The Temperature and Humidity Measurement for the Rooftop Type of Solar Power Plant Development Planning at the Building of Universitas Ichsan Gorontalo

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Abstract. Solar Power Plants can be a solution for future electricity needs in increasing Indonesia's environmentally friendly economy. It can save electricity costs more significantly than fossil energy sources such as coal. It is a profitable investment as Solar Power Plant is proven more environmentally friendly for not causing much pollution. It even helps increase electrical energy capacity. It is very strategic in supporting the direction of leading industrial cluster development in the Sulawesi region, particularly in helping overcome the electricity crisis in Gorontalo City. The Gorontalo City Government must continue to make various efforts to be energy independent in building investment in Gorontalo City. The research sample was the trial results of Internet of Things (IoT)-based monitoring instruments for measuring temperature and humidity. The results of observations on the testing of the instruments illustrated that the difference graph at high humidity with hot air conditions indicated the production of electrical energy on the solar panels. Another condition was the humidity due to weather factors was high. It was covered by clouds above the instruments set up on the building of Universitas Ichsan Gorontalo. The measurement results proved that the roof of the building of Universitas Ichsan Gorontalo is a potential area for the rooftop construction of the Solar Power Plant. Its building roof is uniquely curved with varying slopes. No other buildings share the same large area for an evenly distributed temperature around Universitas Ichsan Gorontalo in Gorontalo city.

Keywords: green building · energy · IoT · solar power plant

1 Introduction

On one side, with the depletion of fossil energy reserves, energy consumption continues to increase on the other side. It poses a threat to the development of the Indonesian economy. Some efforts need to be made to encourage efficient energy use, accompanied

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by an intensive search for new fossil energy sources. It also develops alternative energy as renewable resources [1].

Currently, a solar power plant is one of the sources of electrical energy that are renewable resources. It is widely developed because of its environmentally friendly use and easy supply, especially in countries on the equator such as Indonesia. Indonesia has a very large solar power potential reaching 207.8 gigawatts (GW), but its utilization is only 153.8 MW or 0.07% of the existing potential [2].

The construction of a solar power plant now requires very expensive installation costs. An economic calculation is needed to include the provided amount of initial investment [3]. In addition, an economic study and a feasibility study of the project are required to calculate the initial investment returns, and whether or not the construction of the solar power plant is feasible [4]. The study begins by calculating the capacity and number of equipment used in the construction of the PV mini-grid system, including the number of solar panels, the number of batteries and their capacity, the charge controller, and the type of inverter [5].

Renewable energy generation has become the choice of many countries, including Indonesia. New and Renewable Energy (EBT) generators in Indonesia are solar power plants. Not only does a Solar Power Plant target those unreached by alternative distribution networks, a necessity for public and communal facilities in Indonesia, including the need for public street lighting, but it also plays a role in energy sources in the laboratory. A solar power plant is developed for the Internet of Things (IoT)-based electronic devices. A solar power plant is a concern and is used for residential systems. The residential system's advantage is the ability to connect to the 220V AC/50 Hz PLN network with certain characteristics both in the house and in the buildings used as backup energy other than State Electricity Company [6].

Energy is a necessity vital for society. The increasing population in Indonesia stimulates the increase in energy use. In this case, the role of non-renewable energy is increasingly threatened. It is necessary to utilize and optimize the potential of new and renewable energy existing throughout Indonesia, such as geothermal, hydro energy, wind energy, bioenergy (bioethanol, biodiesel, and biomass), ocean current energy, nuclear energy, and solar energy. This review article is a review of the potential of new and renewable energy in Indonesia. It is expected that the utilization of new and renewable energy can start with people using small-scale energy. By doing so, they can protect the environment, support sustainable development, and support national energy security [7].

Indonesia, one of the countries located on the equator, has a very high radiation potential. The estimated amount is 4800 Wh/m2/day. The potentials can be utilized, one of which is as a direct power plant through the use of Solar Power Plants.

The rooftop type of Solar Power Plant operates as a process of generating electrical energy using photovoltaic modules installed and placed on the roof, walls, or other parts of buildings owned by consumers of PT. PLN (Persero), a State Electricity Company. It distributes electrical energy through the consumer electricity connection system of PT. PLN (Persero). The rooftop system of the Solar Power Plant is a configuration system that includes an on-grid system because it is connected to the electricity network of PT. PLN. It means that the power produced by the Solar Power Plant is not only for single use, but it can be channeled to the system connected to it. During the day, when the electricity production of the Solar Power Plant exceeds the load requirement, its excess is automatically channeled to the grid and automatically recorded by the Export-Import kWh meter. However, when the electricity production of the Solar Power Plant does not meet the load needs, the electrical energy of the Solar Power Plant is prioritized to be used. The remaining electricity shortage is supplied from the grid.

