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The Design and Development of Hybrid Pico Hydro-Solar Fountain for Power Generation

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Abstract: In this era of globalization, the electricity that is being generated by the big company that feeds us the electricity power to cities and villages has made our civilization highly dependent on electricity. With the supply of electricity to the cities and many industrial facilities, the productivity of the economy rises high and electricity demand is very high in every place in the world. Due to the high demand for electrical energy, the bill for electricity is also high. In the case of the low household income family especially one that lives in a poor area and the electricity supplies may not reach it, they will need another method of acquiring electricity for their daily life usage. Such as diesel-fueled generators. However, the diesel-fueled generator is not a free energy that can produce electricity endlessly because it requires diesel fuel to start generating electricity. There is another method of generating free electricity power, that is by using hydroelectric and solar power. Therefore, this project aims to create a pico-sized hybrid hydro-solar generator that is small enough to be placed inside the home. The project is to create an eco-friendly electrical power generator without consuming any other material but only with endless running water and sunlight energy using a DC motor and solar panel. The prototype of this project aim is to generate 5V energy that can charge up to 5V battery and be used as a power supply to many other appliances like the Arduino, ESP8266, water pump, LED lights, and able to charge up smartphones and many other things that require 5V voltage to be able to charge.

Keywords: Hydro-electric, Solar power, Arduino, Internet of Things, Water Pump, 5V, DC Motor, Solar Panel, ESP8266, LED, Charger, Eco-friendly, Free Energy, Pico Hydroelectric, Generator, Hybrid System

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1. Introduction

Electricity has been really helpful for our daily lives and humanity is dependent on electricity to keep our products running continuously. Many places use electricity to provide living necessity to our lives like food factory to fulfill our daily lives need. Without electricity, things like this can't be done without the help of machines because the population of humanity is too far greater than the number of workers we will need to produce that much of a necessity for humans.

This project will cover the minor daily life necessities for our daily living needs. The system that will be designed and developed will help people to generate electricity for the use of charging handphone's battery, provide small light to help us do activities during night time when the sunlight is already gone. The system will also use renewable energy from sunlight during the daytime to charge up the electric bank and continuous running water as the main supply of the system, so the system is very eco-friendly toward nature.

1.1 Hydroelectric

Hydroelectric power facilities typically have a water reservoir, a gate or valve to control how much water flows out of the reservoir, and an outlet or point where the water ends up after flowing downward. Just before it spills over the top of a dam or runs down a hill, water gains potential energy. As water travels downhill, potential energy is transferred to kinetic energy. The water can be utilized to generate energy by turning the blades of a turbine, which is then supplied to the power plant's consumers.

There are many sizes of hydroelectric generators from large hydropower, small hydropower, mini-hydropower, micro hydropower, nano hydropower, and pico hydropower. All of these sizes of hydropower generator is based on how much power they generate.

Large hydropower plants as facilities that can generate more than 30 megawatts (MW) of power from the plants. Small hydropower plants can generate power between 100kW to 10MW of power. Mini hydropower is used in connection-width plants that can generate over 100kW while micro hydropower is for a generator that can generate less than 100kW of power. A pico hydropower is a definition that is used for a hydroelectric generator that is capable to generate less than 5kW of power. [1]

The project aim is to create a pico hydropower to generate 5 watts of power and supply the power to charge up the battery.

1.2 Solar power

Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. The photovoltaic cells in solar panels can convert light into electrical energy using the photovoltaic effect. [2] This energy can be used to generate electricity or be stored in batteries or thermal storage. Solar panels use sunlight as a source of energy to generate direct current electricity.

Concentrated solar power makes up a very small fraction of solar energy. Compared to gas-fired power, concentrated solar power may consume significantly more water. This could be a concern because deserts are frequently used to build solar power plants because they require intense sunlight. [3]

Solar energy is cleaner than electricity produced from fossil fuels. [4] While using solar energy does not produce any hazardous pollutants, the production of solar panels does produce some pollution.

