay Macopa, Surigao del Norte. The system aims to address the lack of reliable energy sources in rural areas by harnessing renewable energy from natural resources. The integration of solar panels, wind turbines, and a Pelton wheel in the local irrigation canal ensures consistent and environmentally friendly power generation. Through strategic site selection and installation, the system maximizes energy output and minimizes environmental impact. A comprehensive performance assessment reveals that the combined system produces a higher energy yield compared to individual components. The results demonstrate significant potential for improving energy autonomy in rural communities while reducing carbon emissions. A survey using the Technology Acceptance Model (TAM) confirms strong community support for the project. The system's modular design allows for scalability, making it adaptable for similar applications in other regions. This project contributes to the growing body of research in sustainable energy solutions for public infrastructure. Overall, the implementation of the multi-renewable energy harvester proves to be an efficient and cost-effective approach to achieving energy independence in rural communities.

Keywords:- Multi-renewable energy harvester, Pelton wheel, Solar and wind energy, Sustainable Street lighting, Energy autonomy, Rural electrification

I. INTRODUCTION

In our quest for sustainable energy solutions, we have developed a pioneering capstone project focused on a multi-renewable energy harvester specifically designed for street lighting [1]. Our capstone project integrates three main renewable energy technologies: the Pelton wheel, the solar panels, and the wind turbines [2]. The Pelton wheel is a traditional hydroelectric energy technology that uses flowing water to produce electricity [3]. The solar panels convert sunlight directly into electricity. At the same time, the wind turbines capture the kinetic motion of the wind and drive generators to generate electricity [4]. By combining these renewable energy technologies, we can develop a versatile and reliable harvester that can provide sustainable energy for street lighting in Barangay Macopa.

Using a multi-renewable energy harvester system offers several advantages [5]. Firstly, it promotes environmental sustainability by utilizing clean energy sources, reducing carbon footprint, and contributing to a greener future [6]. Secondly, it enhances energy resilience by diversifying energy sources, ensuring a more reliable and stable power supply. Additionally, it can lead to cost savings in the long run by reducing dependency on traditional energy sources [7].

The absence of dependable and sustainable energy sources for street lighting in Barangay Macopa is one of the major real-world issues we seek to solve. This problem affects not only nighttime safety and visibility but also energy inefficiency and environmental degradation because of non-renewable energy sources [8]. Our suggested course of action is using a multi-renewable energy harvester system for street lighting [9]. We hope to develop a self-sufficient energy system that can power streetlights effectively and consistently, meeting the community's energy needs while having a minimal negative environmental impact. This will be achieved by combining the Pelton wheel, solar panels, and wind turbines [10].

This study aims to demonstrate whether integrating multiple renewable energy sources for street lighting is feasible and effective. We hope to encourage similar initiatives in other communities, promoting sustainable energy practices and fostering a more environmentally conscious society by showcasing the viability and advantages of such a system in Barangay Macopa.

Review of Related Literature

Energy demand has been a constant concern since the universe's origin, leading to various energy production techniques. Fossil fuels and coal pollute the environment, while renewable energy resources (RERs) offer a natural resource. Still, their use faces limitations due to seasonality, equipment, and storage capacity [11]. The State University of Malang has implemented a solution to inadequate public road lighting in Gondosuli Village, East Java. The solution uses polycrystalline solar panels, a renewable energy source, to turn on lights at night. The project, completed within two months, has resulted in five PJUs installed at various points with minimal lighting conditions, resulting in a positive community response [12]. Libya, a North African country with abundant renewable energy, is considering a RES-based street lighting system to meet the growing population's demand for green energy. The system will use solar photovoltaic (P.V.) and wind turbines as an interface, reducing the burden on the national grid and generating green energy [13].

Sri Lanka's road systems increase electricity demand for street lights, necessitating renewable energy sources. A research study designs a hybrid street lighting system using piezoelectric crystals, solar panels, and wind turbines, generating low power output [14]. Indonesia is utilizing solar energy for public street lighting, particularly in Sulur, a region with abundant solar energy potential. This study compares the solar panels' ability and lamp consumption at PJUTS to assess technology sustainability. Observations show that solar panels can capture an average solar capacity of 150.73 Wh. In comparison, nightlight usage consumes about 120 Wh, indicating that solar energy is sufficient for public road lighting [15]. Sunlight is a widely used energy source in Indonesia, particularly in Kalurahan Sidoharjo, Kulon Progo Regency. However, street lighting conditions in this area are low. Solar-based Public Street Lighting (PJUTS) is a suitable solution, as energy conversion from sunlight is low. Observations show solar panels can capture an average solar capacity of 146.14 Wh, meeting public road lighting needs [16].

