Feasibility of Aero-Hydro Generator

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ABSTRACT

This study investigated the feasibility of Aero-Hydro Generator as a dual system for atmospheric water harvesting and small scale renewable energy generation. Using a research and Development (R&D) approach guided by Engineering Development Model (EDM), a prototype combining mist collection, micro-hydrogenerator, and Arduino -based automation was designed , constructed, and tested in San Agustin, Sagbayan, Bohol. Descriptive statistics (mean, confidence interval and standard deviation) were used to assess performance in water efficiency and power output. Based on the results, the prototype achieved acceptable water efficiency but produced power output was low. Although the prototype has power generation limitations, the results demonstrate functional stability and potential to be a water harvesting system and alternative renewable energy source for rural communities.

Keywords: Aero-Hydro Generator, atmospheric water harvesting, renewable energy, micro-hydropower, feasibility study

INTRODUCTION

The requirement of electricity and clean water is a basic need for human beings. Millions of people are still struggling on a daily basis to meet their basic needs. Both of these factors are interlinked, as water is required to produce electricity, and electricity is also required to pump and treat water. Without the availability of both factors, the constraints for human beings in terms of health, education, livelihood, and development will be harsh.

Globally, the International Energy Agency, around 675 million people are still living without electricity (IEA, 2023). On the other hand, the United Nations state that 2.2 billion people are living without access to safely managed drinking water services (UN, 2023). Climate change, population increase, and environmental deterioration are further increasing these difficulties, and therefore, sustainable and renewable energy sources are more important than ever before.

In the Philippines, energy security remains a concern for many provinces, Especially during times of natural calamities and in remote areas not Connected to the main power grid, and water scarcity are still pressing Concerns. The Department of Energy verifies that many remote areas are still using diesel-fueled generators and are frequently experiencing brownouts (2022). On the other hand, the National Water Resources Board states that many rural areas are experiencing irregular water supply because of old infrastructure, lack of funding, and the fact that water services rely on electricity (2022). Even after the passage of the Renewable Energy Act of 2008, the application of alternative energy solutions still has challenges regarding logistics, maintenance, and adaptability.

In Bohol, there is potential as well as limitations of renewable energy in meeting the power challenges. According to an analysis by Pojadas and Abundo (2021), a mix of solar, wind, biomass, and hydropower energy can help the province reach a 35% or higher share of renewable energy, except for hydropower. This emphasizes the importance of a mix strategy to diversify energy resources to ensure a stable supply.

However, despite the growing use of renewable energy resources, most of the current systems are designed for conventional energy resources and are suited for areas that are resource-rich or have high fog content. There have been very few studies on the concept of harvesting atmospheric moisture as a way of generating electricity and water, particularly in areas that are of low elevation and resource-poor. The lack of suitable technologies for such regions highlights the need for alternative energy systems that can function even in adverse environmental conditions.

To address the need for sustainable energy solutions for rural communities, the development and performance evaluation of an Aero-Hydro Generator, a mist-capturing system integrated with a micro-hydrogenerator. Contrary to most studies that concentrated on high-altitude foggy areas, this study was conducted in San Agustin, Sagbayan, Bohol, which has an elevation of around 265.6 meters above sea level (PhilAtlas,2025).

The research aimed at creating the specifications, circuit, and logical flow of the device to ensure efficiency and functionality. The project also sought to produce an electric current by utilizing the atmospheric moisture. Although regions prone to fog have readily available moisture, there are limited global initiatives that have investigated the use of energy systems that utilize atmospheric moisture as an alternative source of power (Heng et al., 2021). Through the development of a framework that can be applied to rural areas, the research study sought to provide a model for alternative energy that can be applied to provide electricity and water. The study highlighted the need to apply environmental awareness and engineering skills to approach real-world problems.

Research Question

This study aimed to develop and assess the effectiveness of an Aero-Hydro Generator, a mist capturing device with a micro-hydrogenerator system in Barangay San Agustin, Sagbayan, Bohol for the school year 2025-2026.

