# DESIGN AND DEVELOPMENT OF PICO-HYDRO POWER PLANT UTILIZATION AS A SUPPLY FOR IOT- BASED PUBLIC STREET LIGHTING

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**ABSTRACT**
The pico-hydro power generation system operates by utilizing the potential energy of water flowing towards a turbine to produce electrical energy through a DC generator. Since the generated voltage is unstable, a boost converter controlled by a PWM signal from an ESP8266 is used to stabilize it. An INA219 sensor is employed to monitor the generated voltage and current, while a relay controlled by the Thinger.io platform directs power to the street lighting. The energy generated by the pico-hydro power generation system after 24 hours is 19.3 Wh. The energy produced is small because the current generated by the generator is only 0.13 A, making the charging current lower than the current used in the street lighting system. The water entering the turbine is a factor affecting the generated current and voltage.

***Keywords:*** *Pico hydro, Public Street Lighting, IoT, DC generator, ESP8266, INA219*

## 1. INTRODUCTION

Public street lighting (PJU) is a lamp used to provide lighting on the road at night, this street lighting also helps road users see more clearly the road to be traveled at night, so that public road access is safer. With the existence of public street lighting, pedestrian activities are safer and more comfortable.

Indonesia has alternative energy sources including wind, solar, water, geothermal and biomass. Indonesia has a large water potential due to the geographical condition of Indonesia with many rivers and topography consisting of hills. One of the small-scale renewable energy sources that is affordable and does not cause air pollution is the Pico-hydro Power Plant.

Pico Hydro Power Plant is a power plant with an electrical energy output of less than 5 kW with a small-scale generation category. The principle of hydropower is the speed of water from a height of 1 - 3 meters and a discharge of 30 liters / second into electric power, which can drive a turbine so that the generator produces electricity. The picohydro small-scale hydropower plant in principle utilizes the height difference and the amount of water discharge per second in the river flow.(Yusmartato et al., 2022).

With public street lighting, road users will feel safe and helped at night or during bad weather. Currently, public street lighting still uses a lot of supply from PLN, based on Regional Regulation No. 15 of 2010 concerning the basis of imposition, rates, how to calculate taxes and collection areas in the second part, namely the lighting tax rate provided by PLN is set at 2.4%, while the tax rate for the use of self-generated electricity is 1.5%. So the utilization of pico-hydro power plants as a public street lighting supply is a solution for lighting cost efficiency and public lighting tax efficiency.

## 2. METHOD

### 2.1 Research design

In essence, in writing research, there are many stages that must be carried out to achieve what is expected, namely with the following stages, and are presented in the form of diagrams to make it easier to conduct research

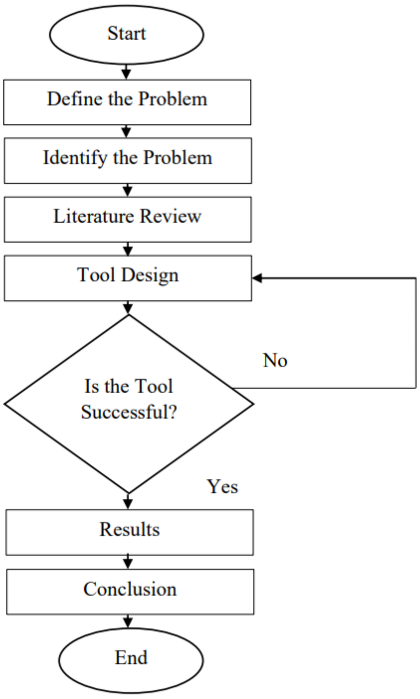


**Figure 1** Flowchart of Research Design

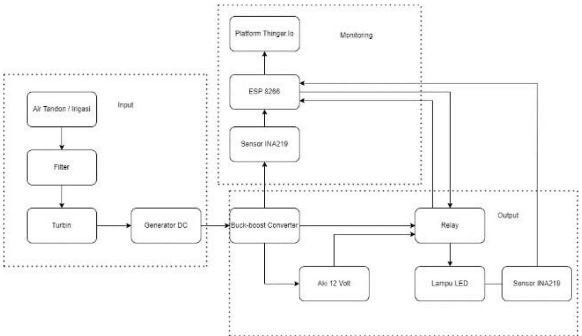


**Figure 2** Tool Design Block Diagram

When the tool is started, the system will initialize the tool, the water reservoir which is simulated as a water source with a height of 1-3 meters will flow water as potential energy towards the turbine, along with the entry of water into the turbine, the 12 Volt DC generator will move which produces mechanical energy, then converted into DC electrical energy. The voltage generated from the DC generator is unstable, so a bost converter is needed as a stabilizer of the DC generator output voltage. The boost converter circuit uses a mosfet driver which functions to continue the pwm signal from ESP 8266 to regulate the mosfet.

The INA219 sensor will read the voltage and current generated by the Pikohydro power plant by placing the INA219 sensor at the output of the bosst converter, if there is a sensor reading failure then INA219 will re-read the voltage and current in the generator.