Considering its geographical features and economic aspects, this study focuses on designing a Solar-based Public Street Lighting system for Inayah Islamic School. The design uses a 20-watt 2-in-1 LED lamp and a 50-watt solar cell capacity per pole, with a pole height of 5 meters and a 1.5-meter polearm. The system meets the requirements of the Indonesian National Standard of 7391:2008, requiring 22 poles [17]. This study proposes a hybrid renewable energy device for traffic monitoring systems and street lighting in the Kingdom of Bahrain. The device uses car-passing wind and solar energy to generate power. The device uses a vertical-axis wind turbine and a solar system to convert solar radiation into electricity. Simulations show the device generates approximately 10 kWh/day of power, with a percentage error of 19% to 28% [18].

A hybrid pole system combining renewable energy, street lighting, and E.V. charging in urban areas. Using a D.C. microgrid with energy storage devices, the system can achieve fast and slow charging. The efficiency model of the smart hybrid poles group shows better performance than a single pole, providing a theoretical basis for practical construction [19]. TALiSMaN-Green is an energy-neutral solar-powered street light management scheme that responds to vehicle and pedestrian traffic by dynamically changing the brightness of street lights. Despite potential energy shortages, this innovative approach maintains a consistent usefulness across an entire overnight period. The system learns traffic volumes and sunrise times, budgeting energy accordingly enhancing safety and security in residential and commercial areas [20]. The project explores the potential of an intelligent street lighting system in Singapore, utilizing solar and wind energy, battery storage, and high-brightness LED lamps to replace current 25-30-year systems, with performance monitored using a weather station and data logger [21].

The study explores piezoelectric material as an alternative energy source for electric energy production. A pilot device was designed to convert mechanical energy from walking and traveling into electrical energy. The piezoelectric energy harvesting system can be used as a micro-mobility, light electric utility vehicle, providing a novel approach to smart city design. The system can generate 13.6 mW of power at regular cycling speed [22]. Energy demand has been increasing globally, leading to various energy production techniques. Fossil fuels and coal are polluting the environment. Renewable energy resources (RERs) are natural but have limitations such as seasonality, equipment, and storage. RERs can be effectively used in households and small industries with minimal power requirements, as they can provide a sustainable alternative to traditional energy sources [23]. The study evaluates the techno-economic feasibility of a multi-renewable energy complementary system (MRECS) in rural areas, focusing on the Jize Economic Development Zone. It finds significant development potential, potential for 168.42 MW of renewable energy units, and potential for cost savings [24].

The book aims to provide a clear vision for scientists, industrialists, and policymakers on renewable energy resources, addressing challenges like fossil fuel depletion, high costs, and greenhouse gas emissions and illustrating new technologies for sustainable, connected, and harvested energy [25]. The reliance on fossil fuels has led to climate change, increased energy usage, and water scarcity. Transitioning to renewable energy sources and efficient energy-water-environmental systems is crucial for a net-zero society. This chapter discusses innovative technologies for a clean, environmentally equitable society, integrating decarbonization with multiple renewable sources [26]. The paper presents a mixed integer linear programming model for optimal solar power system sizing with thermal energy storage. Based on a case study in Saudi Arabia, the model shows a solar field area of 146,013 square meters, reducing carbon dioxide emissions by 96% [27].

Singapore, a key Asian economic hub, focuses on renewable energy options for energy security, decarbonization, and conservation. The Energy Research Institute @ NTU, Singapore, is leading research in these areas, launching two flagship programs to develop innovative solutions for energy transition and green growth, putting Singapore in a leadership position in the tropical region [28]. This study aims to optimize distributed generation (D.G.) integration in modern networks by efficiently allocating Photovoltaic and Wind Turbine resources. It introduces a hybrid optimization technique combining Particle Swarm Optimization (PSO) with Genetic Algorithms (G.A.s). The approach outperforms traditional PSO regarding integration speed, power loss reduction, and grid quality enhancements. The study also highlights the impact of load curve fluctuations and climate changes on D.G. resource location and capacity [29]. The study presents MXene materials as versatile catalysts for multi-energy utilization, with Ti3C2TX MXene showing exceptional performance for organic pollutant decomposition and H2 production. It outperforms most catalysts under light, thermal, and mechanical energy stimulation. The study also reveals the production of hydroxyl and superoxide radicals under diverse energy stimulation [30].