Specifically, this study sought to answer the following questions:

1.What is the technical specification of the device in terms of:

1.1circuit design;

1.2 physical and Mechanical specification;

1.3 logical flow?

2. How does the machine perform in terms of:

2.1. water efficiency;

2.2. power output?

3.What recommendations can be drawn from this study?

Hypothesis

The Aero-Hydro Generator does not perform well.

REVIEW OF LITERATURE

One of the most researched areas of solution for electrification, particularly for remote and off-grid regions, is renewable energy. Hydropower is one of the most prevalent forms of renewable energy. Hydropower utilizes turbines and generators to convert flowing water into hydropower (U.S. Department of Energy, 2017; Union of Concerned Scientists, 2021). Research has shown that, with the proper design, even small quantities of flowing water can yield sufficient power (Sahay & Rachna, 2024). Micro-hydropower systems are considered to be practical options as they are straightforward and fit well with resource-poor settings. On the other hand, most studies on hydropower focus on the use of rivers and streams for water.

Studies have also considered the potential of atmospheric water harvesting to help with water scarcity. Mukhopadhyay, Singh and Patel (2024) found that condensation efficiency varies depending on the mesh material, surface texture and its orientation. Kennedy and Boreyko (2024) showed that bio-inspired mesh designs enhance fog and mist collection and avoid clogging. Li et al. (2025) demonstrated that water can be harvested by advanced fog collection, even at low humidity.

Automation plays an important role in improving renewable energy systems. Supardi and Abdulah (2024) developed an Arduino-based monitoring system for pico-hydropower and showed that automation improves reliability and reduces the need for constant supervision. Tang et al. (2023) demonstrated that micro water generators can power self-sustaining monitoring devices. These studies prove that automated control systems help renewable energy devices operate more efficiently. Automation is especially useful for remote and rural locations.

Despite these advancements, a research gap still exists in combining atmospheric water harvesting and micro-hydropower into one system. Most previous studies focus only on mist collection for water supply or hydropower generation using traditional water sources. Very few studies have examined hybrid systems that use collected mist to generate electricity, especially in low-elevation rural areas. In addition, limited research has tested such systems using locally available materials under real environmental conditions. Because of this gap, the Aero-Hydro Generator study aims to evaluate a combined, automated system that can collect mist and produce electricity at the same time.

METHODOLOGY

This study aimed to assess the performance of Aero-Hydro Generator in terms of water collection efficiency and power generation. The focus was on examining the performance of the constructed device in natural environmental condition. The data collected during the testing process were evaluated for analyzing the performance of the Aero-Hydro Generator.

MATERIALS AND METHODS

- Breadboard
- Arduino Uno
- Micro Servo
- Water Sensor
- LCD
- Jumper wires
- Battery
- DC Motor
- Wheel Rim
- Sprockets
- Bearings
- Inverter (AC to DC)
- Nylon
- PVC
- Synthetic Leather
- Mosquito Net
- Data recording sheets

Development of Innovation

The study used a Research and Development (R&D) and Engineering Development Model (EDM) design to develop and test the Aero-Hydro Generator. This design focused on constructing the device and evaluating its performance based on water collection efficiency and power output. The Aero-Hydro Generator was developed to collect atmospheric moisture and convert the collected water into electrical energy. The device was constructed using a mist collection system, a water collection container, and a turbine-generator mechanism. The components were assembled to allow the collected water to flow through the turbine for power generation.

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Testing and Set-up

The testing of the Aero-Hydro Generator was conducted in San Agustin, Sagbayan, Bohol. The device was placed in an open area exposed to natural airflow and atmospheric moisture. The setup remained the same throughout the testing period to ensure consistency of results.

Performance Evaluation

The performance of the Aero-Hydro Generator was evaluated based on its water collection efficiency and power output. Water efficiency was measured by recording the time required to collect a specific amount of water. Power output was observed during the operation of the device.

Data Gathering Procedure

Data were collected during several trial runs of the Aero-Hydro Generator. For each trial, the amount of water collected and the observed power output were recorded using researcher-made data sheets. The same procedure was followed for all trials to ensure uniformity in data gathering.

