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A DESIGN OF PORTABLE MINI SOLAR PANEL COMBINED WITH MICRO HYDROPOWER SYSTEM FOR POWER GENERATION

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ABSTRACT: Traditionally, power systems are built to take energy from high-voltage levels and distribute it to lower-voltage networks. Transmission networks are connected to major generating units. However, there will be an excessive number of tiny generators connected to distribution networks in the future. The portable power production system is mostly responsible for the excessive energy delivered, particularly when the user is experiencing a breakdown (function). The loss of integrity, as well as the breakdown and failure of electrical power transmission systems, appears to be an issue rooted (problem statement) in the highly practical and applied domains of electrical and power engineering. The objective of this project is to design and construct a portable power production system that uses renewable energy. The research also aims to determine the maximum and sufficient power consumption from solar energy and micro-hydropower systems in order to provide adequate energy for the space in the event of a power fail. The data for this study was collected using a Digital Multimeter, which was used to measure the resistance (R), voltage (V), current (A), and power (W). The results of the test reveal that the portable power production based on renewable energy has enough capacity to create electricity during a power failure as well as provide adequate loads such as LED lights, mini fans, and phone chargers. This study can also be improved by creating a higher-voltage micro turbine motor and a higher-voltage solar panel for the solar system to increase the operation time.

Keywords: portable mini solar panel, micro hydropower system, power generation

1. Introduction

Energy is one of the primary elements in the whole world. It mainly describes the survival and necessary for the activities in daily life serving as health, education, transportation, infrastructure, and human usage presently attached for the standard living and economic development to progress in becoming an industrialized country as the technology popularized [1]. For many decades to come, the most common source of energy is expected to be fossil fuels, where renewable energy sources like solar, biofuels, biomass, geothermal heat and wind are expected to double until 2030. The problem that occurs involving the different types of sources of energy such as oil crisis, climate change, technical capacity limits, continuously growing demands, and restrictions on the wholesale[2]. These challenges are repeatedly expanding that represents the need for alternative sources in the crucial situation that probably occur and implement the potential solutions for consumption demand [3]. Alternative sources such as renewable energy that function to generate electricity as close as possible to consumption demands by using renewable sources that do not cause environmental pollution [4]. Thus, when confronted with a circumstance, the generator design should be adequately prepared. Furthermore, the design must accommodate people's needs by being portable so that users may use it conveniently and receive the necessary power consumption.

1.1 Micro Hydropower System

Micro hydropower is primarily a tiny hydro technology system with its own set of constraints. It does come with its limitations. The drawback is that the hydro potential is located far off from where the demand is concentrated. To enhance the supply according to demand, funds need to be spent towards connecting the micro hydro to the grid system. Hydropower plants can be large, small, mini, and micro, depending on the ability of water supplies and water flow by the force of gravity.

The larger hydropower systems will supply electricity to multiple consumers, while small, mini and micro-hydro power plants operate independently for their own energy needs or to sell power to utilities [5]. Such hydropower energy can provide efficient energy costs for remote rural areas, recreation centres, and restaurants that have sufficient water sources. Several schemes for small, mini and micro hydropower plants, including Pelton, Turgo, Francis, Kaplan, propeller, and cross-flow hydro turbines, have actually been developed, designed and successfully implemented [5]. The turbines Pelton, Turgo, and Francis work with lower water flow with high and medium water heads, while Kaplan, propeller and cross-flow turbines work with lower heads and higher flow speeds [6].

1.2 Solar System

Solar Power with the greatest potential for Malaysia is solar power with Large Scale Solar (LSS) programs and Net Energy Metering (NEM) furthering the reach of solar power generation. LSS aims to expedite power generation from photovoltaic plants and solar farms, while NEM will allow consumers to generate and consume energy. As solar power shows huge potential for Malaysia, "The NEM program is under regulation by photovoltaic and technology [7]. Since the start of the year, NEM has been improved through the adoption of the true NEM concept which allows excess solar PV generated energy to be exported back to the grid on a "one-on-one" offset basis. The limitation with solar as of now is the intermittency drawback, and in planning for future targets, a study was commissioned to address supply security. To resolve this, an efficient storage system with storage batteries needs to be explored. However, for the time being, the commissioned RE penetration studies revealed that our current system can accept solar PV [8].

