



Energy Monitoring in Wave Power Plant Based on Node-Red and ESP 8266

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ABSTRACT

Renewable energy in Indonesia includes solar, water or hydro, bioenergy, wind, geothermal, and ocean waves. The large availability of renewable energy, especially ocean waves, is supported by the geographical conditions of Indonesia, which is the largest archipelagic country. Indonesia has 17,499 islands from Sabang to Merauke, while the area of Indonesia is 7.81 km² and 3.25 million km² is ocean. This is related to the world's electricity needs which are estimated to reach 1000 EJ (EJ = 1018J) and will continue to increase every day. Depletion of reserves and greenhouse gas emissions do not allow fossil fuel energy to dominate. Therefore, the Node Red and ESP 8266 Based Wave Power Plant is one of the profitable renewable alternative energies on a commercial scale. The design of this prototype uses a pendulum system. The up and down motion of the pendulum will be converted into a rotary motion by the crankshaft and distributed to the pulley and DC generator. Thus, it can distribute electrical energy that is controlled first by the charger controller before entering the battery. Then the INA 219 sensor will detect the amount of voltage and current generated and distributed to the internet (Node Red) via ESP 8266 so that the tool can be monitored remotely.

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1. INTRODUCTION

Energy is the ability to do work or cause change. In physics, energy is measured in joules (J) and is a fundamental quantity that plays a role in almost all natural processes. Energy can exist in various forms, such as kinetic energy, potential energy, heat energy, chemical energy, and electrical energy, and can change from one form to another according to the law of conservation of energy [1], [2], [3], [4], [5]. Renewable energy is energy that comes from natural resources that can be renewed naturally and does not run out even if used continuously [6], [7], [8], [9]. This energy source is usually environmentally friendly and plays an important role in efforts to reduce the negative impacts of climate change and dependence on fossil fuels such as oil, gas, and coal [10], [11], [12], [13]. Renewable energy is an important part of the global strategy to reduce the impacts of climate change and provide sustainable energy sources for the future [14], [15], [16], [17], [18], [19].

Indonesia has a renewable energy potential of 3,686 giga watts (GW). However, the utilization of renewable energy is still at 0.3 percent. The large availability of renewable energy, especially ocean waves, is supported by the geographical conditions of Indonesia, which is the largest archipelagic country. Indonesia has 17,499 islands from Sabang to Merauke, while the area of Indonesia is 7.81 km² and 3.25 million km² is ocean. The land zone is around 2.01 million km². Node Red and ESP 8266-Based Wave Power Plants are alternative renewable energy that is profitable on a commercial scale. The world's electricity needs are estimated to reach 1000 EJ (EJ = 1018J) and will continue to increase every day. The depletion of reserves and greenhouse gas emissions do not allow fossil fuel energy to dominate. Renewable energy will replace most of the energy in the future [20], [21], [22], [23], [24].

Controlling the electric power system is key to meeting electricity needs. In addition, increasing load complexity is also a concern. In order to optimize renewable energy and face the future energy crisis that is balanced with the development of internet technology, the Node Red and ESP 8266-Based Wave Power Plant

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can be an environmentally friendly energy investment. The use of Node Red and ESP 8266 is an application of IoT (Internet of Things). The IoT (Internet of Things) system can improve system accuracy and automation through network technology. This system aims to expand the concept of internet connection that can facilitate and improve the efficiency of a job. By implementing IoT (Internet of Things) sensors, we can control work remotely.

2. METHOD

The generation of electrical energy with wave power can convert the mechanical energy contained in the waves into electrical energy. Ocean waves or waves on the shore can generate electricity through the conversion of wave action. Through the wave action, the turbine can move which can then move the generator. Then the kinetic energy is converted into electrical energy through the generator.

2.1. Node-RED

Node-RED is a flow-based development platform designed to ease the integration of hardware, APIs, and online services. Developed by IBM, Node-RED is often used in the development of Internet of Things (IoT) applications, as well as automation and data integration. Node-RED uses a web-based graphical interface where users can connect blocks (called nodes) to create data flows. Users can program by visually connecting blocks (nodes) through a web-based interface. Each block represents a specific function or device. Node-RED has a large modular ecosystem with various nodes that can be downloaded and added, including nodes for integration with IoT protocols, web APIs, and hardware. Node-RED supports integration with various IoT protocols such as MQTT, HTTP, WebSocket, as well as devices such as Raspberry Pi, ESP8266/ESP32, Arduino, and more. Programming in Node-RED is done by creating data flows, where information moves from one node to another based on user-defined logic. Node-RED is widely used for Internet of Things (IoT) projects, home automation, sensor monitoring, and remote hardware control. Node-RED can be installed on various devices such as Raspberry Pi, servers, or cloud services, making it a very flexible and easy-to-use tool for developing data-driven applications. Users can create and manage flows directly through a web-based interface without the need for complicated setup. Node-RED is a very powerful and flexible tool for building flow-based applications, especially in the IoT space. With its ease of use and extensive community support, Node-RED enables developers, both beginners and professionals, to build complex systems quickly and efficiently [25], [26], [27].