1.3 Hybrid systems

A hybrid system combines solar energy with energy storage and/or one or more additional sources of energy. Solar is frequently paired with hydro,[5] wind,[6] and batteries.[7] The combined generation may allow the system to alter power production in response to demand, or at the very least smooth out solar power fluctuations.[8] There is a lot of hydro across the world, and installing solar panels on or near existing hydro reservoirs is especially beneficial because hydro is typically more flexible than wind and cheaper at scale than batteries,[9] and existing power lines may sometimes be utilized.[10]

2. Materials and Methods

Throughout the project, the design and development of the hybrid pico hydro-solar generator, the project flowchart as shown in Figure 1 is used to represent the workflow of the development process.

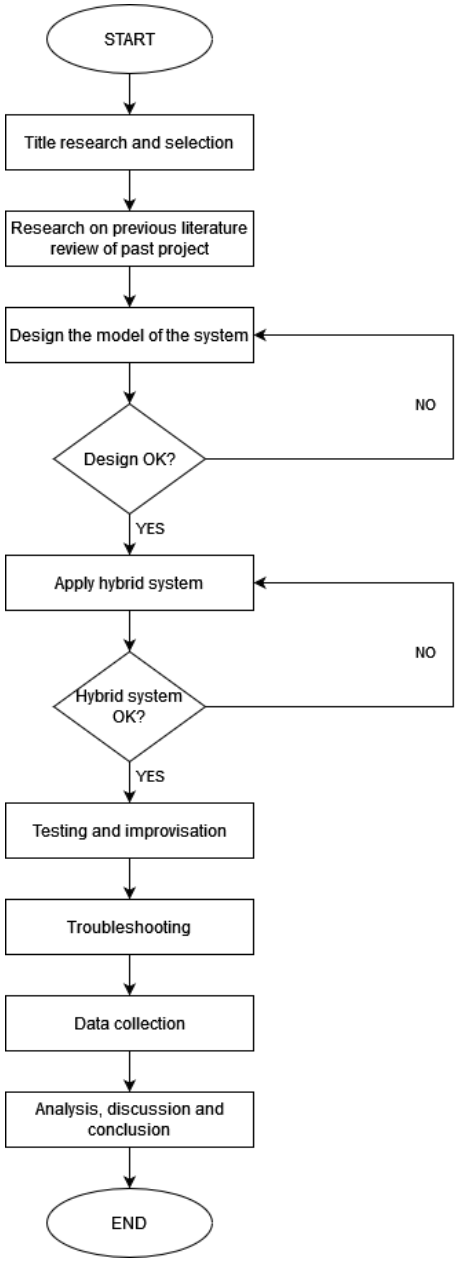

Figure 1: Project Flowchart

The project begins with the title research and selection where the objective and scope of the project are found to counter the problem that has been researched. The literature review of the previous literature project has provided a lot of useful information because of the similarity between the past

project and the current project that is going to be developed. The information is including hybrid systems and a lot of solar power projects.

The design of the hybrid pico hydro-solar generator was sketched using AutoCAD and manual drawing on paper to get a better insight into how the project will work. During the design, the most important thing was the placement of the water flow to spin the motor. The place for all other electronic components like Arduino UNO, ESP8266, LDR, battery, and the wiring was also considered as much as the placement for the water flow.

The coding of the Arduino UNO and ESP8266 was done by using Arduino IDE. The simulation of the coding was done using a breadboard, LED, and Blynk IoT application. While the simulation of the hydro-solar generator was done on the actual hardware because of no available software for physics simulation for the hardware. Plywood is used to build the design of the hybrid system by assembling the plywood according to the sketching that is made on AutoCAD and manual sketching by hand on paper. After finishing the planned design, the system then improvised with other functions as well.

The data of the systems is recorded by using a multimeter on how much voltage and ampere the system generates, and how long the system needs to charge the battery. The data analyzed and discussed with the conclusion later.

2.1 System Block Diagram

A block diagram is used to visualize the operation of the whole system from the power source supply to the output load of the project. The simple block diagram in Figure 2 shows the hybrid systems (solar panel and motor), battery, Arduino UNO, internet of things, LDR, and output loads LED.