Conceptual Framework

The waterfall model, which represents an organized approach, is used in the conceptual framework of the Multi-Renewable Energy Harvester for Street Lighting project. The phases in this model are laid out, guaranteeing an organized flow from problem identification to deployment and maintenance.

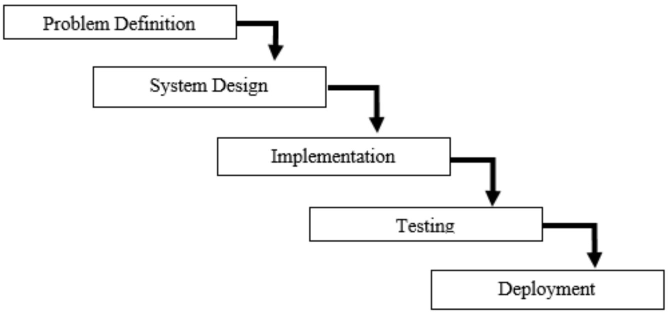


Figure 1. Waterfall Model of the Mechanical Twelve-Blade with Double Catch Design Pelton Wheel Gravity Generator For Multi-Renewable Energy Harvester For Street Lighting

The process starts with the problem definition stage, in which Barangay Macopa needs sustainable street lighting, which is determined by community consultations, assessments of environmental factors, and energy requirements. By defining specific goals and specifications based on community needs, this first phase lays the groundwork for the project.

The System Design phase, which follows the Problem Definition phase, focuses on the planning and analyzing the multi-renewable energy harvester system. An integrated system that uses solar power, wind turbines, and Pelton wheels is designed during this stage. Factors like system scalability, energy generation capacity, and site suitability are considered to guarantee the suggested solution's efficacy and efficiency.

After completing the system design, the project enters the Implementation stage. This is where the planned system is created, and the required parts are bought and set up. Street lighting infrastructure is assembled, and different parts, including sensors, controllers, and monitoring systems, are integrated. To make sure the created system complies with the requirements specified in the earlier phases, this phase necessitates meticulous planning and execution.

The project then moves on to the Testing phase, where the performance and functionality of the created system are assessed. User acceptability testing, performance assessments, and simulation tests are just a few of the stringent testing methods used in this phase. Before deployment, the objective is to confirm that the system satisfies the requirements and to find and fix any potential problems or shortcomings.

After testing is successfully finished, the project moves on to the Deployment stage. The multi-renewable energy harvester system is integrated with the street lighting infrastructure in Barangay Macupa, San Francisco, Surigao del Norte, using the developed system. This phase includes system integration, initial setup, and on-site installation to ensure a seamless transition and smooth operation of the deployed system.

At last, the project moves into the Maintenance and Support phase, during which continuous maintenance, support, and monitoring tasks are completed to guarantee the system's longevity and optimal performance. Frequent maintenance is necessary to address any potential problems and guarantee the ongoing operation of the street lighting infrastructure. This includes component inspections, software updates, and troubleshooting.

Objectives

The general objective of this study is to provide sustainable and reliable street lighting in Barangay Macupa by implementing a multi-renewable energy harvester system utilizing Pelton wheel, solar panel, and wind turbine technologies.

Specifically, the study sought to achieve the following;