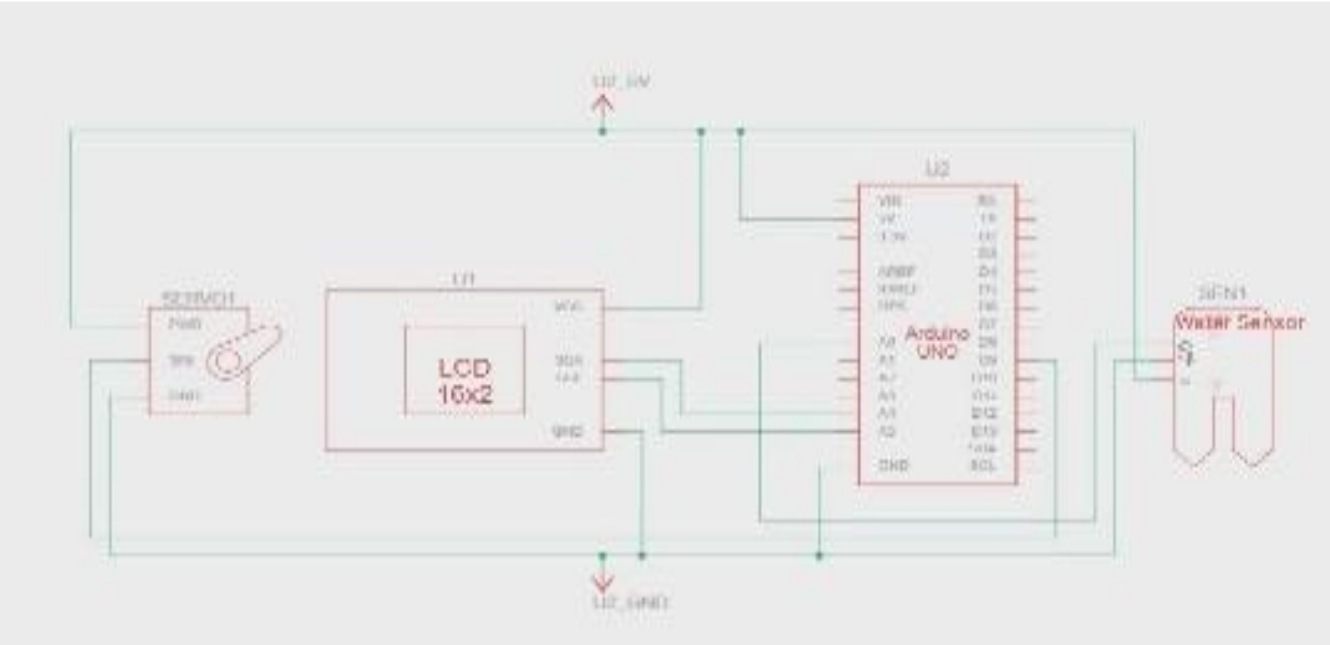
Data Analysis and Ethical Considerations

The collected data were analyzed using descriptive statistical tools such as mean ,Confidence Interval and standard deviation. These were used to summarize the performance of the Aero-Hydro Generator. The study did not involve human participants or animals; therefore, no ethical issues were encountered. Safety precautions were observed during testing to avoid damage to the device and the surroundings.

RESULTS & DISCUSSION

The final circuit design of the Aero-Hydro Generator successfully utilized the Arduino Uno, water level sensor, servo motor, and LCD display into a unified control system. The experiment enables controlled operation and coordination of sensors, controls, and monitoring components. Water level detection allows the system to release water effectively to generate electricity. Display of operational conditions supports monitoring and troubleshooting during operation. Overall, the circuit configuration contributes to stable, dependable, and continuous system performance.

Figure 1. Circuit Design



The physical and mechanical specifications of the Aero-Hydro Generator provided a stable and compact structure for mist collection and energy conversion. The three-layer mist harvesting enhances moisture capture efficiency as each layers are built to ensure moist collection capability. This collection system ensures continuous water flow toward the storage and turbine system. Mechanical integration of the turbine, DC motor and stabilizers enables smooth flow of the testing. This supports the safety of operation and reliable mechanical performance.

