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Develop a Technique for Producing Electricity by Harvesting Rain Water and IoT Monitoring

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ABSTRACT

This project aims to develop a technique for producing electricity by harvesting rainwater. This project is based on prototypes of suitable size to be used in the classroom as a teaching act or during practical sessions. This study focuses on the production of electricity through the collection of rainwater. The size of the tank is 35cm (Height) x 17 cm (length) x 15 cm (width). The observation of this project is based on monitoring the values of voltage, current and power depending on the amount of water stored in the tank at three levels: low (2cm), medium (6 cm) and high (10cm) using IoT. The interface for monitoring is used by the BLYNK application. The electrical energy produced is from a mini turbine that is rotated by the rain coming down. The resulting energy can be stored in the generator and the water collected can be used in an emergency. This system is very suitable for homes, livestock and countries with high rainfall rates. It works through a large collection of water on the roof and then into the rainbow that's inside the mini turbine assembly to produce kinetic energy for the electrical power and then the water will continue through the rainbow and be stored in the storage tank. This project can produce electrical energy between 0 to 8 volts, 0 to 80 µA and 0 to 640 µW. The development of this project is verified by the amount of electrical energy it can produce using the collection of water

1. Introduction

Creating sustainable energy from natural resources is one of the greatest challenges facing humanity. Energy consumption depletes non-renewable resources such as fossil fuels. The production of fossil fuels causes air pollution, greenhouse gas emissions, global warming and numerous annual fatalities. Changing from more efficient energy consumption to renewable energy reduces pollution and energy waste. According to Adnan *et al.,* [1] renewable energy sources like solar, water and wind produce pure energy and are sustainable. Today, the production of electrical energy by using renewable energy concepts is important to ensure that production is maintained for the next generation and to protect our environment. According to Ferreira *et al.,* [2] the most

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beneficial approach is to reduce the environmental issues caused by the production of energy using fossil fuels and achieve clean and sustainable energy production. Renewable energy resources are used in a variety of technologies, including solar, biomass, hydro, piezo and others. In this paper, the study focuses on the development of a prototype mini-hydro power plant using rainwater harvesting (RWH) and mini-turbine concepts. RWH is a method of capturing and preserving rainwater from roofs, flat surfaces or rock catchments by applying basic methods like natural drainage ponds and reservoirs created artificially. This statement is mentioned by Helmreich *et al.,* [3]. The objectives of this research are to recycle rainwater as a 6-volt source of electricity, to display current voltage, current and energy produced in an app and to recycle rainwater as a source of natural backup water for daily use.

Yanine *et al.,* [4] stated that to maximize the cost-benefit ratio of the production of renewable energy and raise the added value of the real estate, it is suggested that existing infrastructure be upgraded with microscale hydroelectric systems. This prototype project is designed to apply microscale concepts. The concept of harvesting water is stated by Gurung and Sharma [5]; communal rainwater tank systems offer an alternate urban water supply solution that reduces reliance on a centralized water supply network. A rainwater harvesting (RWH) system is a method of collecting rainwater and storing this free water in a tank before reusing it for a particular purpose stated by Campisano *et al.,* [6]. This system has been widely used in most regions of the world because it suits their local climatic conditions. The RWH system is typically used for domestic usage, agriculture and environmental management.

In general, as stated by Wang, Jasim and Chen [7] RWH systems can be managed using various methods. In modern applications, the simple RWH system typically consists of a catchment area, storage tank, piping, treatment facility and supply facility. Energy harvesting from RWH is a potential approach that can help provide renewable and clean energy while also improving infrastructure sustainability. The RWH system can also be used as a source for the mini turbine to generate the pressure needed to rotate the blade and produce kinetic energy. The higher the pressure coming from the RWH, the more electrical energy it will produce. The technical approaches used by Comino *et al.,* [8] for the mini-hydro power plant, consider how the green/blue infrastructure concept could merge the reduction of flood risk and the production of renewable energy.

The production of electrical energy from a mini turbine can produce more electrical energy, although the pressure of the water is minimal. Although the mini turbine can produce more electrical energy, based on Nair and Nithiyananthan [9] paper stated that Mini hydro design is improved by considering capacity factor, estimated operating costs and efficiency. That means that to use a mini turbine, there are several factors to consider.