The rooftop type of Solar Power Plant is a form of electricity generation environmentally friendly. It is also suitable for development in urban areas because this plant installation can be installed and placed on the roof, walls, or other parts of the building. The rooftop type of Solar Power Plant installation is a form of renewable energy utilization (in this case, solar energy), which can be installed on the roof of a building of a residence, office, or educational and shopping center. To further encourage the use of solar energy, it is necessary to develop a rooftop type of solar power plant that generally has a small-scale capacity (<1 MWp). The Rooftop PV mini-grid has its advantages compared to large-scale PV mini-grid. It is easier and cheaper to integrate with existing electrical systems. It can utilize existing land (reducing land investment costs) and reduce the loads on the existing system network. The government regulates all activities of rooftop type of solar PV in every building. It is under the recommendations based on the Presidential Regulation in Attachment 1 to the Presidential Regulation of the Republic of Indonesia Number 22 of 2017 concerning the General National Energy Plan [8].

Feasibility studies are a very critical stage to determine whether or not an area is feasible for a power plant development, including the Solar Power Plant in some ways, covering technical, economic, and environmental aspects. In some cases, based on development priorities, before conducting a feasibility study, it is also necessary to undergo a pre-feasibility study on the Solar Power Plant in Gorontalo City. The two studies share the same object of investigation and sequence of implementation. The difference is the weight of investigation and assessment [9]. Gorontalo Province is a province that has an area that occupies part of the northern region of Sulawesi Island with various regional characteristics, ranging from coastal areas to mountainous areas. It has some areas that attract investors to invest in the industrial and commercial sectors. The existence of various industries has an impact on economic growth, followed by population growth. The conditions affect energy needs, both now and in the future. Currently, the fulfillment of energy in Gorontalo Province is not fully evenly distributed, especially in several districts. The condition is influenced by the existence of poor people (reaching 18.32%).

In addition, the unequal distribution of energy infrastructure is an energy problem faced by this province. The Regional Energy General Plan (REGP) of Gorontalo Province is expected to be a reference for an integrated regional energy management system in overcoming energy problems and challenges to achieve energy security and independence in Gorontalo Province. The electricity supply in Gorontalo Province, where the peak load reached 81.9 MW in 2015, is fulfilled by power plants located in Gorontalo Province and the North Sulawesi-Gorontalo Interconnection System. In t Gorontalo province, the power generation is still dominated by fuel-based power plants, Diesel Power Plant, reaching 63.08 percent of the total generating capacity in Gorontalo Province.

The composition of power generation as previously mentioned creates problems in the basic costs of providing electricity. It directly affects the selling price of electricity. On the other hand, the purchase price of electricity customers has been determined based on the Electricity Tariff of PT. PLN (Persero). The difference in the price is charged to the subsidy provided by the Government [10].

Indonesia is a country that has a large area and a high population. As a country with diverse geographical conditions and a dispersed population, Indonesia still faces challenges in meeting the energy of all its citizens. In 2016, there were still 7 million households or around 28 million Indonesians who did not have access to electricity. Inequality in access to electricity in Java and outside Java is indeed quite high, where the electrification ratio of DKI Jakarta has reached almost 100%, while provinces outside Java, particularly eastern Indonesia, such as East Nusa Tenggara and Papua, are still below 70%. This means that the fulfillment of energy in Indonesia is not evenly distributed. Besides electricity, energy challenges in Indonesia include limited access to energy demands to carry out daily activities such as cooking. Many Indonesians do not have access to fuel.

They still utilize traditional stoves for cooking. In addition to being unavailable all the time, the smoke from burning using the stove also causes health problems for the family, especially mothers and kids. In other sectors, limited access to energy plays a role in hampering economic development and education. Meanwhile, Indonesia has a high potential for clean and renewable energy. Based on data from the Ministry of Energy and Mineral Resources, Indonesia has enormous potential for renewable energy resources. The resource's potential can be utilized to create equitable and clean energy access. Even so, currently, the use of clean and renewable energy in Indonesia has only reached 6% of the national energy mix range. By looking at the scattered renewable energy potentials, domestic energy supply, especially in areas with no access to energy, can be fulfilled by utilizing local potentials.