2. Materials and Methods

In this methodology research, three parts will be explained which are the way, method, and procedure to manufacture the portable power generation. It also contains a collection of data, testing, and result. There is three important part to collect the data such as equipping the materials, set up the combination process of the solar system and mini-hydropower system design and construct the power supply system. To see the overall procedure and analysis of this study can be referred to the methodology flow chart in Figure 1 to enhance the understanding of the study.

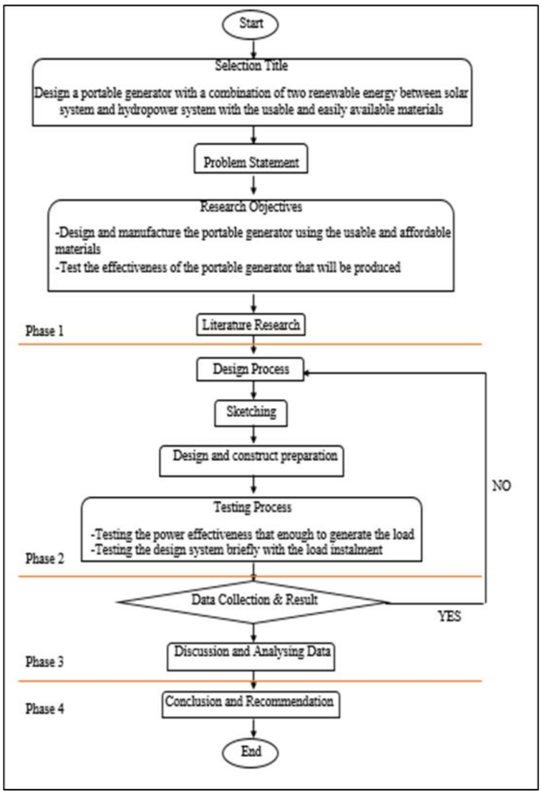

Figure 1 Flowchart of methodology

2.1 Materials

Mechanical and electrical components consist of several rules and understanding. The combination of two renewable energy and wiring process needs to be carried out precisely by going through the testing procedure using the Digital Multimeter. The components that were used for this project are as follows:

2.1.1 Micro Hydropower System

- 3.7V Battery – Stores current generated by the turbine.
- 12V DC Motor – Generates electricity with the flow of water.
- Plastic spoon – Act as turbine wheel.
- Wire – Connects the components.
- Mini Beaker – Utilized as a micro turbine's operation.
- Digital Multimeter – Records the data collection of Resistance (Ω), Voltage (V), Current (A) and Power (W).

- Solder Core Wire – Connects the wire to the components.
- Mini Fan – Act as load.

2.1.2 Solar System

- 6V Mini Solar Panel – Delivers the load.
- LED Light – Delivers the load.
- 12V Battery – Stores the gained power.
- Wire – Connects the components.
- USB Phone Cable – Supply load.
- Digital Multimeter – Records the data collection of Resistance (Ω), Voltage (V), Current (A) and Power (W).
- Hot Glue Gun – Connects the components.
- Solder Core Wire – Connects wire to the components.

2.2 Methods

The design and the performance of the study involve in testing and collection of data. By using this strategy, the investigator will be able to conduct the research with greater accuracy and adhere to the protocol that has been established in order to meet the goals of creating portable power generation. The data was recorded by charging the solar panel and micro turbine system within 1-3 hours. The data average was collected within the time period.

2.2.1 Solar System and Micro Hydro System

The testing for the solar panel will be performed by using Digital Multimeter device to measure the Resistance (Ω), Voltage (V), Current (A) and Power (W). Preliminary (often definitive) tests generally take place using the ubiquitous multimeter. This tester is capable of providing diagnostic information for all sorts of motors. If the motor is completely unresponsive, no ac humming or false starts, take a reading at the motor terminals. If there is no voltage or reduced voltage, work back upstream.

Take readings at accessible points including disconnect(s), the motor controller, any fuses or junction boxes, back to the over-current device output at the entrance panel. Make sure the voltage level are same as measured at the entrance panel main breaker.

Figure 2 Shows the solar panel and micro turbine tested using Digital Multimeter device When there is no electrical load, the same voltage should appear at both ends of the branch circuit conductors. When the circuit electrical load is close to the circuit capacity, the voltage drop should not exceed 3% for optimum motor efficiency. In a three-phase hook-up, all legs should have substantially equal voltage readings with no dropped phase. If these readings vary by a few volts, it may be possible to equalize them by rolling the connections, taking care not to reverse rotation [9].