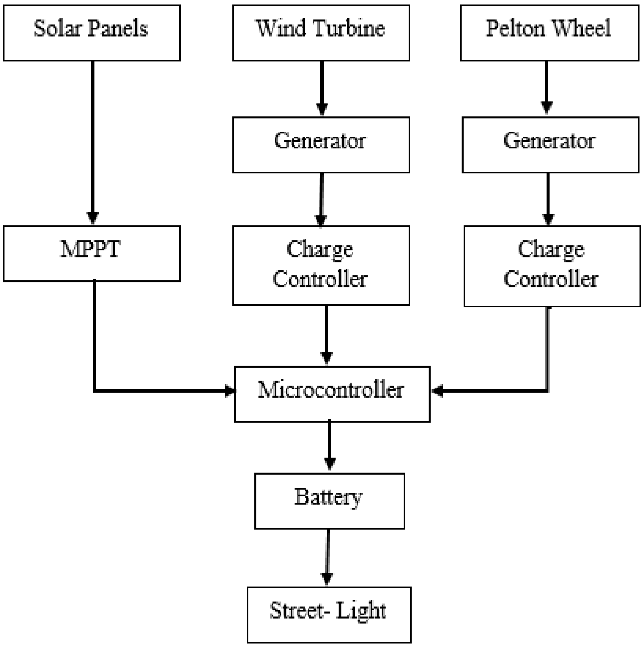
1. To design and integrate a multi-renewable system that combines a Pelton wheel (for hydropower), solar photovoltaic panels, and a small wind turbine to harness multiple renewable energy sources in the area.
2. To assess the individual and combined energy generation capacities of the Pelton wheel, solar panel, and wind turbine components in the proposed renewable energy harvester system.
3. To evaluate the acceptance and attitudes of stakeholders towards the multi-renewable energy harvester system using the Technology Acceptance Model (TAM) questionnaire and Learning Attitude (L.A.) model in Barangay Macopa, San Francisco, Surigao del Norte.
4. Evaluate the financial and economic implications of rural community-based renewable energy development projects in Brgy. Macopa, San Francisco, Surigao del Norte.

METHODS

Research Design

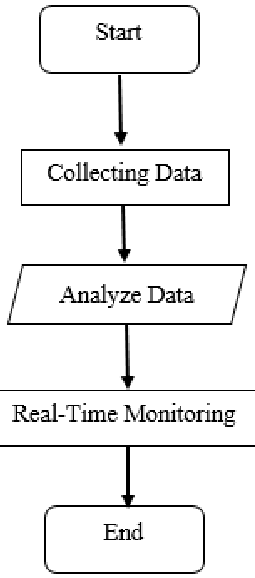
This research aims to develop a sustainable street lighting solution for Barangay Macupa by integrating solar panels, wind turbines, and Pelton wheel technologies. The study aims to design an optimized system tailored to the area's energy needs through a thorough review of current renewable energy systems and on-site assessments to determine environmental suitability. While implementation and testing will determine performance and reliability, economic analysis will assess viability. Finally, with implications for sustainability and energy efficiency, this research aims to shed light on how multi-renewable energy sources might improve street lighting infrastructure in urban areas.

Project Design



Fiure2. Hardware – Block Diagram of the project

The block diagram illustrates an advanced renewable energy setup combining solar, wind, and water sources. These elements generate electricity, including the solar panel, wind turbine, and Pelton Wheel. A charge controller regulates the voltage and current from these sources to manage the fluctuating energy output before channeling it to the battery for storage. Acting as a reservoir, the battery stores excess energy for future use during low production or high demand. Powering the entire system is a microcontroller, which derives its energy from the battery. Responsible for overseeing the system's functions, the microcontroller collects data from the renewable sources, monitors the battery's condition, and controls the power supply to the load. The load, representing electrical appliances, receives a consistent and dependable power supply from the battery, managed and optimized by the microcontroller to ensure efficient performance. This block diagram outlines a sophisticated renewable energy framework aimed at harnessing and distributing sustainable energy while prioritizing effectiveness and dependability.



Fiure3. System flowchart of the project

Our system flowchart project will involve several phases, including research and planning, design and prototyping, integration and testing, microcontroller programming, installation, monitoring and optimization, and documentation and reporting. The project's expected outcomes include reliable and sustainable street lighting, energy efficiency, environmental impact reduction, scalability, and community awareness. The search results provide some relevant studies and articles on renewable energy harvesting devices for street lighting, including solar panels, wind turbines, and piezoelectric harvesters. These studies highlight the potential of renewable energy sources for street lighting and the importance of intelligent energy management systems to optimize energy harvesting and consumption.

Project Development

In Figure 4, with the project development, the researcher outlines a systematic approach from project initiation to evaluation. System integration combines hardware and software programs, components, and calibration to optimize performance. The study concludes with a project monitoring and documentation to assess outcomes and impact, providing a structured overview of the process.