1.1 The Process of the System

Figure 1 shows the process of producing electrical energy. The process starts with harvesting the rainwater during the rain and the water will be stored in the water tank. When the water tank is full, the water will flow to the penstock under the pressure and go through to the mini-turbine blade. Elbatran *et al*., [10] stated that Hydropower is produced from the extracted energy of water moving from higher to lower locations. Based on Hatata, El-Saadawi and Saad [11] stated that the number of available heads and the local water flow rate are frequently the major factors in determining which type of hydro turbine is best for a given circumstance. The mini-turbine blade will be rotated to produce kinetic energy. At the same point, the shaft is connected between the mini turbine and the generator, so the generator will get the kinetic energy and convert it to electrical energy. Marinescu *et al*., [12] said that to maintain the specified frequency and voltage, the systems rely on voltage regulators and dump loads. The recycled water from the penstock will go back to the water tank to recycle the process.

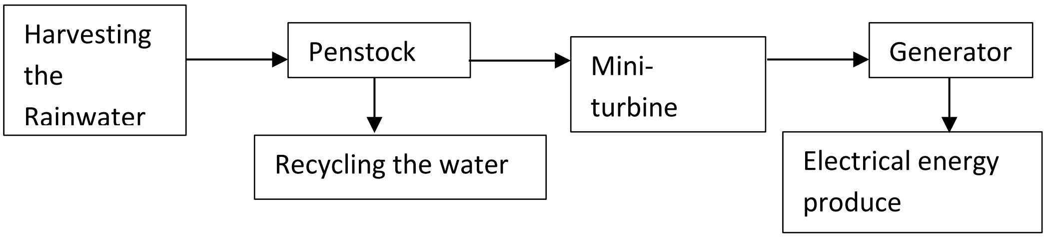


Fig. 1. The process production electrical energy

2. Methodology

2.1 Rainwater Harvesting System Performance Determination

Figure 2 shows the design of the rainwater harvesting system. Based on Nguyen and Moo [14] Qin is the number of days during which the water supply in the storage reservoir is insufficient to meet demand. Water saving is the amount of rainwater supplied (m3). A high-water savings value indicates that more tap water can be conserved by rainfall. Vt is the ratio between the total quantity of precipitation and the amount of precipitation collected. The system starts with rainwater harvesting and the water will be collected and stored in the water tank. Khastagir and Jayasuriya [13] stated, the amount of rainfall in the tank depends on how much water is poured into it and how much demand there is for it in comparison to other water sources. When the system wants to produce electrical energy, the piping from the water turns on and the water flows to the mini-turbine and gives the kinetic energy to the generator to produce electricity.

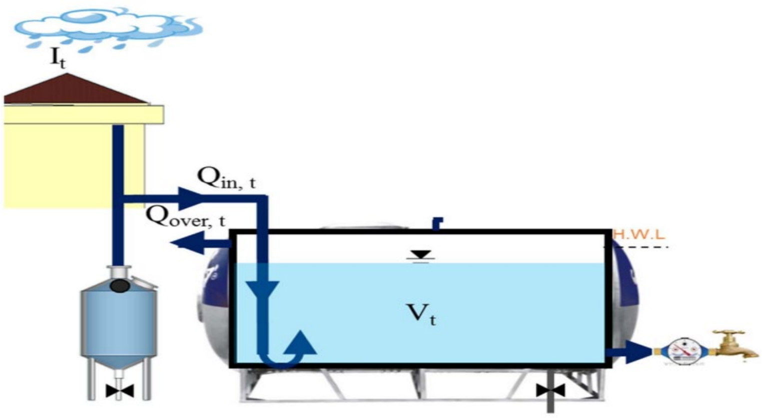


Fig. 2. The Design of rainwater harvesting system by Nguyen and Moo [14]