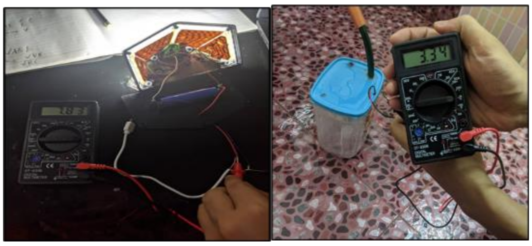

Figure 2 Solar panel and micro turbine tested using Digital Multimeter device When there is no electrical load

2.2.2 Data Collection

The loads that utilized renewable energy are presented in quantity to estimate the amount of electricity that renewable energy can create. The Multimeter successfully recorded Resistance (R), Voltage (V), Current (A), and Power (W) in the data collected. The data is calculated by averaging the power generated by the battery ampere and stored by the solar panel and micro turbine over a period of time. The value will then be measured by the graph plot between Power (W) and Voltage (V) to observe the maximum voltage that can be created by the load within the specified time. Thus, the data collection when the battery was charge are collected for the mini solar panel and micro hydro turbine within 1-3 hours. The loads and quantity of loads installed for the power supply are as shown in Table 1.

Table 1 Loads and quantity of loads installed for the power supply.

No.	Loads (ohms)	Quantity
1.	LED Light	1
2.	Mini Fan	1
3.	Phone Charger	2

Once the value was recorded, the resistance was switched to the next lowest value and the results was recorded for that setting. The process was repeated, until we have recorded values for all resistance settings.

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2.3 Results and Discussion

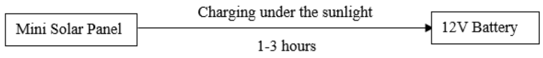
2.3.1 Data Measurement

The data of the power consumption are recorded in the table. The testing was conducted within 1-3 hours to record the uniform power that can be generated within the time. The testing divided periodically into Solar System and Micro Hydro System.

2.3.1.1 Solar System

During the charging process, the data was collected when the solar panel was charging under the sunlight directly and stores to the 12V battery within 1-3 hours. Then, the value that were recorded was analyse using the average of the ampere-hours (ah).

Table 2 12V battery charge from the 6V mini solar panel



Battery Capacities (V)	Time Charging (hrs)	Ampere-hours (ah)	Average (ah)
12V	1	5.50	5.00
	2	4.00	
	3	5.00	

Table 2 indicates that the average battery increase of 3 hours is effective for loads such as LED lights and phone chargers. The variations in readings are due to adverse weather, which makes it difficult to reflect sunlight effectively. Based on the data collected, the average of 5ah would be sufficient to provide the load effectively.

Table 3 Data collected from a mini solar panel using a Digital Multimeter Test.

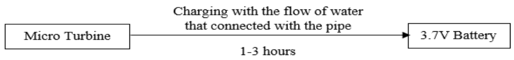
No.	Loads	Resistance (ohms)	Voltage (V)	Current (A)	Power (W)	Operation Time (hrs)
1.	LED Light	12.50	4.50-5.00	0,18	0.50-1.00	1-3
2.	Phone Charger	7.43	4.80-5.10	0,24	3.36-3.50	1-2

Table 3 shows the data collected using a Digital Multimeter Test. The data collection include the Resistance (Ω), Voltage (V), Current (A) and Power (W). The solar panel provides electricity for the loads, including light and a phone charger. The electricity obtained has been tested with operation, resulting in the energy from solar panels being able to operate continuously for roughly 1-3 hours.

2.3.1.2 Micro Hydro System

The data was taken when the micro turbine was charging with the water flow that is connected with the pipe for 1-3 hours during the charging procedure. The recorded number was then analysed using the average of the ampere-hours (ah).

Table 4 3.7V battery charge from the 12V DC motor



Battery Capacities (V)	Time Charging (hrs)	Ampere-hours (ah)	Average (ah)
3.7V	1	1.72	1.50
	2	1.44	
	3	1.30	

Table 4 shows the 3.7V battery that have been charged with the micro turbine. The average ampere-hours gained was 1.50 ah. The flow of water pipe fully played an important role in gaining the effective ampere-hours. Then, the average shows that the value have an enough power supply for the mini fan within the specified 1-3 hours operation.