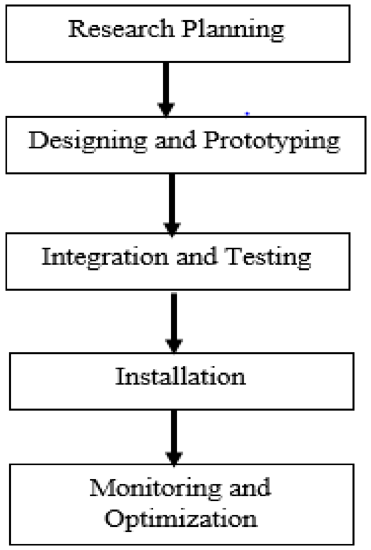


Figure 4. Project Development Flow Chart of the Study

The system would also include a power management circuit to regulate energy flow and ensure that the streetlights receive a consistent power supply. The software system for the energy harvester would include features such as real-time monitoring of energy production and storage levels, automated control of energy storage based on energy production and storage levels, and an automated lighting system.

Overall, the system would involve collecting and converting energy from multiple renewable sources, storing excess energy, and managing and regulating energy flow to ensure a consistent power supply for the street lighting in Barangay Macupa.

Participants of the Study

The study involves 30 participants representing various stakeholder groups essential for the multi-renewable energy harvester project in Barangay Macopa, San Francisco, Surigao del Norte. These participants include technicians (25%), local community members (25%), suppliers (20%), local authorities (10%), and advisors (20%).

Participants	f(n=30).	Percentage
Technicians	5	25
Local Community Members	10	25
Suppliers	7	20
Local Authorities	10	10
Advisor	1	20

Table 1. Participants of the study

Technicians bring technical expertise, community members offer local insights, suppliers provide materials, authorities offer support, and advisors offer specialized guidance. Together, they form a diverse and interdisciplinary network crucial for the successful implementation of the renewable energy project.

Project Evaluation

The project evaluation involves assessing various quantitative and qualitative variables to determine their effectiveness and impact. Quantitative evaluation measures energy generation, efficiency, reliability, cost-effectiveness, and lighting output. Qualitative evaluation involves gathering feedback on user satisfaction, environmental impact, safety improvements, and economic benefits. By analyzing these factors, a comprehensive understanding of the project's success and areas for improvement can be obtained, facilitating informed decision-making and optimizing outcomes.

Instruments

In this study, the following components will be used as an instrument for the fulfillment of this experimental study:

- **Arduino Uno –** This is for controlling and monitoring the system.
- **Laptop** - To program the Arduino.
- **Sensors** - To monitor and current of the sources
- **Micro DC Generator Motors** – For converting mechanical energy into electrical energy.

Materials and Methods

This section presents materials and methods for making a mechanical twelve-blade with double catch design pelton wheel gravity generator for multi-renewable energy harvester for street lighting in Barangay Macupa, San Francisco, Surigao del Norte.

Materials

Design and Fabrication of the Multi-Renewable Energy Harvester.

1. Pelton Wheel*:* A Pelton wheel was designed and fabricated using a round and flat steel bar for the body frame and a PVC for its runner.

Figure 5. Pelton Wheel Design

2. Solar Panel: Monocrystalline silicon solar panels were used, consisting of photovoltaic cells encapsulated in tempered glass with an aluminum frame.

Figure 6. Solar Panels

3. Wind Turbine: A small-scale vertical-axis wind turbine was constructed using PVC blades, incorporating aerodynamic design principles for optimal performance.

Figure 7. Wind Turbine Design

***4. Battery Storage System*:** To store excess energy generated during low-energy production periods.

Figure 8. Storage System

5. D.C Light Bulb: Enery-efficient lighting fixture for street illumination.

Figure 9. 12V D.C LED Bulb.

6. Control System: To regulate the energy flow and distribution among the different energy sources.

Figure 10. Pelton Wheel and Wind Turbine Charge Controller

Figure 11. Solar Panels Maximum Power Point Tracking

Methods

1. ***Site Selection:*** Identify suitable locations for installing the renewable energy harvester, considering sunlight exposure, wind patterns, and water availability for the Pelton Wheel.
2. ***Installation****:* Solar Panels are mounted at the top of the steel pole, ensuring optimal exposure to sunlight. The wind turbine was installed above the solar panels to capture wind energy efficiently. The Pelton wheel was integrated into the Brgy. Macopa canal irrigation system.

3. ***Testing*****:** The researchers conduct performance tests on each energy harvester individually and as a combined system to ensure optimal operation.
4. **Data Collection and Analysis:** Collect data on energy generation from each source, analyze the system's efficiency, and make adjustments as needed to maximize the energy output for street lighting.