2.2 Block Diagram of the Overall System

Figure 3 shows the block diagram of the overall process, which consists of three parts. The first part is the input process that is related to Figure 2. After the electrical energy is produced, the signal will go through the processing parts and at this part, the NodeMCU will process the reading and communicate with IoT/BLYNK. Ginting *et al.*, [15] stated that a Wi-Fi router should be used to connect the microcontroller of the electronic power output to the internet. After that, the last part of the process is the output, which will display the readings of voltage, current and power on the smartphone and allow the smartphone to control the function of loads. Putra *et al.,* [16] stated that the user can view these real-time parameters at any time and from anywhere by uploading all the parameters the Arduino has analysed to the cloud. The smartphone can be used to monitor the actual work. Besides that, the electricity produced will also be stored in the battery system. This function of the battery system is used as the backup or input to the load to ensure the load always gets a suitable and constant voltage.

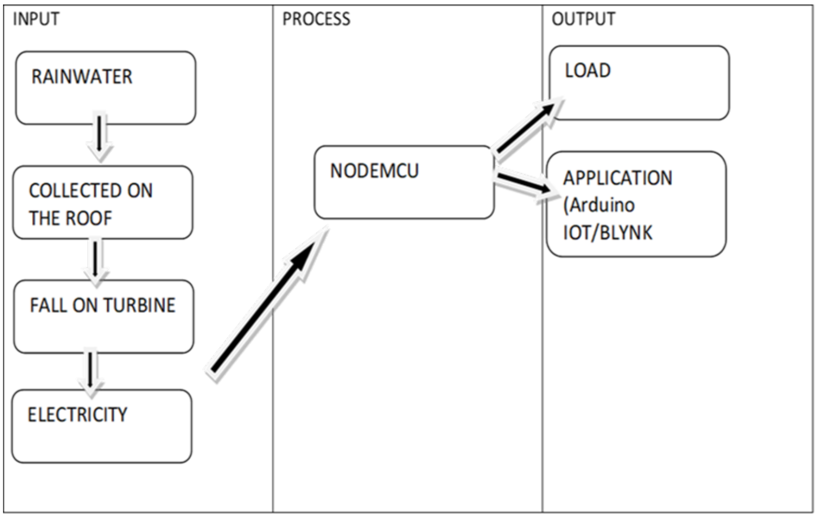


Fig. 3. The block diagram of the overall process

2.3 Schematic Diagram of the Overall System

Figure 4 shows the schematic diagram of the overall process. The process starts at the mini turbine, which will start to operate when the water flows to the turbine. The pressure of the turbine influences the production of the voltage. When reading, it will go through the voltage divider to stabilize or regulate the value of the produced voltage. In addition, the signal of the producing electrical energy will go through to the microcontroller, NodeMCU and the reading of all the results will be displayed on the smartphone by using BYLNK interfacing. Meanwhile, the produced voltage will be stored in the battery, which this charging process is helped by the charger controller.