The voltage stored in the battery will be flowed to the load through a relay that will disconnect and connect electricity according to user commands using the Thinger.Io platform. When the PJU lights are on, the power, voltage, and current flowing to the PJU lights will be read by the INA219 sensor which will be displayed on Thinger. Io, but when the PJU lights are off, the sensor will read that the voltage, current, and power are not on the PJU lights..

## 2.2 Tool Components

A. Hardware

1. Turbine

A water turbine is a device that converts the potential energy of water into mechanical energy, then the turbine will rotate so that the mechanical energy is converted into electrical energy with the help of a generator.

2. NodeMCU ESP 8266

NodeMCU is an Internet of Things (IoT)-based development board that uses eLua firmware and the ESP8266-12E System on Chip (SoC). The ESP8266 is a WiFi chip with a fully integrated TCP/IP protocol stack, making it very suitable for IoT projects. The microcontroller used in the NodeMCU V3 is the ESP8266 with a board size of 57 mm x 30 mm. The supported input voltage ranges from 3.4 to 5 V. This NodeMCU has 13 GPIO pins, 10 PWM channels, and 1 ADC pin with 10 bit resolution. The available flash memory is 4 MB, while the clock speed reaches 40/26/24 MHz. The module also supports IEEE 802.11 b/g/n WiFi connectivity at frequencies from 2.4 GHz to 22.5 GHz. The NodeMCU V3 comes with a Micro USB port and a USB to Serial converter CH340G, but no card reader. With these specifications, the NodeMCU V3 is an ideal platform for IoT applications that require network integration and wireless device control.

3. DC Generator

A DC generator is a type of generator that produces direct current (DC) as output. The working principle is similar to AC (alternating current) generators, but differs in the arrangement of magnetic field coils and armature coils. In a DC generator, electric current is generated by the relative motion between the permanent magnetic field or electromagnetic field and the coil on the armature. As the armature rotates, the conductors in the coil will intersect the magnetic field, producing a direct electric current..

4. INA 219 Sensor

The sensor is a multifunctional sensor module, for example used for measuring active power, AC and DC voltage, frequency, active energy, and current contained in an electric stream. Installation of this sensor is specifically for indoor use, besides that the installed load must not exceed the specified power.

5. Relay

Relay is included in the electronic component in the form of an electronic switch that is driven by electric current. The existing low voltage coil on the relay is wrapped around a core, an iron armature that will pull towards the core when a current flows through the coil, the spring-loaded armature will be attracted to the contact line simultaneously changing its position from normally open contact to normally closed contact.

6. Buck-Boost Converter

Buck-boost converter is a type of converter that is able to change the DC voltage value to be higher or lower than its initial value. By changing the polarity value of the output voltage against The input voltage.

7. Battery

The battery used in this research is a VRLA (Valve Regulated Lead Acid) battery with AGM (Absorbent Glass Mat) technology. This battery has a nominal voltage of 12VDC and a capacity of 7 Ah, which is suitable for various applications that require stable and reliable energy storage. The battery connector uses an M8 connector, which ensures a strong and secure connection. With a weight of 2.5 kg and dimensions of 181 mm x 183 mm x 176 mm (P x L x T), this battery is designed to provide good performance under various usage conditions. AGM technology enables this battery to have long-lasting power, minimal maintenance, and be able to operate safely in various positions, making it an ideal choice for energy storage systems such as solar panels and other applications that require durability and reliability.

B. Software

1. Arduino IDE

Integrated Developmnet Environment (IDE) is a program used to create programs that are used to create programs on the Arduino microcontroller. Programs written using the Arduino IDE software are called sketches.

2. Thinger.Io

Arduino IDE requires supporting applications to monitor and control public street lighting in this tool design with the Thinger.Io application. This application can be used to control hardware devices, display sensor data, and store data. From this Thinger.Io application, we can control anything remotely wherever we are with an internet connection, so we don't have to check the device directly.

## 2.3 Testing Technique

1. Turbine Testing for Pico-hydro

In the design of the tool made requires a turbine to convert the potential energy of water into mechanical energy by driving a generator which will be used as a source of electricity generation, the test carried out aims to test the turbine is able to move or not, with the result that the turbine can rotate properly..

2. DC Generator Testing for Pico-Hydro

In the design of the tool made this requires a generator which will be used as a source of electricity generation, the test carried out aims to test the generator output. This test is carried out with variations in the height of the water flow.

3. ESP 8266 Testing

When ESP8266 has a supply, the microcontroller will flash blue, so ESP 8266 is working properly. This test is to find out the microcontroller can work properly..

## 2.4 Data Analysis Technique

This research will design a device to overcome the problems that have been identified previously. The data analysis techniques used include several methods.

