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Current and Voltage Monitoring in Wind Power Plants Using ESP8266 And Node-Red

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ABSTRACT

Fossil energy which is the main energy producer can be converted by utilizing wind power as an alternative renewable energy. The tool used as a wind power converter is a wind turbine, where wind power is kinetic energy that is converted into mechanical energy which is used to produce alternative energy is electrical energy. The working principle of this generator comes from the kinetic energy of the wind that rotates the propeller or windmill, then this mechanical energy runs the generator to create electrical energy. The design is carried out to find out and understand about operating Wind Power Plant Monitoring using Node-Red-based ESP8266 which is integrated with a smartphone or PC as a monitor for the tool. The design of the Wind Power Plant voltage and current monitor uses the ESP8266 microcontroller and the programmer uses the Arduino IDE software which will be applied to Node Red to create a display on the smartphone or PC screen. This study aims to produce a wind turbine prototype using the Savonius wind turbine model and monitor the output of the wind power plant using the ESP8266 which is displayed using the Node-Red dashboard.

1. INTRODUCTION

Wind is one of the renewable energy sources that has the potential to meet the energy needs of the community, one of which is to generate electricity. The study and development of wind energy utilization technology is very necessary so that its application can be adjusted and support domestic technological independence[1]–[3]. Therefore, seeing the great opportunities provided by Indonesia's natural conditions, it is very important for the young generation of Indonesia, especially students and college students, to develop and continue to improve their understanding of wind utilization as an energy conversion tool[4]–[6]. To realize this, wind energy can be utilized as a renewable alternative energy to replace fossil fuels, which have so far been the main energy source in Indonesia. The tool that can be used to convert wind energy is a wind turbine, where wind energy, which is kinetic energy, is converted into mechanical energy (rotation) which can then be utilized according to needs, namely electrical energy[7]–[10].

The increase in electrical energy every day is caused by several factors, namely the increase in population, the increase in lifestyles in high communities, and the increase in industrial growth[11]–[13]. It is very important for the young generation of Indonesia, especially students and college students to develop and continue to improve their understanding of the use of natural energy, namely wind energy as an alternative energy conversion to overcome these problems[14]–[16]. Wind Power Plants are power plants with good work efficiency compared to other power plants. The way this wind power plant works comes from the pressure and

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direction of the wind that rotates the wind turbine, then this mechanical energy runs the generator to create electrical energy[17]–[19]. To maintain the operation of this wind power plant and ensure the condition of the generator from the wind power plant from the wind speed, voltage and current produced, an operation is made, namely monitoring the wind turbine and generator, so that the plant can be monitored and does not work beyond its capabilities[20]. The monitoring used for this wind power plant will be through a web application, namely Node Red. Node Red is an internet-based or web-based application to create an Internet of Things (IoT) program. This study intends to test the monitoring system on windmills such as monitoring current and voltage on wind turbines. This study is expected to be a reference and input in building a wind power plant monitoring system on a larger scale.

2. METHOD

2.1. Node-RED

Node-RED is a very useful tool in IoT and automation application development, especially because of its ease of use with a flow-based visual interface. With extensive support for communication protocols and online services, Node-RED allows users to quickly create integrated workflows between devices and systems. Node-RED allows users to create programs by connecting "nodes" which are blocks of logic or functions through an intuitive visual interface[21]–[23]. Each node has a specific function, and developers can create workflows (flows) by connecting these nodes. Users do not need to write code manually, but simply connect functional blocks through a web-based visual interface. This makes it easy to develop and prototype applications, especially for those who are not familiar with complex programming languages. Node-RED provides various nodes that can be used to interact with hardware (such as Raspberry Pi, Arduino), network protocols, and cloud services (such as MQTT, HTTP, WebSocket, etc.)[24]. Node-RED has a large ecosystem and support from the community, so there are many nodes developed by the community to support various applications and devices[25]. Users can also create their own custom nodes if needed. Users can extend the functionality of Node-RED by adding modules available in the Node-RED Library. It includes various integrations for IoT services, databases, communication protocols, and so on. Node-RED is very popular in IoT application development because it supports various protocols such as MQTT, CoAP, Modbus, and many more, which makes it easy to manage data from sensors, actuators, and other IoT devices[26][27].