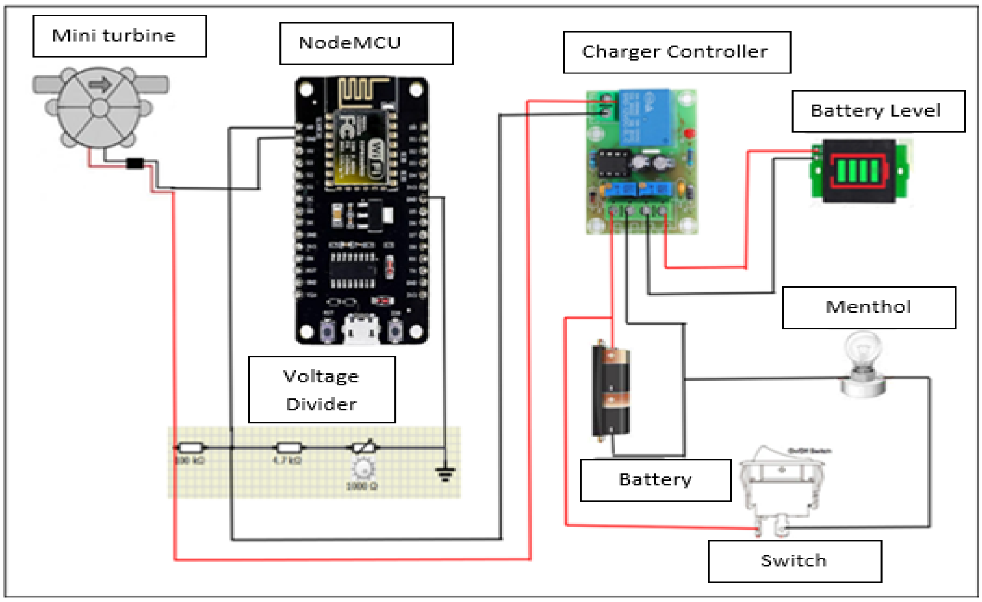


Fig. 4. The schematic diagram of the overall process

The battery level indicator is used to display the percentage of the charging level. Menthol is used as an example of the load that is controlled by the switch. All the components that were used are shown in Table 1.

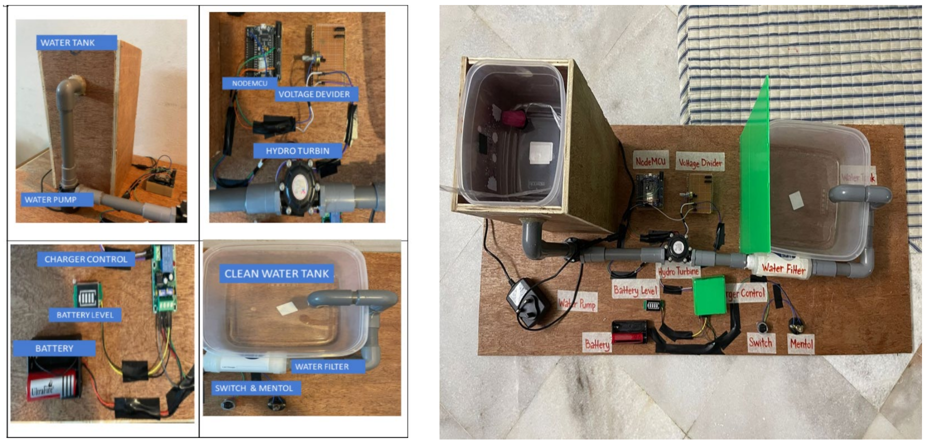
Table 1
List of the components of the protype

No	Components	Function
1	Mini turbine	Produce the kinetic energy
2	NodeMCU	Generates readings and connects to the blink programme, acting as a brain. Micro Hydro Power Plant [17] stated that this component will enhance the functionality of remote controllability and mechanical governor systems.
3	Voltage divider	Works as a device that stabilises the hydro turbine's electrical reading. According to Putra *et al.,* [16] the advantages of using the resistor as a voltage divider are that it can give a high accuracy of reading.
4	Charger control	Its function is to regulate the voltage and current from the PV array to prevent overcharging and over-discharging of the battery.
5	Battery level	Displays the battery's charge level.
6	Battery	To store the electricity generated
7	Switch and menthol	To show as simple circuit and simple load

3. Result

3.1 Product Layout

Figure 5(a) and 5(b) shows the overall product layout. These prototypes consist of a water tank, charger circuit, load, mini turbine, water tank and IoT circuit. The materials used in this project are PVC pipe, plywood and plastic boxes. Figure 5(a) shows the overview of a water tank and water pump; the size of this water tank is 35cmHx17cmLx15cmW. Moreover, the controlling circuit which consist of voltage divider to regulate the voltage output, the charger controller to control the process of charging and discharging. The last part is recycling water that can be utilize to other application.