III. RESULTS AND DISCUSSIONS

1. **Site Selection**

The Multi-Renewable Energy Harvester project in Barangay Macopa, San Francisco, Surigao del Norte, strategically capitalizes on the region's abundant renewable energy resources.

Figure 12. Map of Barangay Macopa

Situated in an area blessed with ample sunlight, consistent wind patterns, and a local canal irrigation system, Barangay Macopa provides an ideal environment for harnessing solar, wind, and hydroelectric power.

Figure 13. Local canal irrigation site for Pelton Wheel

Street lighting was chosen as the focal point for energy utilization, addressing the community's need for sustainable and reliable illumination while reducing dependence on traditional grid electricity.

Figure 14. Site for Streetlight and Wind Turbine

Solar panels installed atop streetlight poles capture sunlight, while strategically placed wind turbines harness kinetic energy from the wind. Additionally, Pelton wheel turbines integrated into the local canal irrigation system enable hydroelectric power generation, further supplementing the energy needs of the barangay.

Through careful planning and design, the project aims to maximize energy production while minimizing environmental impact. Solar panels are positioned to receive maximum sunlight exposure, while wind turbines are strategically placed to optimize energy yield without disrupting the landscape. Integrating Pelton wheel turbines into the existing canal irrigation system utilizes a renewable energy resource while minimizing environmental disruption. The Multi-Renewable Energy Harvester project in Barangay Macopa demonstrates a holistic approach to sustainable energy development, fostering community resilience, enhancing public safety, and reducing carbon emissions by leveraging multiple renewable energy sources.

2. Installation

The innovative approach of combining solar panels mounted on steel poles atop wind turbines maximizes renewable energy generation by optimizing space and infrastructure. This integration takes advantage of the complementary nature of wind and solar power, ensuring consistent and reliable energy output across varying weather conditions.

Figure 15. Solar Panels and Wind Turbine Installation

By generating electricity throughout the day, this setup reduces reliance on fossil fuels, enhances grid stability, and offers increased energy production efficiency. Placing solar panels at an elevated height atop wind turbines enhances sunlight exposure, minimizes shading, and reduces atmospheric interference, ultimately leading to higher energy output and improved overall system performance.

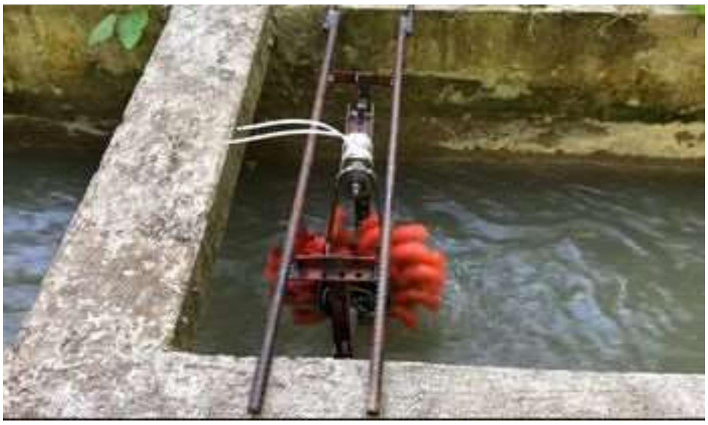


Figure 16. Pelton Wheel Installation

Installing a Pelton wheel in a canal irrigation system harnesses the kinetic energy of flowing water for electricity generation, offering reliability and sustainability. By integrating turbines into existing water infrastructure, the project minimizes environmental impact and maximizes resource efficiency. This approach ensures consistent energy production throughout the year while promoting energy independence and economic growth within the community.

Figure 17. Streetlight Installation

The installation of streetlights in Barangay Macopa integrates solar panels and wind turbines atop steel poles to provide reliable and sustainable lighting. Strategically placed throughout the barangay, these streetlights enhance public safety while reducing reliance on traditional grid electricity. Through careful planning, each streetlight pole maximizes energy generation while minimizing visual impact, representing a significant step towards sustainable development and community resilience.

3. Testing

Figure 18. Components Testing

Figure 19. Actual Testing

Table 2: Combined Power Output of Hybrid Energy System

Date	Solar Panel Output (Wh)	Wind Turbine Output (Wh)	Pelton Wheel Output (Wh)	Combined Output (Wh)
2024-04-28	1150	230	495	1,875
2024-04-29	1020	260	530	1810
2024-04-30	980	280	578	1838

This table displays the energy output (in watt-hours) of each renewable energy component (solar panel, wind turbine, and Pelton wheel) individually and in combination over three days from April 28th, 2024, to April 30th, 2024. The data illustrates how each component contributes to overall energy generation, showcasing the varying contributions and complementarity of the different renewable energy sources.