Table 5 Shows the data collection recorded from micro hydro turbine using Digital Multimeter Test

No.	Loads	Resistance (ohms)	Voltage (V)	Current (A)	Power (W)	Operation Time (hrs)
1.	Mini Fan	12.50	4.80-5.00	0,40	1.60-2.00	1-3

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Table 5 shows the data collection from the micro hydro turbine using the Digital Multimeter Test. The result obtain shows the Resistance (Ω), Voltage (V), Current (A) and Power (W) were recorded. The loads resistance that were recorded is 12.50 ohm and the working hours are about 3 hours maximum.

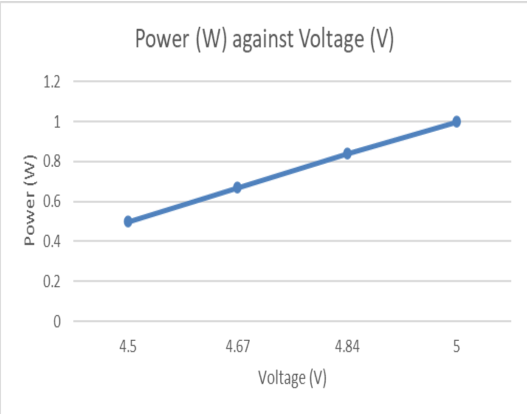

Figure 3 Power (W) against Voltage (V) for LED light.

Figure 3 shows the graph maximum power 1W and maximum voltage 5V were recorded to light up the LED light. The LED light is a load that consume the energy from the solar system. Within the operation, the power and voltage that were recorded state that the load could be supply continuously within 1-3 hours in 12ft x 12ft room. The graph also stated that the maximum power and voltage that gain indicates that the portable generator can be utilised in our daily life.

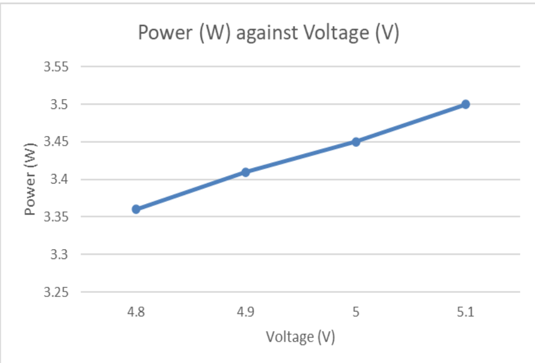

Figure 4 Power (W) against Voltage (V) for phone charger

The Figure 4 shows the graph of maximum power 3.5W and maximum voltage 5.1V was recorded to charge the phone. The graph plotted was analyze briefly that the power and voltage that created be able to be used for phone charger about 1-2 hours with continuously power usage. The limitation time that recorded at least be able to supply the effective power that can be generated by this renewable energy.

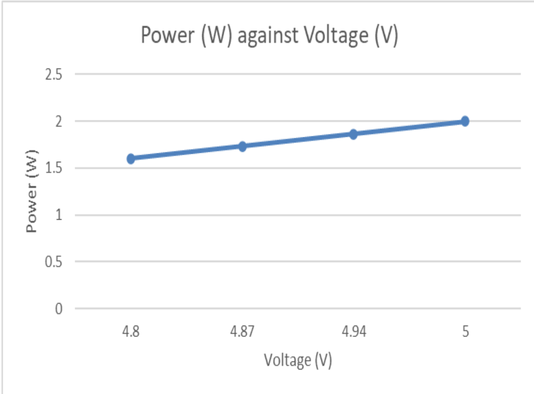

Figure 5 Power (W) against Voltage (V) for mini Fan

Figure 5 illustrates a graph of a mini fan with a maximum power of 2W and a maximum voltage of 5V. Due to the micro turbine that is created and supplied to the 3.7V battery, a mini fan can definitely gain greater operating time for this load and supply just one load for the consumers. As a result, a micro turbine that generates power from the flow of water has the highest wattage and voltage that can be operated precisely.

2.3.2 Discussions

The graph depicts the loads that were used to measure the generator's output power and voltage. Power (W) and Voltage (V) are directly proportional. When comparing a mini solar panel to a water wheel turbine, the energy generated by the mini solar panel is more than the energy generated by the water wheel turbine. For load resistance such as LED lights, mini fans, and phone chargers. The resistance provided by a mini solar panel is higher than that created by a water wheel turbine. Hence, changes in power supply are likely due to the size and power consumption of portable power production that uses renewable energy. Due to the cost and power consumption, generators derived from fuel combustion and others may have a lengthy operating period and power supply [10].