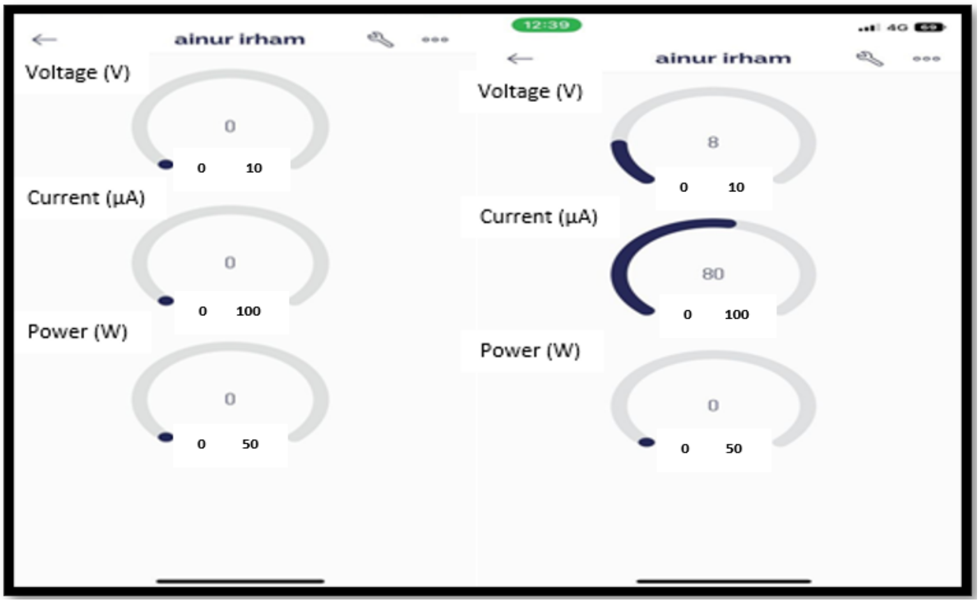


(a) (b)

Fig. 5. The product layout (a) side view (b) overall view

3.2 Project Testing

Figure 6 shows the performance of the output current, voltage and power when the harvested rainwater flows to the mini turbine. Based on Okedu *et al.*, [18] the basic principle of operation is as follows: a barrier is made on water flow known as weirs or dams that causes a water head and high-water concentration flow that enters a penstock. It means that the amount of water stored in the water tank determines the amount of output. The higher/more water stored in the water tank, the higher the pressure of the water flow.



(a) (b)

Fig. 6. The performance of overall system (a) without water flow (b) with water flow

3.3 Result of the Production of Electricity

Table 2 shows the performance of producing electricity based on water level. From the observations, the maximum voltage that can be produced for this prototype is 8 volts when the tank is fully filled with water and the minimum voltage is 0 volts when the water level in the tank is low. In addition, the value of the output current is smaller than the voltage. It is because, based on Ohm's law, the equation for the calculation of current is:

$$I = \frac{V}{R} \tag{1}$$

Table 2
Performance of producing electricity based on water level

No	Water Level	Output Voltage (V)	Output Current (µA)	Output Power (µW)
1	Full tank (10cm)	8	80	640
2	Medium(6cm)	4	40	160
3	Low (2cm)	0	0	0

I refer to current, V refers to voltage and R refers to the load. So, from Eq. (1), the reading of the current is inversely proportional to the voltage. Meanwhile, the reading of power is calculated based on the Eq. (2).

$$P = VI \tag{2}$$

The analysis shows that the bigger the water tank, the more water can be stored and the higher the electrical reading. When there is a lot of water, the water pressure will be high, causing the turbine to rotate faster and the electricity-producing reading to be higher. The generator concept is based on the magnetic force. The magnetic force produces an anti-rotational torque. The generator has a motor-like action that opposes the turbine's attempt to rotate it. Counter torque is produced by the induced forces operating on the loop. These forces are produced by the interaction between the induced current and the applied magnetic field. According to Troldborg, Heslop and Hough [19] and Brent and Rogers [20], to implement the project at the chosen potential site, the sustainability of renewable energy should be assessed based on the technologies needed for implementation, economic growth, social and economic benefits, technical requirements, reliability and turbine type suitability. That is, to implement this project, the location and potential need to do so must be considered. Areri and Bibi [21] stated that as a result, the sustainability of small-scale hydropower plants in the study area is evaluated in terms of economic growth, environmental impact and cost.

4. Conclusions

In this paper, the developing technique for producing electricity by harvesting rainwater has been presented and it is dependent upon the size of the water tank and the pressure of the water. Thus, to ensure the production of electricity is good, the pressure of the water needs to increase. Besides that, with this project, the monitoring of current, voltage and power can be done in real-time by using the BYLNK application. This project also incorporates the sustainability concept, which states that RWH can be recycled.

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