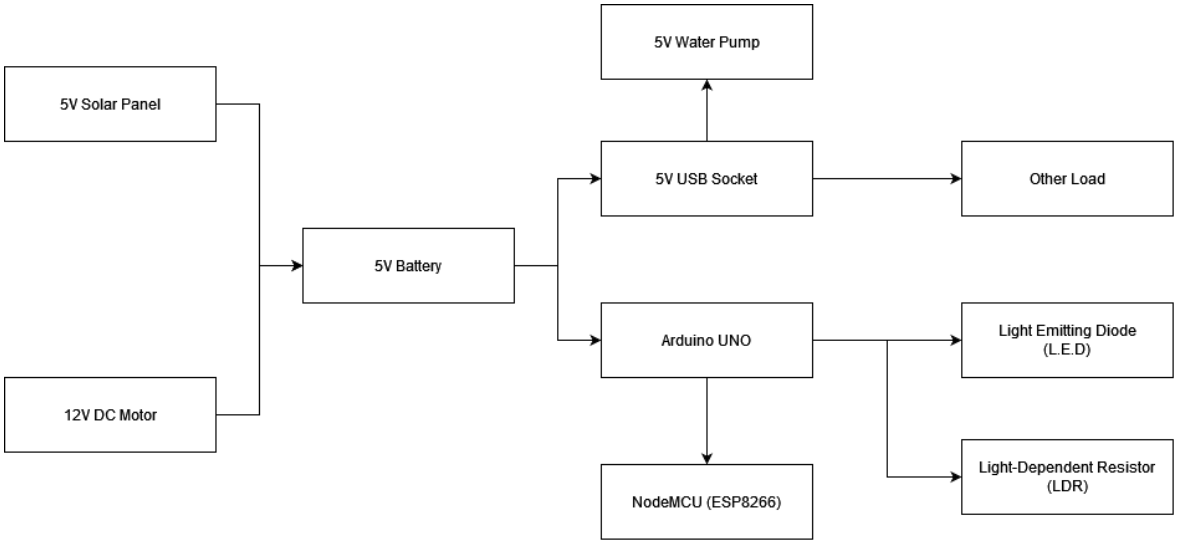

Figure 2: Simple system block diagram of hybrid systems and Arduino

The hybrid systems, solar and motor are both connected to the battery. The solar power and DC motor wiring connection are combined before going to the battery. So a diode is used to block the flow back of the current from the solar panel to the motor but only allows the current to flow only in one direction from the motor to the battery.

The battery will be the power supply for the 5V USB Socket, and Arduino UNO. The 5V USB socket will be the switch for the 5V water pump to keep the water flow for the motor to spin. Aside from the water pump, the USB socket will be the charging spot for smartphones. The Arduino UNO will provide 5V and 3.3V supply from its pin for the ESP8266, Light Emitting Diode, and Light-Dependent Resistor.

2.2 System Flowchart

A system flowchart is used to show the detailed flow of the system and the program the Arduino of how the system work. The simple system flowchart in Figure 3 shows the flow of everything and how it works.