2.2. Arduino IDE

Arduino IDE (Integrated Development Environment) is an open-source software used to write, upload, and test code on Arduino microcontroller boards and compatible devices. Arduino IDE simplifies the development of electronics projects with a simple and intuitive interface, allowing users of all skill levels, including beginners, to create microcontroller-based projects. Arduino IDE provides a text editor where users can write code in C/C++ programming language with additional Arduino libraries. This editor has basic features such as syntax coloring, auto-formatting, and line numbering. Arduino IDE has a Verify/Compile button to check for errors in code, and an Upload button to upload code to an Arduino board via USB cable. Arduino IDE provides easy access to additional libraries, allowing users to extend the functionality of the Arduino board. These libraries can be used to control sensors, communication modules, motors, and more. In addition to the official Arduino boards, Arduino IDE also supports a variety of other microcontroller boards such as ESP8266, ESP32, and many more. Support for additional boards can be added through the Boards Manager settings. The Serial Monitor feature is used to display data sent by the Arduino board via serial communication. This is very useful for debugging and monitoring the results of sensors or other connected devices. Arduino IDE can be run on various operating systems such as Windows, macOS, and Linux. Users can manage libraries and choose the type of board used with the Board Manager and Library Manager features, which allow users to add support for new microcontroller boards and third-party libraries. Arduino IDE is designed for beginners with a clean and simple interface. Users only need a little programming experience to get started [28], [29], [30].

2.3. Proposed Method

The method used in this study is the experimental method which includes the design of hardware, software, and performance flowchart on the device. In this power plant prototype, the Node MCU ESP 8266 microcontroller is used to process the values obtained from the INA 219 sensor, namely voltage (V) and current (I). After the results/values from the INA 219 sensor are transferred from the microcontroller to the NODE RED dashboard with an internet network, so that the voltage and current can be monitored. The system in this generator uses a pendulum system where the pendulum that moves up and down is hit by sea waves can be converted into rotary motion by the crankshaft and distributed to the pulley and DC generator so that it can

produce electricity. Then the current generated will be stabilized by the solar charge controller and then transferred to the battery. After the mechanical design is the hardware design or electrical wiring process such as installing step ups, step downs, sensors and other electrical components. Then continued with the software design containing the design of the installation of IoT components such as the ESP 8266 Node MCU, INA 219 Sensor, Arduino IDE programming, to the Node-Red design process. The current and voltage that appear will be transferred from the INA 219 sensor to the ESP 8266 Node MCU so that it can be monitored via Node Red.

Mechanical Design in the prototype of wave power generator can be seen in Figure 1. The pendulum that moves up and down according to the wave frequency will be channeled to the crankshaft to produce a rotary motion. Then the pulley and DC generator will rotate to produce electrical energy that is first controlled by the charger controller and then stored in the battery. The design of the tool can be seen in Figure 1 below:

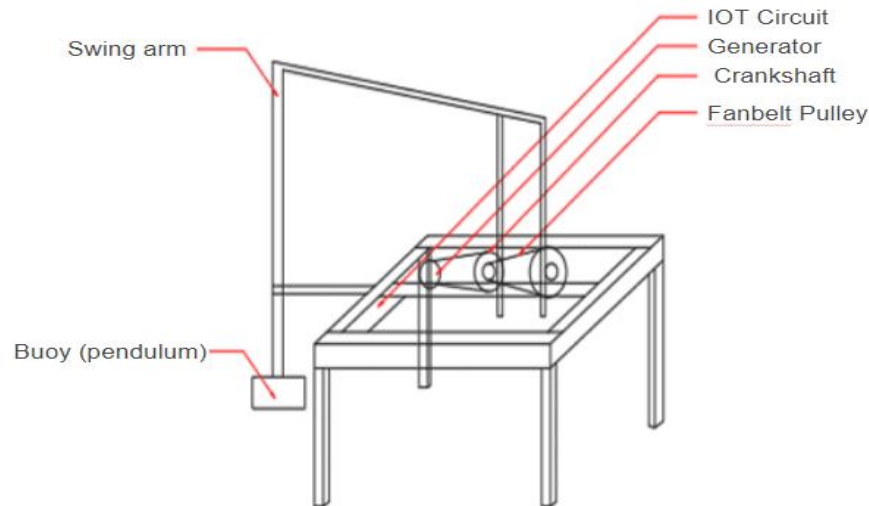


Figure 1 Power Plant Prototype Design

The wiring system in this power plant can be seen in Figure 2. The generator will rotate according to the wave speed and then be stepped up so that it can be received by the Solar Charger Controller. Then it is stepped down to adjust the voltage capacity with the sensor and microcontroller so that the current and voltage can be monitored by Node-Red. The use of lights as current indicators and resistors to stabilize the voltage so as not to damage the lights.

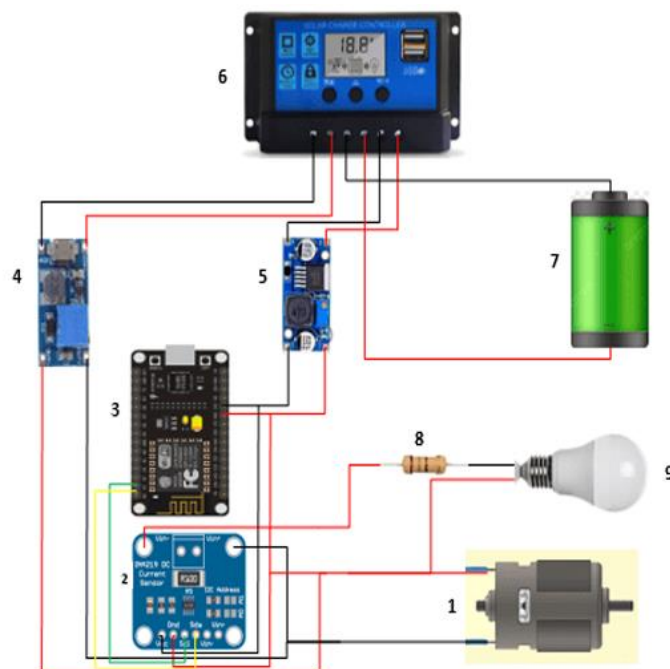


Figure 2 Wiring Components

Description of Figure 2:

1. DC Generator
2. INA 219 Sensor
3. ESP 8266 MCU Node
4. Step Up MT
5. Step Down LM 2596
6. Solar Charger Controller
7. Battery
8. Resistor
9. Lamp

The voltage (V) and current (I) generated by the prototype will be received by the INA 219 sensor which has been stabilized by step down and then transferred to the Node MCU ESP 8266 microcontroller. After being processed in the microcontroller, the data will be sent via the MQTT protocol. After that, the data is transferred to Node Red for monitoring.