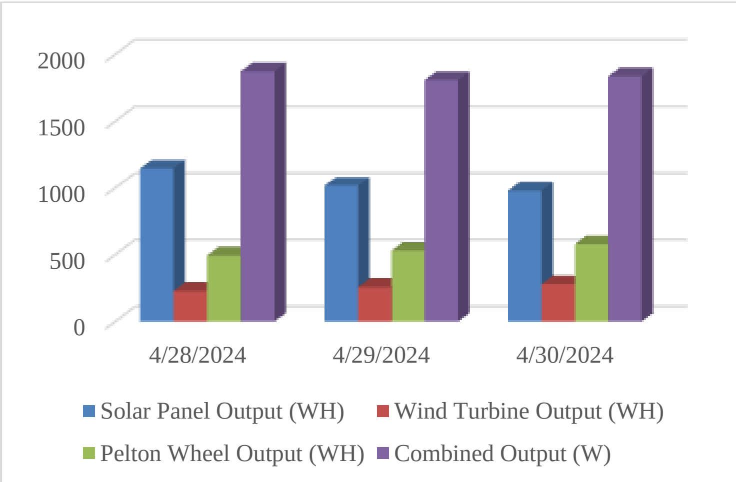


Figure 13. Comparison of Energy Generation from Each Component

The table presents the energy output of solar panels, wind turbines, and Pelton wheels over three days. Solar panels consistently contribute the most energy, harnessing sunlight effectively. Pelton wheels generate less than solar panels but still make a significant impact, utilizing the kinetic energy of flowing water. Wind turbines produce the least energy, reflecting their reliance on variable wind conditions.

A comparison between the total combined power output of the hybrid energy system and the individual power output of each renewable source (wind turbine, solar panels, and Pelton wheels) is shown in the figure. It demonstrates the synergistic effect that arises from integrating several renewable energy sources, which produces more energy overall than if the sources were used separately.

Figure 20. Harvested Energy

Figure 21. Indiviual Harvested Energy

The harvested energy from the Pelton wheel, solar panels, and wind turbine in Barangay Macopa converges to charge a centralized battery system, ensuring a reliable and renewable energy source for the community. The Pelton wheel harnesses flowing water's kinetic energy in the canal irrigation system, while solar panels capture sunlight and wind turbines utilize wind energy, all directing their generated electricity to charge the battery. This integrated approach optimizes energy production, providing a consistent power supply throughout the day and under varying weather conditions.

4. Survey as to technology acceptance and learning assessment in the technology from the community

Perceived usefulness (PU)	Mean	SD	SQ
1. Using Multi-Renewable Energy Harvester in my job will enable me to accomplish tasks more quickly	1.9	0.29	Strongly Agree
2. Using Multi-Renewable Energy Harvester will improve my job performance	1.87	0.33	Strongly Agree
3. Using Multi-Renewable Energy Harvester System in my job will increase my productivity	1.9	0.29	Strongly Agree
4. Using Multi-Renewable Energy Harvester will enhance my effectiveness on the job.	1.97	0.18	Strongly Agree
5. Using Multi-Renewable Energy Harvester will make it easier to do my job	1.87	0.33	Strongly Agree
6. I will find Multi-Renewable Energy Harvester useful in my job.	1.87	0.33	Strongly Agree
Perceived ease of use (PEU			
7. Learning to operate Multi-Renewable Energy Harvester will be easy for me.	1.9	0.29	Strongly Agree
8. I will find it easy to use Multi-Renewable Energy Harvester to do what I want to do.	2.13	0.74	Strongly Agree
9. My interaction with Multi-Renewable Energy Harvester will be clear and understandable.	1.93	0.26	Strongly Agree
10. I will find Multi-Renewable Energy Harvester to be flexible to interact with.	2.1	0.44	Strongly Agree
11. It will be easy for me to become skillful at using Multi-Renewable Energy Harvester.	1.93	0.26	Strongly Agree
12. I will find Multi-Renewable Energy Harvester easy to use.	2	0.2	Strongly Agree
Attitude toward using (ATU)			
13. I accept the use of Multi-Renewable Energy Harvester in learning activities.	1.03	0.18	Strongly Agree
Behavioral intentions (BI)			
14. I will continue to incorporate Multi-Renewable Energy Harvester into my learning activities.	1.9	0.29	Strongly Agree
Overall	1.708	0.3034	Strongly Agree