According to Law No. 30 of 2007 concerning energy, as mandated, the National Energy Policy is prepared based on the principles of justice, sustainability, and environmental insight to support the creation of energy independence and national energy security. The implication of the policy is the need for energy diversification to meet domestic energy needs, one of which is by developing New and Renewable Energy (NRE). Indonesia is one of the 195 countries that signed the Paris Agreement and one of 164 countries in collaboration with the European Union that ratify it. With this international commitment, Indonesia has a national target to reduce greenhouse gas emissions by 29% from business as usual conditions in 2030 with its efforts and a further 41% with international assistance. This commitment requires Indonesia to develop renewable energy consistently, especially in the electricity sector. With the perspective of energy as development capital, renewable energy has a significant role in driving a green, sustainable, and low-carbon economic system. The development supported by long-term awareness has become a development trend throughout the world, responding to the increasing population, human needs, and human activities that cause environmental damage. Indonesia has renewable energy potential spread throughout the country, including solar energy sources, water energy sources and micro-hydro, wind energy sources, geothermal energy sources, ocean wave energy sources, and biomass energy

Table 1. Targets for the development of NRE power plants

Type of Generator	Target 2025 (MW)	Target 2050 (MW)
Geothermal	7.241	17.546
Water	20.96	45.397
Sun	6.379	45
Wind	1.807	28.607
Bioenergy	5.532	26.123
Other renewable energy	3.128	6.383

sources. In the context of sustainable development, current energy consumption also has the potential for energy efficiency and conservation [11] (Table 1).

Most of the installed power plants in Indonesia are still dominated by fossil fuel power plants. The continuous use of fossil fuels can cause environmental damage to occur increasingly. Therefore, to reduce the use of fossil fuels, it is necessary to develop power plants from renewable energy sources, one of which is solar power plants [12].

2 Research Method

Based on the geographical location, the administrative boundaries of Gorontalo City in the North is Tapa Subdistrict of Bone Bolango District. In the East are Kabila and Tilongkabila Subdistricts of Bone Bolango Districts. In the West are Telaga, Batudaa, and Batudaa Pantai Subdistricts of Gorontalo District. While in the South is the Gulf of Tomini. The hydrological state of Gorontalo City is presented in pictures and tables containing information or facts about hydrologic phenomena. Hydrological data is very important information in the inventory implementation of potential water sources, proper use, management of water sources, and the rehabilitation of damaged natural resources such as water, soil, and forests.

This study situates at the building of Universitas Ichsan Gorontalo in Gorontalo City, where the current availability of electrical energy is unable to keep up with demand growth, both in the short and long term in Gorontalo City (Fig. 1).

The study employs a research design through an experimental approach. It is by designing and assembling a temperature and humidity measurement instrument. It aims to analyze the operating results of a prototype device with a temperature and humidity standard calibration test instrument and the Internet of Things (IoT)-based monitoring [13].

This study conducts observations at the building of Universitas Ichsan Gorontalo. It is to find the condition of the building and the geographical location of the research site. It collects data needed to support the study. The sample in this study is through the results of the Internet of Things (IoT)-based monitoring instruments for measuring temperature

Fig. 1. Research Site Building at Universitas Ichsan Gorontalo

and humidity by designing devices consisting of NodeMCU and temperature sensors DHT11.

2.1 Hardware Tools

Hardware is one component of a computer with properties that can be seen and touched directly or in physical appearance. It serves to support the computerization process. Hardware is a computer device consisting of an arrangement of electronic components in physical form (objects) [14]. Hardware is a tool or object that can be seen, touched, held, and has a specific function. It is equipment that is physically visible and can be touched. The tool designed consists of a DHT 11 sensor, NodeMCU, battery, solar control charger, and solar panels.

2.2 Software Tools

The device software consists of programming temperature, humidity, and Blynk application for temperature and humidity monitoring. Blynk is a platform for Mobile OS applications (iOS and Android) that aims to control Arduino, Raspberry Pi, ESP8266, WEMOS D1 modules, and similar modules via the Internet [15]. The application is a creative forum to create a graphical interface for projects that will be applied only by the drag-and-drop widget method [16]. In Fig. 2, there is a DHT 11 sensor which is a temperature and humidity sensor. NodeMCU is a control system that manages programs and hardware. The 12 V DC battery is a place for storing electrical energy at night. Charger Control System (SCC) is a charging controller on batteries and solar panels functioning as power plants that utilize sunlight to fill electrical energy in the equipment.

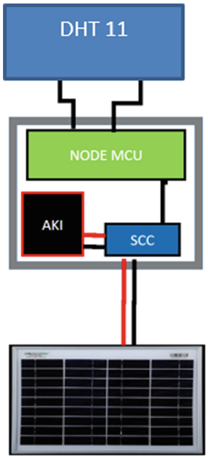

Fig. 2. Component Diagram of the Internet of Things (IoT)-Based Monitoring of Results of Temperature and Humidity Measurements

3 Result and Discussion

3.1 Design of IoT-Based Measuring Instruments at the Building of Universitas Ichsan Gorontalo

NodeMCU is an electronic board that uses the ESP8266 IC. The IC can perform functions such as those in the microcontroller. The advantage of this type of IC is that it has the feature of being able to connect to the internet network. The feature enables a device to connect to a computer or smartphone via the internet. Sending sensor data or tool control systems can be connected via the internet. The connection system used on the IC is a WiFi network system. It means that it can connect without using a network cable. Based on the results of the study on the Internet of Things (IoT)-based temperature and humidity monitoring at the building of Universitas Ichsan Gorontalo using measuring instruments as shown in Fig. 3.