1. First, the literature study method, which examines, explores, and reviews theories that are relevant to the problem under study.
2. Second, the literature study method involved the use of various reference books, information from lecturers and colleagues, as well as websites that provide theoretical foundations as sources in this writing, as well as references related to the research topic.
3. Third, the observation method used to study and ensure the application of theories that support the problem under study.
4. Fourth, the calculation analysis method which includes analyzing the construction of the components designed in this research.
5. Fifth, the experimental method which involves trials to obtain data on the simulation results of the designed program, so that it can help in solving existing problems.
6. Sixth, the discussion method which includes consultation and guidance with teachers and other competent parties in supporting the implementation of this tool design.

# 3. RESULTS AND DISCUSSION

## 3.1 Research Result

A. DC Generator Testing

| Water Speed | Turbine speed | Output (V) | Output (I) |
|---|---|---|---|
| 1.60 m/s | 100 Rpm | 2.93 V | 10.6 mA |
| 2.08 m/s | 135 Rpm | 3.38 V | 12.5 mA |
| 4.12 m/s | 158 Rpm | 4.67 V | 14.9 mA |

**Table 1** DC Generator Testing

Analysis Results:

shows that a turbine speed of 158 rpm produces an output voltage of 4.67 V. And with 135 rpm turbine speed resulted in an output voltage of 3.38V, the speed of water entering the turbine affects the output..

B. Converter Buck- Boost Testing

Buck-Boost converter testing is done to stabilize, increase and decrease the output voltage of the generator. For testing, measuring the voltage incoming to the Buck-Boost Converter and measuring the voltage output from the buck-boost converter is carried out.

| No | Buck Converter | | Boost Converter | |
|---|---|---|---|---|
| | *Input* (V) | *Output* (V) | *Input* (V) | *Output*(V) |
| 1. | 4.67 V | 12.14 VDC | 12 VDC | 5.08 VDC |
| 2. | 3.38 V | 12.12 VDC | 12.12 VDC | 5 VDC |
| 2. | 2.93 V | 12 VDC | 12 VDC | 5 VDC |

**Table 2** Converter Buck - Boost Testing

C. Software and hardware Integration Testing

In making this tool, the fuzzy logic method used is fuzzy mamdani. The use of mamdani fuzzy is to control all data in real time. The following is the basic concept of fuzzy logic control in this study.

| No | Kontrol Melalui *Thinger.Io* | Koneksi *Wifi* | Kondisi Lampu | Tegangan Lampu | Arus Lampu |
|---|---|---|---|---|---|
| 1 | *ON* | *ON* | *ON* | 12.12 V | 330.9 mA |
| 2 | *OFF* | *OFF* | *ON* | - | - |
| 3 | *ON* | *OFF* | *ON* | - | - |
| 4 | *OFF* | *ON* | *OFF* | *0 V* | *0 mA* |
| 5 | *ON* | *ON* | *ON* | 12.12 V | 330.8 mA |

**Table 3** Software and hardware Integration

From the table of results of controlling public street lighting, it shows that the lights can be controlled by the application if the esp8266 is connected to wifi, and if the wifi is disconnected then the lights cannot be controlled, and the condition of the lights will remain in the position before the wifi connection is disconnected. For the light controls time is 3 seconds.

## 3.2 Advantages and disadvantages of tools

In this study, various positive aspects and areas of improvement can be applied to the reviewed devices. The following are some of the main points:

A. Advantages of the device

1. The picohydro power plant is equipped with an Iot-based current and voltage monitoring system that is displayed on an android screen through the Thinger.Io application..
2. Remote Monitoring: This system can display the results of picohydro power plant output readings and can remotely control pju lights..

B. Disadvantages of the device

1. The design of this tool still uses a generator on a small scale and there is no SCC (solar charger controller) for charging the battery, so it can cause overvoltage when charging the battery.
2. ESP8266 must stay connected to the Internet or wifi network, if it cannot be connected to the internet then the device cannot be monitored and controlled remotely and errors often occur in the Thinger.Io application.

## 4. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

If you cannot see the IoT-based Pikohydro Power Plant Utilization Design, as described in the previous chapter, you can draw conclusions, among others.

1. Making a Picohydro power plant design with turbine components connected to a generator, ESP8266, Buck-boost Converter, INA219 sensor, LCD, battery, relay and lamp as Public Street Lighting, can run well which is operated with a control system with Iot..
2. The system created in this study can work well. The current generated in the generator is not stable because the turbine rotation is not maximized. The energy flowing in the Picohydro power generation system after 24 hours is 19.3 Wh and the current produced by the generator is only 0.13 A. The water entering the turbine becomes a factor in the current and voltage produced. The monitoring system can be read properly which makes it easier for users by using the INA 219 sensor and processed by ESP8266 which is connected to the Internet and then displayed on the LCD and sent to the Thinger.Io application.

B. Recommendations

n perfecting and increasing the performance function of a tool, modification and development are needed. The writer's suggestions for improving and developing this tool include:

1. If you want a larger scale, what needs to be done is to increase the capacity of the battery and DC generator used and add turbine speed monitoring and recorded in the application, making it easier to maintain the turbine and generator.
2. For further research, it is necessary to add SCC so that battery charging is safer to prevent overvoltage and add a timer to turn on Public Street Lighting, so that users do not need to control the lights all the time.

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