2.2. NodeMCU ESP8266

NodeMCU ESP8266 is a very powerful and flexible platform for IoT project development with integrated Wi-Fi capabilities[28]. With extensive community support, ease of development using the Arduino IDE, and its affordable price, NodeMCU is one of the top choices for prototyping and developing IoT applications. NodeMCU ESP8266 is a microcontroller-based development platform designed for Internet of Things (IoT) projects[29]–[31]. This platform uses the ESP8266 chip manufactured by Espressif Systems, which has the ability to connect devices to Wi-Fi networks and the internet. NodeMCU ESP8266 is very popular among IoT developers because of its affordable price, small size, and very capable capabilities[32][33]. NodeMCU ESP8266 has an integrated Wi-Fi module, which makes it easy for devices to communicate wirelessly over a Wi-Fi network. This is perfect for IoT applications that require internet connectivity to interact with the cloud or send data to a server. The ESP8266 uses a 32-bit Tensilica L106 processor with a clock speed of up to 160 MHz, which is fast enough to handle various data processing tasks in IoT applications[34]. The NodeMCU ESP8266 is equipped with several GPIO pins that allow users to connect various sensors, actuators, or other modules. By default, the NodeMCU uses the Lua interpreter, which allows programming using Lua scripts[35]. However, many developers prefer to program the ESP8266 using the Arduino IDE, which provides extensive libraries and community, making development easier. The ESP8266 supports various internet communication protocols such as HTTP, MQTT, and WebSocket[36]–[38]. This makes it well-suited for applications that require web connectivity or communication with cloud servers[39]. The ESP8266 has 50 KB of RAM and up to 4 MB of flash memory depending on the version, which is sufficient for many simple IoT applications[40][41]. Using the Arduino IDE, users can take advantage of a variety of existing libraries to add functionality to the NodeMCU, such as connecting sensors, accessing internet APIs, or communicating with other devices via I2C, SPI, or UART[42].

2.3. Modul XH-M604

The XH-M604 module is a practical and affordable solution for managing battery charging automatically and safely. It is widely used in various projects, including solar power systems, battery backup systems, and DIY applications involving 12V batteries. It is designed to control the battery charging process automatically. When the battery voltage drops below a predetermined limit, the module will activate charging, and automatically turn off charging when the battery reaches the upper voltage limit set. The XH-M604 allows users to set a lower voltage limit (at which charging starts) and an upper voltage limit (at which charging stops). This helps prevent the battery from overcharging and ensures stable power. The module is usually equipped

with an LED indicator to show the charging status. The LED will light up when charging is in progress and turn off when charging is complete. The module has a simple design with input (for charging power source) and output (for battery) connections, making it easy for users to connect it to a charging system. The module operates on DC voltage, usually supporting charging for 12V batteries. Some versions of the module have protection features such as overload protection and short circuit protection, thus increasing the safety of the charging system.

2.4. Proposed Method

The research method is one of the crucial aspects in conducting research with the aim of obtaining correct results on a research question. The research method is essentially a scientific means of collecting data with a specific purpose. To achieve this goal, a method is needed that is in accordance with the objectives to be achieved. The research method used is the experimental method with the aim of producing a wind power plant prototype using the Savonius turbine model and monitoring the output of the power plant. The flow of the first research design is. Starting with a Literature Study containing theoretical discussions from books, scientific journals and sources related to Wind Power Plants, a series of equipment installations. The next step is to identify the stages of the problems that arise. By identifying these problems, we can provide limitations in order to focus on research. And create design stages that are divided into two, namely hardware and software design.