Figure 2. Physical and Mechanical Specification

The logical flow of the Aero-Hydro Generator followed the clear sequence given from water collection to power generation. The programmed control logic activates the system only if the required two-liter water volume is reached. Once activated, the servo-controlled valve releases water to drive the turbine in a controlled manner. The coordinated operation of the turbine, DC motor, battery, and inverter ensures stable energy conversion. This structured sequence improves reliability and prevents unnecessary system operation.

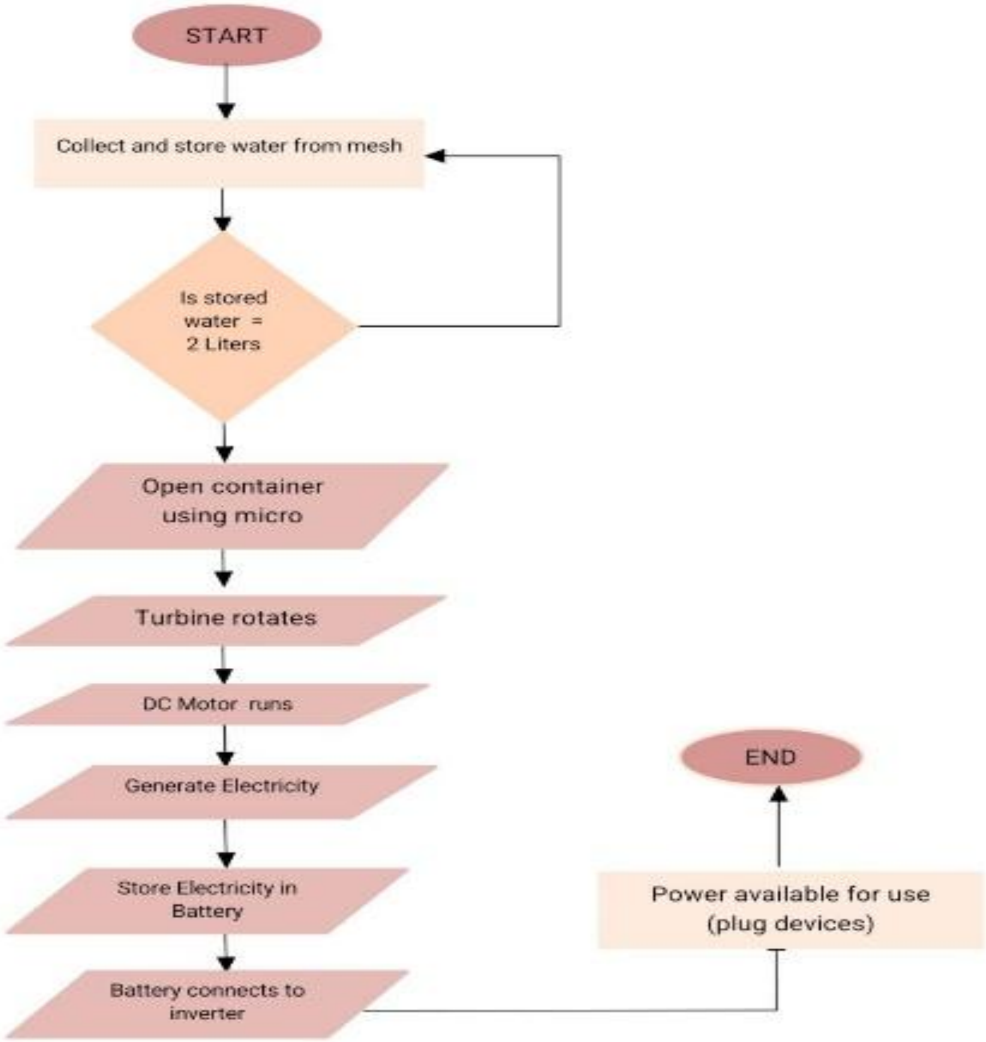


Figure 3. Logical Flow

The Aero-Hydro Generator reported an average period of 4.75 days per cycle. This translates to an average standardized harvesting rate of 0.42 liters per day. It captures water from the atmosphere and shows persistence under tropical lowland conditions. The collection time remaining constant indicates that the layered mesh mist-capture structure worked well to capture mist under varying environmental conditions.