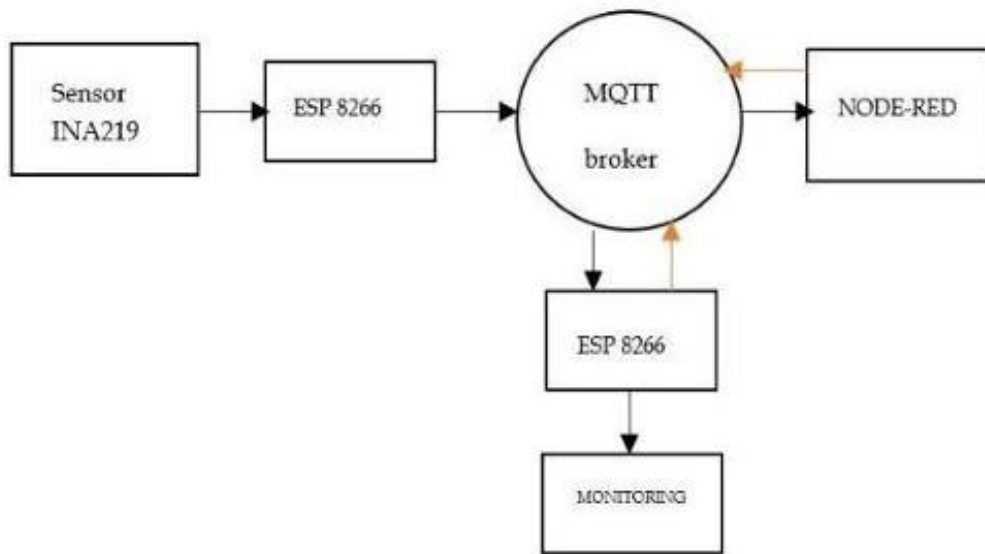


Figure 3 Software Flowchart

Table 1. Tool size specifications

No	Component	Size
1	Float arm length	58 cm
2	Tool length	100 cm
3	Tool width	80 cm
4	Tool height	85 cm
5	Float arm size	58 cm
6	Pulley 1 diameter	20 cm
7	Pulley 2 diameter	7.5 cm
8	Pulley 3 diameter	20 cm
9	Pulley 4 diameter	5 cm
10	V-Belt Pulley 1 to Pulley 2 length	120 cm
11	V-Belt Pulley 3 to Pulley 4 length	90 cm
12	Gear diameter	17 cm
13	Chain Length	45 cm

Table 1 is the specification of the length, width, height, and diameter of the tool. The results of the tool design can be seen in Figure 4. The test location point is at Goa Petapa Beach (Madura Strait), Labang District, Bangkalan Regency, Madura, East Java. 69163 (-7.1546519,112.8029124)

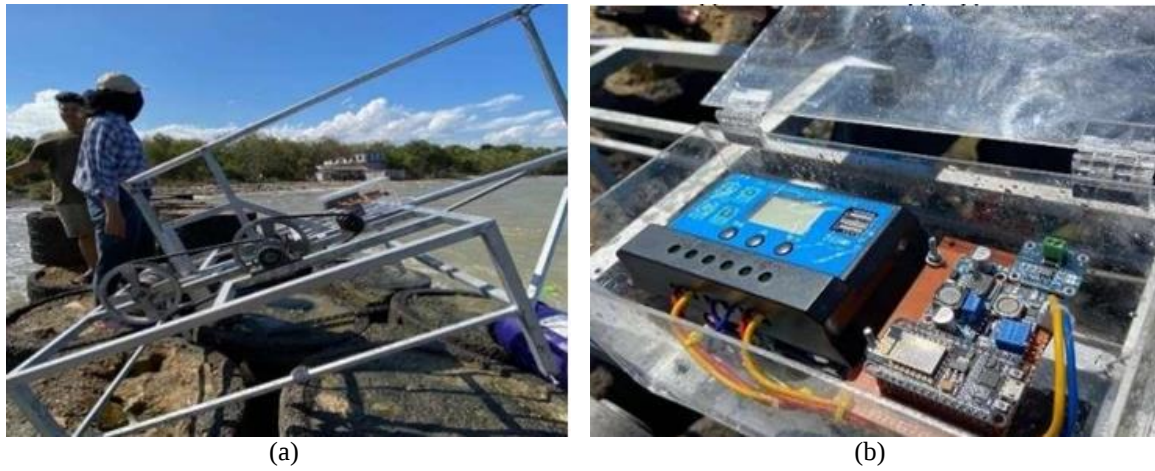


Figure 4 (a) Prototype Design (b) Component Wiring

3. RESULTS AND DISCUSSION (10 PT)

Based on the voltage graph in Figure 5 (a), the voltage in the morning at 10:00-11:00 on the blue line graph is the lowest each day. While in the afternoon at 13:00-14:00, on the orange line graph the voltage increases slightly. And in the afternoon at 16:00-17:00, the voltage is at its highest peak. On the current graph in Figure 5 (b), it can be seen that in the morning at 10:00-11:00 the current flows more stably. During the day, at 13:00-14:00 the current flow increases but is unstable. While in the afternoon at 16:00-17:00 the current flows larger and experiences the highest increase.