Monitoring Device Design

In Figure 1, is the design of the tool or wiring of the Wind Power Plant Monitoring system using ESP8266 and using a voltage sensor then entering the automatic step up down module to stabilize the voltage and go to the charger controller which is then distributed to the battery. Before going to the battery, from the charger output the controller is measured using the INA219 sensor. All of these sensors are received by the Arduino Nano which is connected to the ESP8266, namely Serial Communication. After the ESP8266 receives all the data, it will be sent to the 16x2 LCD to display the current and voltage. Before going to the battery, from the charger output the controller is measured using the INA219 sensor. All of these sensors are received by the Arduino Nano which is connected to the ESP8266, namely Serial Communication. After the ESP8266 receives all the data, it will be sent to the 16x2 LCD to display the current and voltage

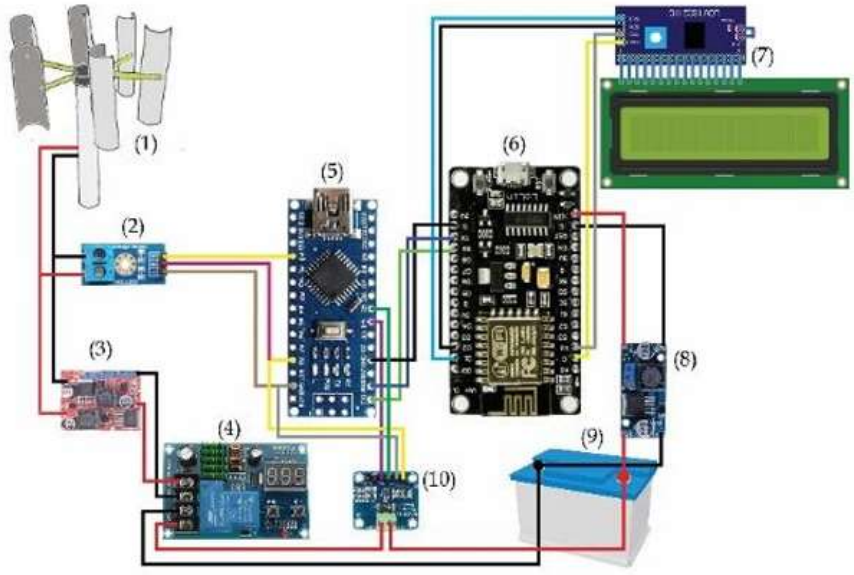


Figure 2. Wind Power Plant Monitoring Tool Design

Table 1. Monitoring System Components

No	Name
1	Wind Turbine
2	Voltage Sensor
3	Step Up Module
4	Automatic Cut Off Charger Module
5	Arduino Nano
6	NodeMCU ESP8266
7	LCD 16x2
8	Step Down Module
9	Battery Aki
10	INA219 Sensor

Monitoring System Design

This monitoring begins by using the Arduino IDE software as a program creation application for commands to hardware components connected by the Arduino Nano and distributed to the ESP8266. Then by using a Hotspot or Wifi network connected by the ESP8266, data from the ESP8266 is sent via the MQTT protocol and enters the web-based Node-Red application as an interface for monitoring the Wind Power Plant.

Based on Figure 3, the flowchart explains that the voltage from the wind turbine input will be measured using a voltage sensor, and measured using the INA219 sensor to obtain voltage and current data when charging the battery. The voltage and current data measured are read by the Arduino Nano and sent directly via serial communication to the ESP8266. On ESP8266 connects internet connection from hotspot or wifi and sends the data via mqtt protocol and is received by Node-Red application which functions to display voltage and current data results on the available dashboard. After the dashboard displayed by Node-Red, the displayed data can be placed on Google Sheets. That is where the data will be displayed in real time every second and if needed for checking incoming data, it can be saved and distributed in .xlsx format