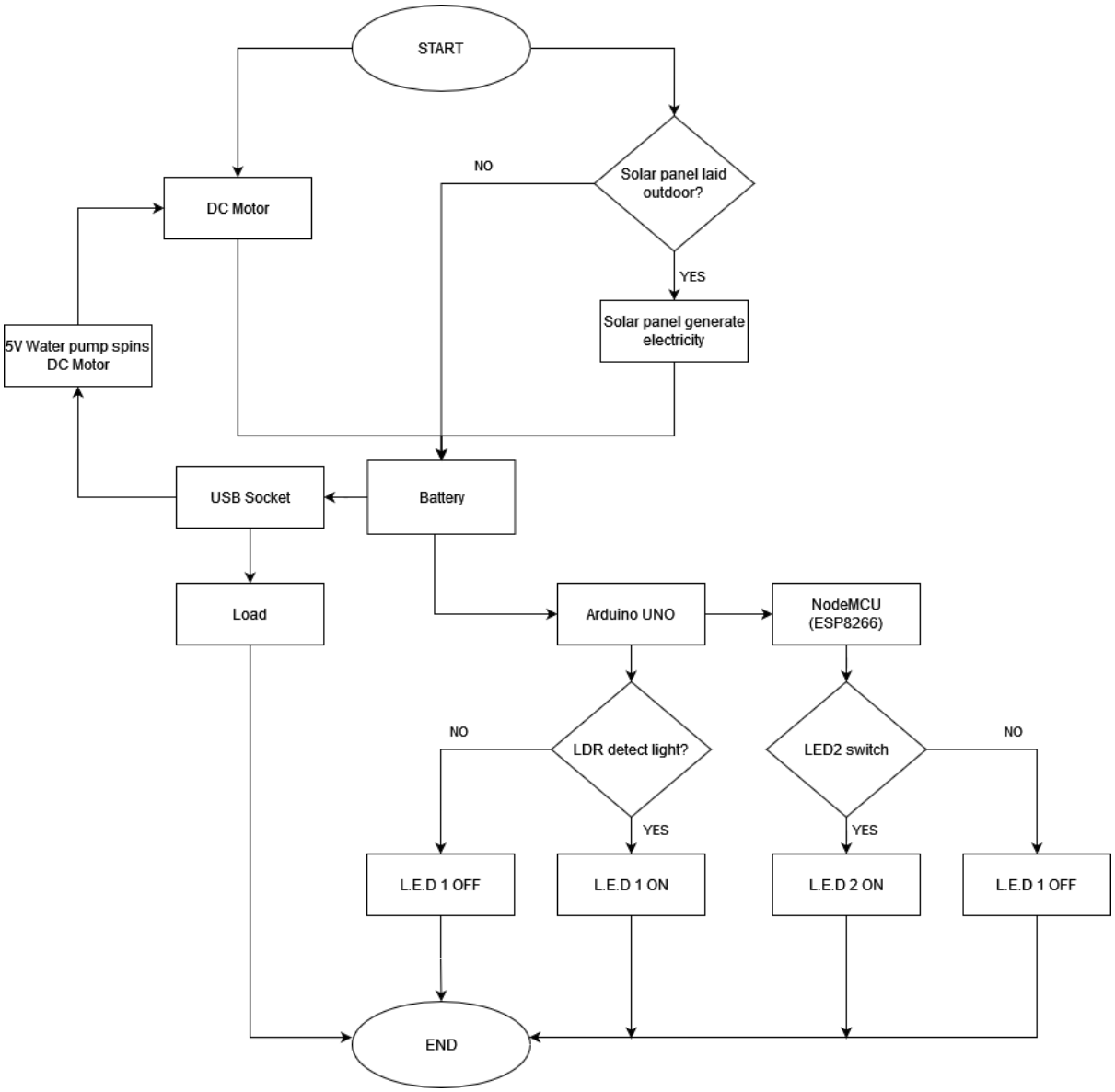

Figure 3: Simple system flowchart of hybrid pico hydro-solar generator

Firstly, the system starts with a DC motor and solar panel as a method to charge up the battery, the connection of the wire from the DC motor and solar panel will be combined before charging up the battery. A diode is used to block the backflow of the current and only allow it to flow from the solar panel/DC motor to the battery only.

The battery will be the power supply for Arduino UNO and the USB socket for the output load. From the USB socket, it will be the switch for the water pump to turn on and off the water whenever the water pump is needed. The USB socket will power up the output load, such as a smartphone charger. Simply use a USB cable to charge smartphones from the USB socket.

Arduino UNO will supply power from its pin to ESP8266, and LED. The LDR will detect light and the LDR will send the signal from 0 to 1 to the Arduino to turn on the LED or turn it off. The ESP8266

will send the data it receives to Arduino UNO and Arduino UNO will act according to the program implemented on it to execute an action.

2.3 Blynk Application

Blynk is an IoT platform for iOS and Android devices that uses the Internet to control Arduino, Raspberry Pi, and NodeMCU. This program is used to compile and provide the required address on the available widgets to construct a graphical interface or human-machine interface (HMI). Blynk is a platform that is designed for IoT purposes. It can connect a project to the internet to control, store and monitor the data of the hardware from the application remotely.

There are three major components in the Blynk platform, that is Blynk App, Blynk Server, and Blynk Libraries. Blynk App allows the creation of interfaces for projects using various widgets that are provided in the Blynk platform. All communication between smartphones and the hardware is the responsibility of the Blynk Server. The Blynk Libraries enable the communication of the popular hardware that is being used in the project and it can handle all the incoming and outcoming commands. [11]

3. Results and Discussion

A multimeter and breadboard had been used to collect the data about the function of the hybrid system, Arduino, and IoT that is developed, Hybrid Pico Hydro-Solar Fountain for Power Generation. The data of the power produced by the solar panel is tested using a multimeter while the solar panel is being exposed to the sunlight, and the reading of the voltage and ampere were taken. As for the motor data, it is also taken by using a multimeter while the motor is spun by a water pipe. The 5V water pump was not enough for the motor to spin. The data of the motor was taken by using strong pipe water.