This harvesting system shows that in areas of deep humidity, water vapor can be sustainably harvested. Although the rate of collection is dependent on several factors, collection can happen is in areas of deep humidity. Future studies can be aimed more specifically to test meteorological phenomena > humidity and wind speed to test mesh without regard to the ambient conditions.

Table 1: Electrical Output Performance of the Aero-Hydro Generator

Trial	Power Output (W)
1	0.0003136
2	0.0000900
3	0.0001156
4	0.0002500
Mean	0.0001923 W (0.192 mW)
Standard Deviation	0.000097 W
95% Confidence Interval	0.000038 – 0.000346 W

Electrical output was measured from 0.00009 W to 0.0003136 W, with an average of 0.192 mW. Despite generation being consistently measurable, the output was very low; the relatively wide confidence interval is due to the irregularity of the water flow, leading to irregular rotation of the turbine.

Poor performance is to be expected due to restriction of the hydraulic head and the flow rate. In terms of the hydropower equation ($P = \rho g Q H$), the output is directly proportional to flow rate and height difference, because of the reliance of the system on suspended moisture, both of those parameters are always going to be of a significant restriction. Furthermore, there are bound to be friction losses in the turbine shaft and electrical conversion losses in the DC generator, which are likely to be responsible for loss of useable output.

The output of the prototype is considerably lower than the average micro-hydropower system output of several watts to kilowatts. While the concept shows feasibility, there is clear need for optimization of turbine design and flow concentration.

This findings of the study have important significant for rural areas, but they also show limitations. The device can be useful as an alternative water-harvesting system in areas with limited access to clean water, but its power output is currently insufficient to meet regular energy needs. Testing the device was done at only one location under certain meteorological conditions. Also the turbine and generator designs had limited energy production. These limitations emphasize the need for more testing and system enhancements. This study’s findings are significant for rural areas, but they also had a limitations.

CONCLUSION AND RECOMMENDATIONS

Based on the findings, the Aero-Hydro Generator is a feasible hybrid system for mist gathering and small-scale energy generation. During testing, the water efficiency showed enough and remained. This shows that the atmospheric mist collected with low-cost materials and designs. The system showed responsible and automated operation. Therefore, it is recommended for the future researchers improve the turbine and

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generator design to increase power output, enhance the mist collection design, and conduct further testing under different environmental condition to improve overall performance.

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APPENDICES

Appendix A: Raw Data

Day	Water Collected (ML)	Cumulative Water (ML)	Generator Run (2 L)
1	428 mL	428 mL	No
2	347 mL	775 mL	No
3	382 mL	1,157 mL	No
4	412 mL	1,569 mL	No
5	486 mL	2,055 mL	Yes (1st Run)
6	439 mL	439 mL	No(Reset)
7	457 mL	896 mL	No
8	482 mL	1,378 mL	No
9	384 mL	1,762 mL	No
10	458 mL	2,220 mL	Yes(2nd Run)
11	476mL	476 mL	No(Reset)
12	394mL	870 mL	No

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13	418 mL	1,288 mL	No
14	465 mL	1,753 mL	No
15	485 mL	2,238 mL	Yes(3rd Run)
16	493 mL	493 mL	No(Reset)
17	463 mL	956 mL	No
18	452 mL	1,408 mL	No
19	396 mL	1,804 mL	Yes(Last Trial)
Number of Generator Runs			4

Trial	Voltage(V)	Current(A)	Power(V x A)	Score
1	0.28V	0.00112A	0.0003136W	1
2	0.15V	0.0006A	0.00009W	1
3	0.17V	0.00068A	0.0001156W	1
4	0.25V	0.001A	0.00025W	1
Mean				1

Trial	Day Interval	Score
1	5	2
2	4	2
3	5	2
4	5	2
Average Time per Run	4.75	2

Appendix B: Photograph of the 19-days testing of the device