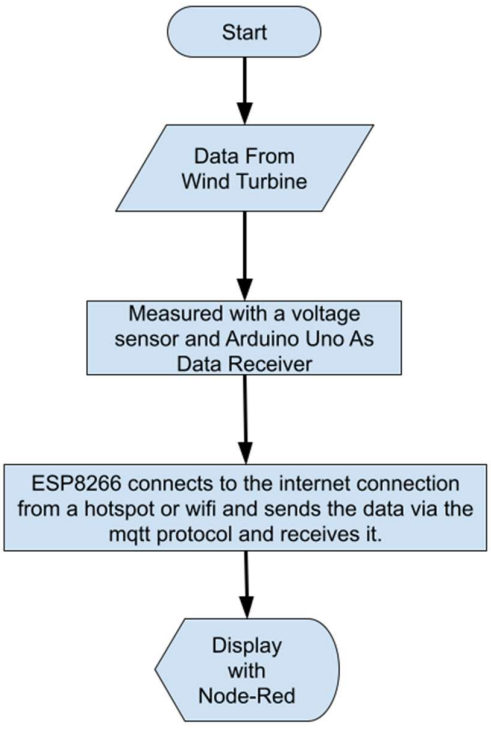


Figure 3. Monitoring System Design Flowchart

3. RESULTS AND DISCUSSION

The results of this study are in the form of a prototype of current and voltage monitoring for wind power plants where the voltage from the turbine, the voltage entering the battery and the current to the battery will be monitored with the Internet of Things system using Node-Red. In making this tool with the title Current and Voltage Monitoring on Wind Power Plants using ESP8266 based on Node-Red, using several software namely Arduino IDE and Node-Red. First, there is a wind turbine that forms a vertical with a height of 2M which rotates a 12V DC Permanent Magnet generator, as shown in Figure 4 and Figure 5.