The testing of electronic is done by using a breadboard before soldering it for a permanent connection. The coding of the program into Arduino and NodeMCU is tested using a breadboard for its connection and using an LED bulb as the output testing. It took numerous tries and researches for the program to work as properly, but not quite as expected. The most testing that is being performed is the IoT and serial communication of the ESP8266 NodeMCU with Arduino UNO. A lot of troubleshooting and research on tutorial videos on Youtube were done.

3.1 Results of Solar Panel

The result of the testing had been done with data collection through a multimeter and by using Microsoft Excel to sort the data. The voltage and time taken were recorded when testing are done.

Table 1: Solar panel with medium exposure (5.8 - 6.0V)

No.	Time (minutes)	Battery Percentage (%)
1	61.43	25%
2	125.85	50%
3	192.77	75%
4	261.52	100%

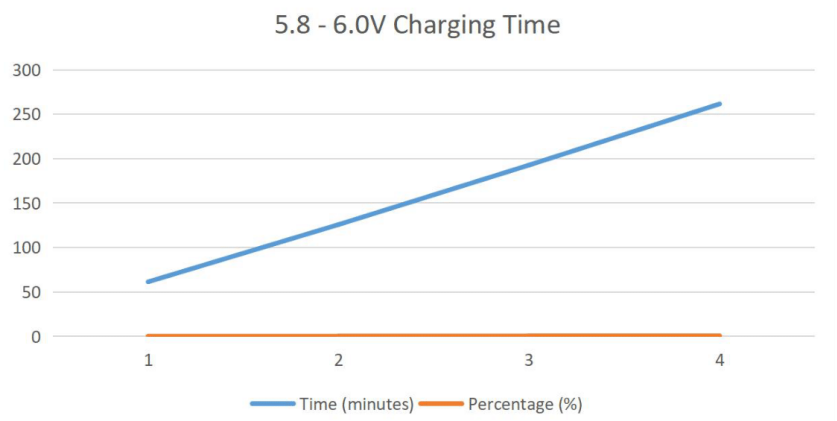

Figure 4: Graph of Time over Percentage of Battery Charging (5.8 - 6.0V)

From Table 1 and Figure 4, the data that have been collected shows that the higher the percentage of the battery, the slower the charging time it takes to fully charge the battery. This is because lithium batteries are built to slow charge speed at 80% to protect them from overheating. [12]

Table 2: Solar panel with medium exposure (6.1 - 6.4V)

No.	Time (minutes)	Battery Percentage (%)
1	59.46	25%
2	124.70	50%
3	187.42	75%
4	258.12	100%

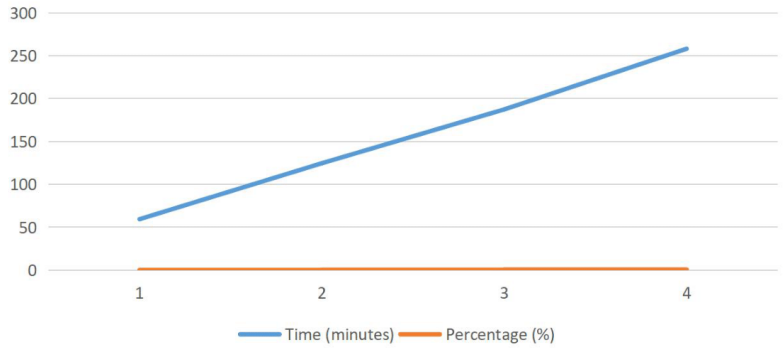

Figure 5: Graph of Time over Percentage of Battery Charging (6.1 - 6.4V)

The data obtained from the charging speed of solar panels with high exposure to sunlight that generate 6.1 to 6.4V of voltages is shown in Figure 5. The higher the voltage the lesser time it takes to charge a battery to its full capacity. But the higher the percentage of the battery, the speed of the charging time will be lower. This is the same as the result of the charging time of 5.8 - 6.0V, it is to protect the battery from overheating. Lithium batteries are specially built for this purpose.