The result shows that portable power generation has a greater influence on power supply than traditional generators that rely on coal combustion, fuel, and other sources of energy. The data collected from a mini solar panel and a water turbine reveals that energy generated using two renewable energy sources on a small scale may provide adequate power during a power failure.

3. Conclusions

In conclusion, a portable power production based on renewable energy must be developed to counter the ease with which electricity may be used daily. Then, a study will need to be conducted to develop a portable power production system that is acceptable for use in the room and toilet, as well as to determine the maximum and sufficient power consumption from solar energy and water wheel turbine to supply enough energy for the room during a power failure. The research on current technology in Malaysia and around the world reveals smart ways to use renewable energy not only on a large scale, but also on a small scale and in portable form for power generation, as stated in the Air Pollutant Index (API) that aims to reduce pollution and other substances that can endanger public health and deplete the ozone layer if used in diesel generators [11]. The project model was developed and tested based on the capacity and consumption of Malaysian consumers who wished to utilise the given load on a daily basis regardless of the scenario.

The investigation of existing technology in Malaysia and other Asian countries was carried out in order to find the operation generator. Every generator, whether huge or small, has its own advantages and disadvantages. Aside from that, data analysis has revealed that a number of components need to be enhanced in order for consumers to consume less energy. Several aspects of the study were noted as future improvement, including:

3.1 Solar Panel

- Increasing the voltage capacity of solar panels to achieve longer power utilisation.
- Place the solar panel in hot weather to properly charge electricity.

3.2 Micro Hydro Turbine

- Add turbine blades to increase the rotation of the blades so that the motor will provide energy efficienctly.
- Increase the voltage capacity above 12V to generate greater energy supply

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References

[1] Keeley A.R.. (2016). “Renewable Energy in Pacific Small Island Developing States: the role of international aid and the enabling environment from donor's perspectives,” Journal of Cleaner Production, Volume 146

[2] Mundra IW .(2020). System Dynamics For Simulation Model Of. Journal of Sustainable Technology and Applied Science (JSTAS). 1:25–32

[3] Pelesaraei A.N., Bayat R., Bandbafha H.H., Afrasyabi H., Kwok-wing Chau R . (2017). “Modeling of energy consumption and environmental life cycle assessment for incineration and landfill systems of municipal solid waste management,” Journal of Cleaner Production, Volume 148.

[4] Oh T.H., Hasanuzzaman Md., JeyrajSelvaraj, Teo S.C., Chua S.C. (2018). “Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth – An update,” Renewable and Sustainable Energy Reviews, Volume 81, Part 2, 3021-3031

[5] Devabhaktuni V., Alam M., Soma Shekara Sreenadh Reddy Depuru, Robert C. Green, Douglas Nims, Craig Near .(2013). “Solar energy: Trends and enabling technologies,” Renewable and Sustainable Energy Reviews, Volume 19, 555-564.

[6] Aroonrat K., Wongwises S..(2015). “Current status and potential of hydro energy in Thailand: a review,” Renewable and Sustainable Energy Reviews, Volume 46, 70-78

[7] Bilal Abdullah Nasir .(2014). “Design of Micro-Hydro-Electric Power Station,” International Journal of Engineering and Advanced Technology (IJEAT), Volume 3, 2249-8958.

[8] E. Kaloudis, E.Papanicolaou, V.Belessiotis. (2016). “Numerical simulations of a parabolic trough solar collector with nanofluid using a two-phase model,” Renewable Energy, Volume 97, 218-229.

[9] Awang, M.B., Noor Alshrudin, S., Hassan, M.N., Abdullah, A.M., Yunos, W.M.Z., Haron, M.J. (1997). Air Pollution in Malaysia: Proceedings of National Conference on Air Pollution and Health Implications. Centre for Environmental Research, Institute for Medical Research in Malaysia.

[10] Tick Hui Oh, Shen Yee Pang, Shing Chyi Chua. (2010).“Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth,” Renewable and Sustainable Energy Reviews, Volume 14, 1241-1252.

[11] Grigorios L., Kyriakopoulos, Garyfallos Arabatzis. (2016). “Electrical energy storage systems in electricity generation: Energy policies, innovative technologies, and regulatory regimes,” Renewable and Sustainable Energy Reviews, Volume 56, 1044-106.