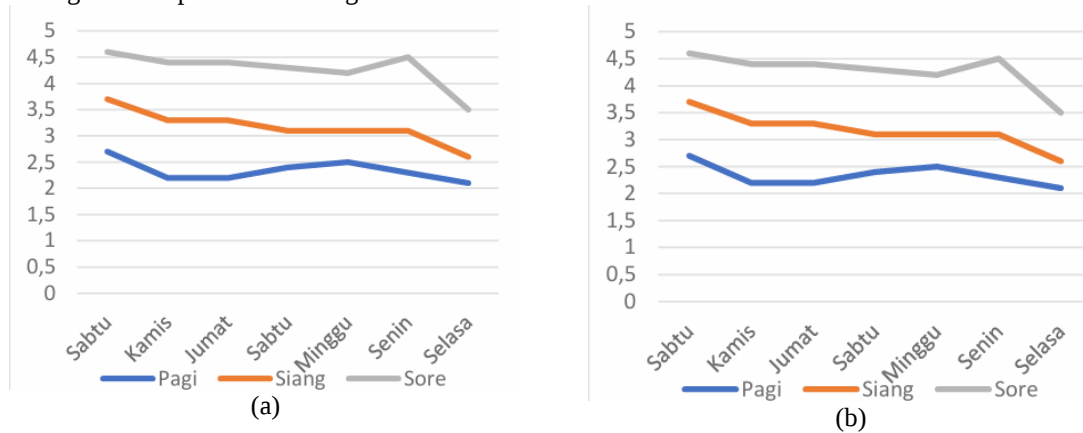


Figure 5 (a) Voltage comparison graph (b) Current comparison graph

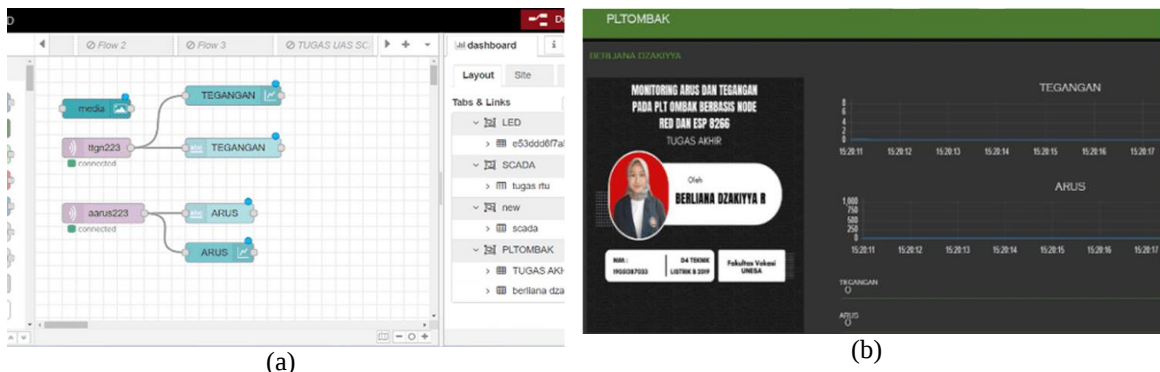


Figure 6 (a) Dashboard Settings (b) Design Results

Prototype Monitoring System via Node Red, namely with the Module providing the logic of the Node MCU ESP 8266 with the Arduino IDE program by entering the IP address and address of the module. It can be seen in Figure 6. So that mqtt can be read in the Node Red dashboard, it must be configured by matching the topic to be created. The next step is setting the graph (chart) that will be displayed. The graph setting is the Node-Red dashboard setting. The dashboard can be set according to the desired size and placement. This dashboard will later appear when monitoring is carried out.

4. CONCLUSION

Based on the test results of the design and monitoring of the Node-Red and ESP 8266 based wave power plant prototype, the following conclusions can be drawn: The performance of the wave power plant is influenced by wind speed which affects the height of sea waves. The higher the sea waves, the greater the motor rotation or rpm on the DC motor will be, resulting in high voltage. The waves reach their highest point in the afternoon. So, the most optimal time for testing is in the afternoon. The maximum generator monitoring voltage was 5.1 V with a generator rotation speed of 402 rpm which occurred on Sunday, July 9, 2023 at 17:00 with a wind speed of 4-12 kts and a wave height of 0.5-1.25 m. Meanwhile, the monitoring voltage results were at least 1.8 V with a generator rotation speed of 81 rpm which occurred on Tuesday, July 11, 2023 at 10:00 with a wind speed of 3-11 kts and a wave height of 0.5-1.25 m. Monitoring the LED lamp current of 321 mA with the condition that 9 LED lamps were on which occurred on Sunday, July 9, 2023 at 17:00 with a wind speed of 4-12 kts and a wave height of 0.5-1.25 m. Meanwhile, the results of monitoring the minimum current of 87 mA with the condition that the LED lamps were not on which occurred on Friday, July 7, 2023 at 10:32 with a wind speed of 5-18 kts and a wave height of 0.5-1.25 m. This research went well or was successful because the error in the sensor and tool was relatively small, namely 0.04% and 0.05%.

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