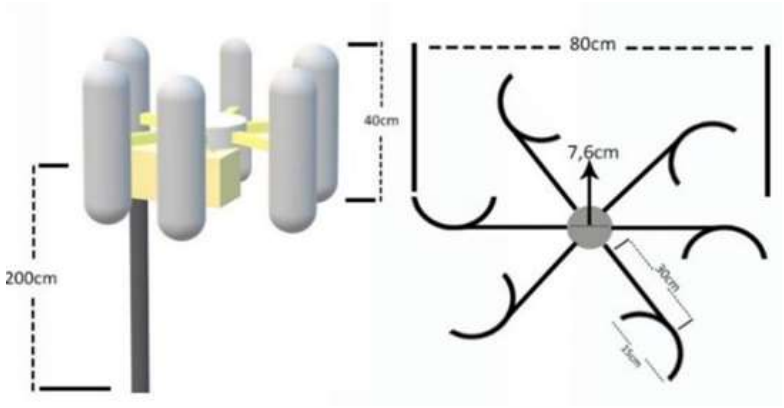


Figure 4. Savonius Wind Turbine

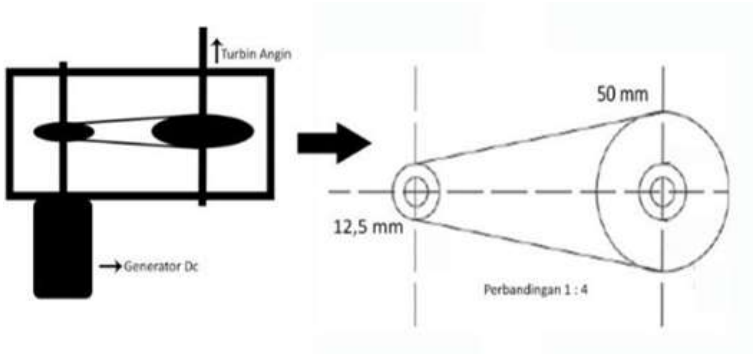


Figure 5. Gearbox Pulley

The Step Up module is used to increase the voltage from the wind turbine if the voltage produced by the turbine is less than 12V and also as a voltage stabilizer. Next, the Step Down Module is used to reduce the voltage from 12V of the battery voltage to 5V as a power source for the ESP8266 microcontroller and Arduino Nano. The next tool is the Charger Cut Off module, which is a module used to control the voltage that enters from the wind turbine to the battery and there is a cut system. off if the voltage entering the battery is in accordance with the desired limit, there is a battery as a place to store the voltage generated by the wind turbine and as a power source for the ESP8266 microcontroller and Arduino Nano. There is a wifi component, namely ESP8266 as a microcontroller that sends data to the IoT platform, namely Node Red. via the Internet network and receives data that has been sent by the Arduino Nano, namely as a microcontroller capturing data that has been taken by the INA219 sensor and DC voltage sensor. Using the INA219 sensor as a measure of voltage and current that enters the battery. And the DC voltage sensor on this tool is used as a reader of the wind turbine output voltage. Finally, this LCD is added to this tool to have a function to display data results in the form of input voltage to the battery, input current to the battery, power, and turbine output voltage. The following is a program or software design using the Arduino IDE used to run this monitoring tool. This program is divided into two parts because it uses two microcontrollers, as illustrated in Figure 6.

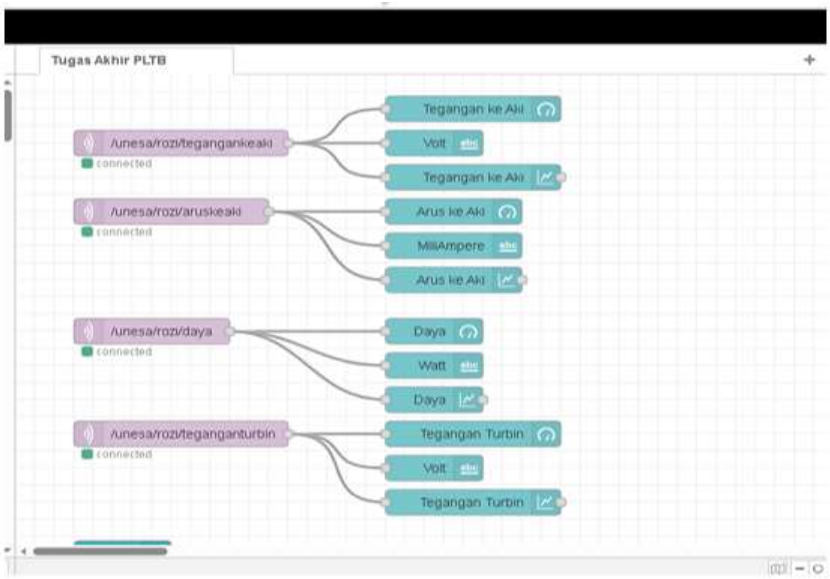
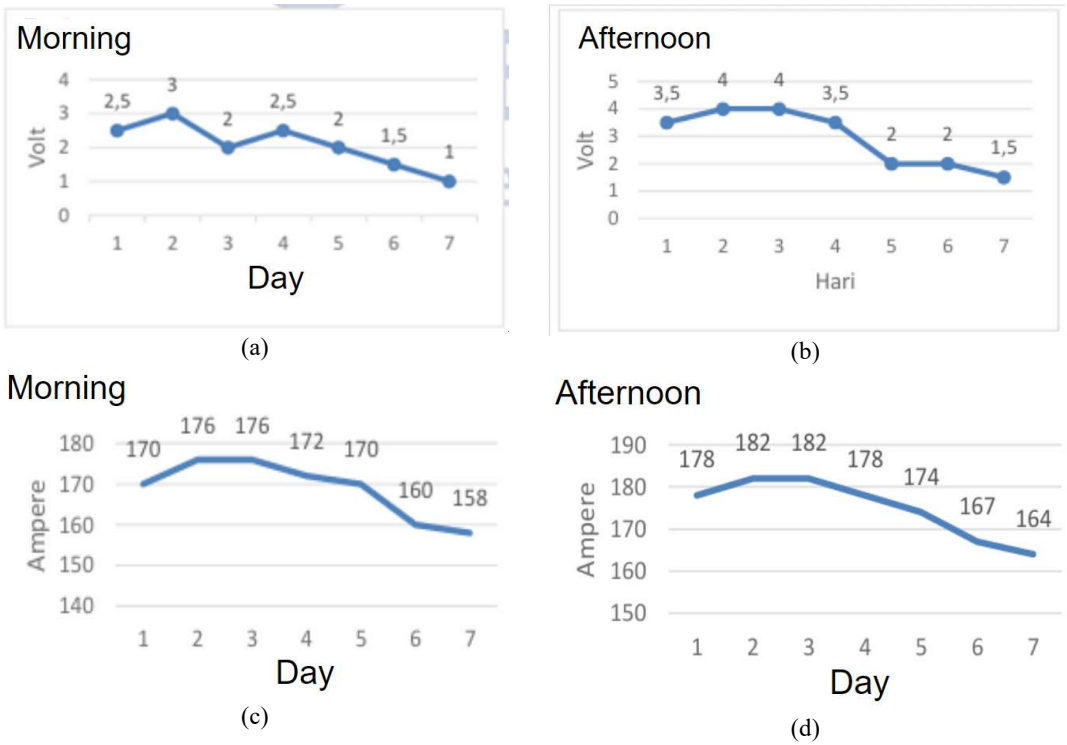