Table 3: TAM survey results

The findings from the survey on the perceived usefulness, ease of use, attitude toward using, and behavioral intentions regarding the implementation of a Multi-Renewable Energy Harvester for street lighting in Barangay Macopa, San Francisco, Surigao del Norte offer valuable insights into the potential success of such a renewable energy initiative. The overall mean perception of 1.708 indicates a generally positive attitude toward the adoption of this technology, suggesting that residents and stakeholders perceive it as beneficial and feasible for enhancing street lighting infrastructure. Moreover, the overall standard deviation of 0.3034 suggests a relatively consistent agreement among respondents across the surveyed dimensions, implying a coherent perception regarding the potential benefits and ease of use associated with the Multi-Renewable Energy Harvester system.

These results underscore the potential of Multi-Renewable Energy Harvesters to address energy needs sustainably in Barangay Macopa. The high overall sum of squares (Strongly Agree) further reinforces the robustness of the positive perceptions, indicating a strong collective agreement among stakeholders regarding the perceived usefulness, ease of use, attitude, and behavioral intentions toward adopting this innovative energy solution. However, to ensure successful implementation, it's crucial to address any potential challenges or barriers that may arise during the deployment process. By leveraging the positive perceptions highlighted in this survey and addressing potential challenges proactively, stakeholders can effectively harness the benefits of Multi-Renewable Energy Harvesters to improve street lighting infrastructure and contribute to the sustainable development of Barangay Macopa, San Francisco, Surigao del Norte.

Learning Attitudes (LA)	Mean	SD	SQ
1. I think learning Multi-Renewable Energy Harvester is interesting and valuable.	1.9	0.29	Strongly Agree
2. I would like to learn more and observe more in the programming course.	1.87	0.33	Strongly Agree
3. It is worth learning those things about Multi-Renewable Energy Harvester	1.9	0.29	Strongly Agree
4. It is important for me to learn the programming course well.	1.87	0.33	Strongly Agree
5. It is important to know the Multi-Renewable Energy Harvester knowledge related to our living environment.	1.9	0.29	Strongly Agree
6. I will actively search for more information and learn about	1.9	0.29	Strongly Agree
7. It is important for everyone to take the programming course.	1.87	0.33	Strongly Agree
Overall	1.896	0.310	Strongly Agree

Table 3: L.A. survey results

The survey results regarding learning attitudes towards Multi-Renewable Energy Harvesters and programming courses in Barangay Macopa, San Francisco, Surigao del Norte, reflect a generally positive outlook among respondents. With an overall mean of approximately 1.896, indicating a favorable perception across the surveyed dimensions, and a relatively low standard deviation of 0.310, suggesting consistent agreement, it's evident that there's significant interest and recognition of the value in learning about these technologies. The high sum of squares (Strongly Agree) further emphasizes the collective affirmation towards the importance and relevance of acquiring knowledge in renewable energy systems and programming, underscoring the potential for fostering a learning environment conducive to sustainable development and technological literacy within the community.

IV. CONCLUSIONS

Conclusions

In conclusion, Barangay Macopa has shown great promise for sustainable energy generation and environmental conservation through the installation of multi-renewable energy harvesters for street lighting. The system uses a Pelton wheel, wind turbines, and solar panels to generate electricity for street lighting infrastructure. This reduces the need for non-renewable energy sources and lowers carbon emissions.

The system's performance assessment shows encouraging outcomes, with consistent energy generation detected under various environmental circumstances, such as changing weather patterns, seasons, and times of day. The system is resilient and adaptive, capturing and distributing energy optimally to guarantee dependable street lighting performance all year long, even in the face of fluctuations in the availability of renewable energy. The effectiveness of the multi-renewable energy harvester in transforming input energy from renewable sources into useful output energy for street lighting is further highlighted by the analysis of system efficiency. Stakeholders can improve the sustainability and economic viability of the renewable energy solution, encouraging long-term energy resilience and environmental stewardship in the community by optimizing system efficiency and minimizing energy losses.

V. ACKNOWLEDGMENTS

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