With the connection feature, the use of NodeMCU in this study is very suitable because it requires monitoring of temperature and humidity from the building roof of Universitas Ichsan Gorontalo. The monitoring system needed is not constrained by place and time. The use of an Android smartphone is very suitable for this system.

DHT11 is a sensor that can measure two environmental parameters covering temperature and humidity. In the sensor, a thermistor type NTC (Negative Temperature Coefficient) is used to measure temperature. It also has a humidity sensor resistive type and an 8-bit microcontroller that processes the two sensors and sends the results to the output pins. The reading of the DHT11 sensor using NodeMcu is quite easy by just installing the Adafruit_DHT library adapted to the Arduino IDE.

The position of DHT11 temperature sensor is placed at one point on the building roof of Universitas Ichsan Gorontalo to get the actual measurement results. The position considers the temperature sensor, namely DHT11. It can be directly positioned into the

Fig. 3. Laying Temperature and Humidity Measuring Instruments on the Building Roof of Universitas Ichsan Gorontalo

Fig. 4. DHT11 sensor placement

air around Universitas Ichsan Gorontalo. The position of the DHT11 temperature sensor can be seen as shown in Fig. 4.

The testing of the instruments in this study was carried out on the building roof of Universitas Ichsan Gorontalo observed in Fig. 4. The test was carried out regarding the applicable Occupational Safety and Health. The results of observations on testing instruments can be seen in Fig. 5.

The measurement results explained that the building roof of Universitas Ichsan Gorontalo in Gorontalo is a potential construction area for the rooftop type of Solar Power Plant. The building roof of Universitas Ichsan Gorontalo is curved with varying

Fig. 5. Calibration of Instruments

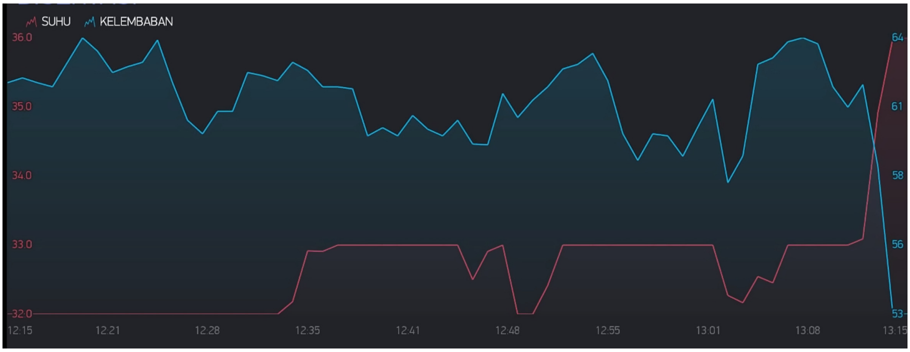

Fig. 6. Graph of Temperature Instrument Testing Process at Rooftop of Universitas Ichsan Gorontalo

slopes. Meanwhile, no other buildings share a large roof area for an evenly distributed temperature around the university building.

Based on the temperature and humidity measurement on the building roof of Universitas Ichsan Gorontalo, the characteristics of temperature and humidity are illustrated in Fig. 6.

In Fig. 6, it can be seen that the maximum humidity occurs at 64% and the minimum value is 53%. The maximum temperature on the building roof of Universitas Ichsan Gorontalo is a maximum of 36 °C and a minimum of 32 °C.

In Fig. 7, it can be seen that the maximum temperature on the building roof of Universitas Ichsan Gorontalo is a maximum of 33.1 °C and a minimum of 32.0 °C. Based on the analysis results, it was caused by the building roof being covered by clouds causing humidity to rise where the concentration of the content on the building roof increases.

Fig. 7. Graph of Humidity Instrument Testing Process at Rooftop of Universitas Ichsan Gorontalo

4 Conclusion

High temperatures (hot conditions) in the air, in this position, were able to produce electrical energy on solar panels. There are also conditions with high humidity due to weather factors, such as the place being covered by clouds above the building of Universitas Ichsan Gorontalo.

Based on measurement results, it explained that the building roof of Universitas Ichsan Gorontalo is a potential construction area for the rooftop type of Solar Power Plant. The building roof of Universitas Ichsan Gorontalo is curved with varying slopes. No other roof buildings share a large enough area for an evenly distributed temperature around Universitas Ichsan Gorontalo in Gorontalo.

The maximum temperature on the building roof of Universitas Ichsan Gorontalo is a maximum of 33.1 °C and a minimum of 32.0 °C. It is due to the analysis results indicating that the building roof was covered by clouds causing the humidity to rise where the concentration of the content on the building roof increases.

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