3.2 Results of 12V DC Motor

The result of the testing had been done with data collection through a multimeter and by using Microsoft Excel to sort the data. The voltage, ampere, and speed taken were recorded when testing are done.

Table 3: Average Voltage and Ampere Generated by 12V DC Motor

Speed	0	1	2	3	4
Voltage (V)	0	0.16	0.18	0.20	0.22
Ampere (mA)	0	5.25	5.45	5.9	6.75

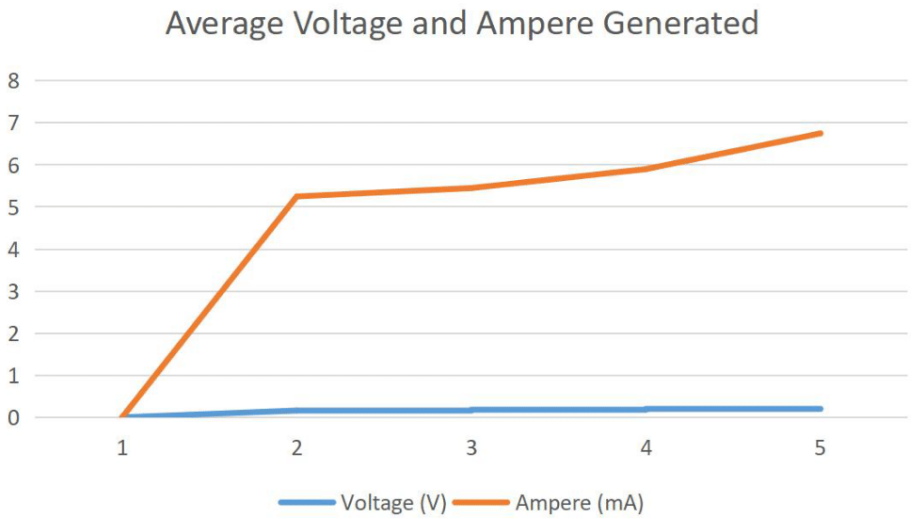

Figure 6: Average Voltage and Ampere Generated

The data that is collected from the voltage and ampere output based on the speed of the pipe water are shown in Table 3 and Figure 6. The data was taken by using pipe water to spin the DC motor, a 5V water pump is not powerful enough to spin the motor.

The ampere that is generated by the motor exponentially increases the speed of the spins of the motor. The voltage that is generated is from 0.16V up to 0.22V.

3.3 Results of the Internet of Things

The IoT module used is NodeMCU ESP8266 a wireless WiFi module that allows the Arduino UNO to be connected and controlled via the internet and through the Blynk platform.