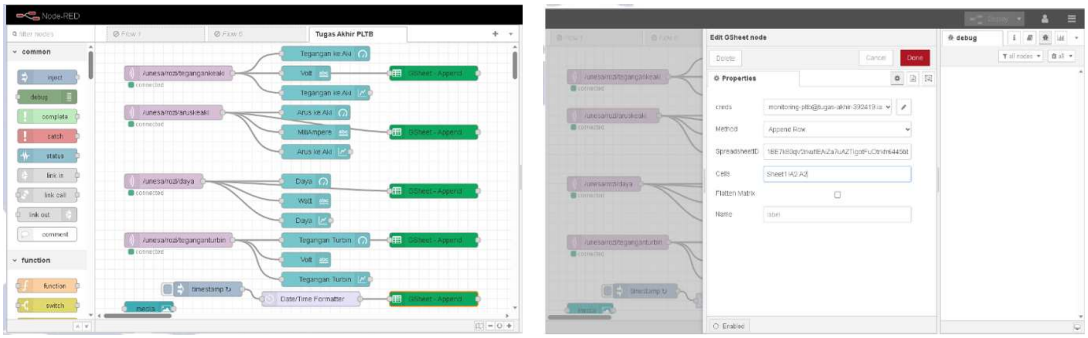
Figure 6. Screen Shoot of Node-Red Display



(a) (b) (c) (d)

Figure 7. Output from (a) Voltage in the morning (b) Voltage at noon (c) Current in the morning (d) Current at noon

Node-Red Monitoring Test as a data sender in real time via Google Sheets This test aims to send data received by Node-Red from the monitoring tool in real time so that it can monitor the development of voltage and current fluctuations via Google Sheets without having to open Node-Red again. Deploy or start on Node-Red which will make node-red run and the results from Node-Red can also be monitored via Google Sheets. From the Google Sheet results above, the resulting value is indeed irregular or not neatly arranged because the monitoring tool uses a program that can send data from each sensor and alternate for 1 second. Monitoring from Node-Red can also be done from anywhere, but is limited by the device used for monitoring and the PLTB monitoring tool must be connected to the internet.



(a) (b)

Figure 8. (a) Node-Red Flow View (b) Google Sheets Flow Settings on Node-Red

4. CONCLUSION AND LIMITATION (10 PT)

The Node-Red based IoT system installed on the Wind Power Plant can monitor the current and voltage in the Node-Red Dashboard and read with an average error range of 0.06%. Then the performance produced by this wind power plant affects the wind speed obtained, the greater the wind obtained, the voltage produced by the wind turbine also produces a large voltage, such as on the first day, the wind speed in the morning was around 2.1 - 3.0 m / s producing a voltage of 2 - 3 volts and ampere for battery charging, namely 170mApm. And the use of Google Sheets in receiving data in real time via Node-Red can function well, namely with the output of voltage, current, and power data every time, but for the output of the data it comes out one by one, such as voltage data coming out first, then followed by current, power and so on

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