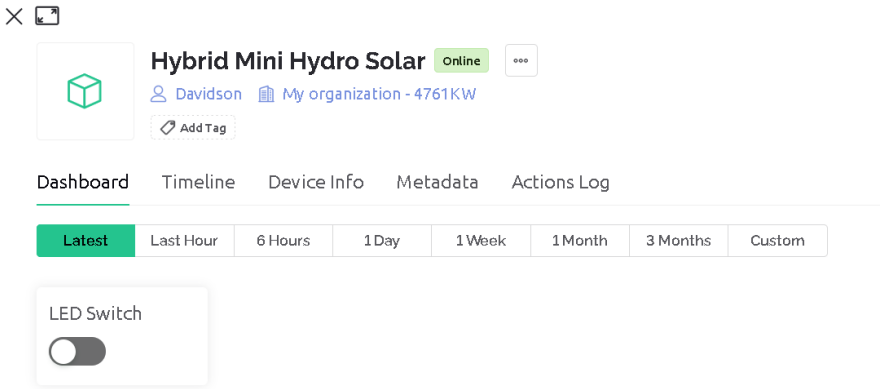

Figure 7: LED Switch OFF on the Blynk platform

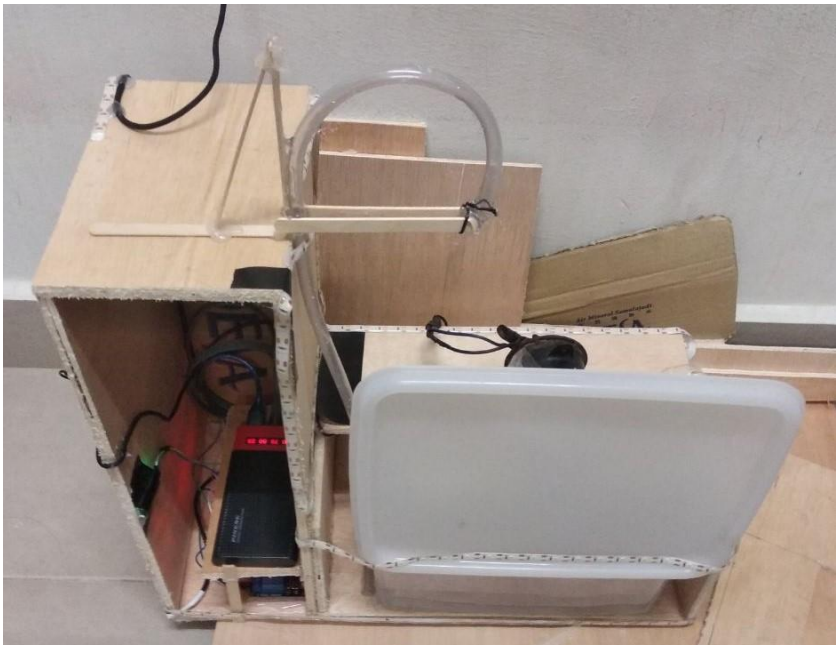

Figure 8: The project when the switch is turned OFF

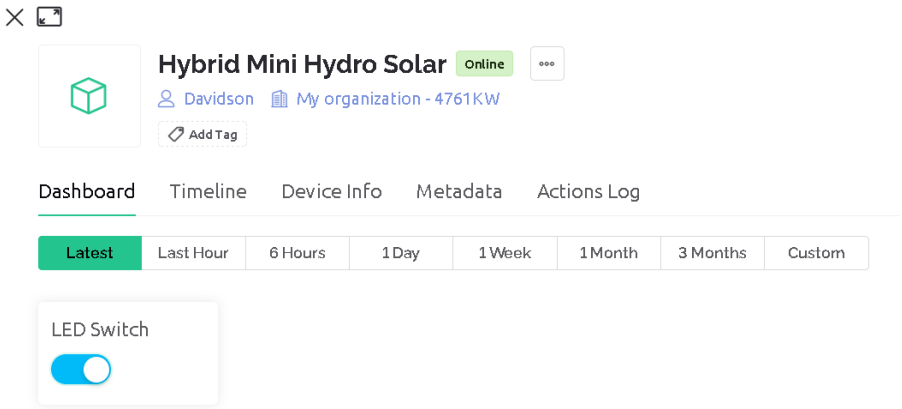

Figure 9: LED Switch ON on the Blynk platform

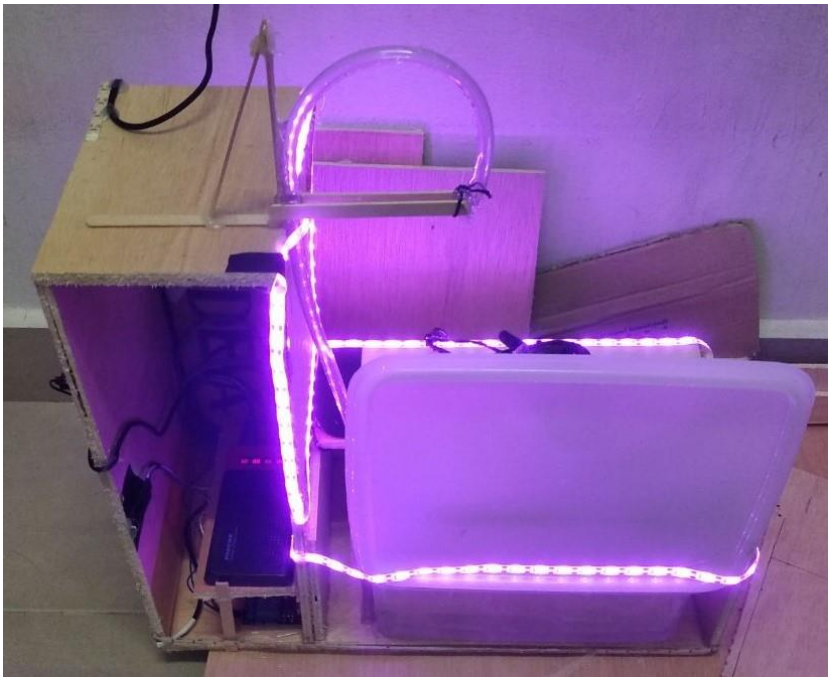

Figure 10: The project when the switch is turned ON

The result of IoT programming in Arduino UNO and ESP8266 made controlling the LED remotely easier from wherever and whenever. The virtual pin that is being controlled via Blynk will send the data of the switch to turn OFF and ON the LED to ESP8266 and it will be sent to Arduino UNO by using serial communication of the NodeMCU and the Arduino. The virtual pin data that are sent to ESP8266 will be sended to Arduino and trigger the coding to operate the relay module to open and close the connection of the LED.

4. Conclusion

Throughout the project testing and actual, the hybrid pico hydro-solar fountain for power generation has been developed. Some of the functions are not working as expected such as the function to cut off or open the connection of the LED that is being controlled by the LDR. This is because the Arduino UNO can't handle multiple actions at the same time. So it will ignore the command to trigger the relay module when the pin to LED is currently being controlled by the Arduino.

The result of the 12V DC motor to generate electricity has shown that the system needs a more powerful water pump to enable strong water flow so that the motor will be able to be spun by the water and generate more electricity. The hydro system needs a strong water current which may disrupt the idea of having a power output lesser than the power input. However, this case is easily solved by having a solar panel contribute free energy to the system. While the water running, it can reduce the power consumption of the system by spinning the motor to generate electricity.

The result of the solar panel has achieved its objective, despite that, the solar panel became the main power source of the hybrid system due to the motor being unable to spin by the low-pressure water current. The solar panel has successfully shown its result by being able to charge up the battery. However, the solar panel will make the battery overcharged due to the incomplete circuit for cut-off charging when the battery is fully charged.

A lead acid battery will be a better replacement for the lithium-ion battery because the lithium-ion battery might explode if used while charging. During the project, the power bank which is a lithium-ion battery can impose the risk of explosion during usage while charging the battery. The protection circuit that cut off usage while charging makes the power bank able to charge up safely.

4.1 Discussion

The development process of the hybrid system shows many improvable and fixable errors that were encountered. Some of the components or items may need to be replaced with something else.

As for the hydro system, the 12V DC Motor couldn't be spun by the water flow that is being pumped by the 5V water pump. The hydropower system in this project failed due to the failure of providing enough water force to spin the DC motor.

A smaller torque DC motor may have been able to be spun by low-pressure water and create an electric current. However, a smaller motor might only generate a small voltage and current of electricity. The other method is to replace the water pump with a stronger water pump to enable the motor to be spun by the water flow. A bigger fountain may need to be considered by using this method.

Next is the solar panel, the result that the solar panel shown made it obvious that the number of solar panels may need to be increased. Nonetheless, that will break the idea of having solar power to be the additional power, not the main power of the hybrid system. However, the hybrid system should not know which of the two combinations of power generators is the main power generator. It will be more efficient and better if the solar panel is added more.

The result of the project shows that the hybrid system of the project failed due to a missing circuit for charging the power bank. The battery that should have been used should be able to be used while charging. The power bank that is used in this project will impose the risk of danger because the power bank might explode when used during charging. The reason why the power bank is not exploded while being connected to the output load while charging is because of the existence of a protection circuit that cut off the outgoing current when the battery is being charged. Some of the proper batteries that should have been chosen as the battery should be lead acid type batteries because they can be used while being charged.

Other than that, the circuit to combine the solar and hydro should be able to switch the incoming power supply to the battery. The battery will need to be able to take one power supply from either the solar panel or the motor.

4.2 Recommendations

Throughout the design and development process of the hybrid pico hydro-solar fountain for power generation, several recommendations are being suggested.

The recommendation is to add current, voltage, and power monitoring on the Blynk platform by using the PZEM-017 DC module. It can monitor the voltage, current, power, frequency, and energy that are flowing into the system. This idea can be implemented between the power input of solar power and hydropower before the battery.

Acknowledgment

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