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Characteristics of Sunrise Intensity to Support Rooftop PV to Produce Electric Power in The Laboratory of Faculty of Engineering of The University of Riau

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Abstract

The energy production of solar modules is affected by several factors, namely sunlight irradiation, temperature, orientation, tilt angle, structural shadows, and surrounding shadows. Solar energy is a clean and inexhaustible renewable energy source. Photovoltaic cells are a key component in solar power generation, making thorough research on their output characteristics essential. This research was conducted at the Faculty of Engineering building at Riau University, located at a latitude of 0.479994°, a longitude of 101.376736°, and an altitude of 26 meters. The analysis evaluates the potential of solar energy resources at the Faculty of Engineering Campus of Riau University. The characteristics of solar energy output were measured directly using an Automatic Weather Station (AWS) throughout 2020. The AWS can measure data on radiation, temperature, humidity, and wind speed. Based on the results of direct AWS measurements, the average solar irradiation is 3.88 kWh/m²/day. The highest average irradiation occurs in May at 4.24 kWh/m²/day, and the lowest occurs in November at 3.42 kWh/m²/day.

Keywords: Campus, Photovoltaic, Characteristic, Solar, Energy

1. Introduction

Global climate change, caused by the excessive use of fossil fuels such as coal, petroleum products, and natural gas from power plants, transportation, and factories, has released billions of tons of carbon into the atmosphere [1]. Global surveys show that Indonesia is the world's largest contributor to climate change, accounting for 18 percent of global emissions. Therefore, it is crucial for Indonesia to develop an accessible platform to reduce its contribution to climate change. Coal accounted for more than 40% of the overall growth in global CO2 emissions in 2021. Coal emissions have now reached an all-time high of 15.3 Gt, surpassing the previous peak in 2014 by nearly 200 Mt of emissions [2]. The proportion of carbon emissions from fossil fuel-based power generation contributes even more significantly [3].

Emissions by sector for world regions show that Asia's CO2 emissions from heat and power generation are particularly high. Emissions from buildings and industry in Asia are also among the highest compared to other regions. It should be noted that these emissions exclude the international marine transportation and aviation sectors. Greenhouse gas (GHG) emissions are measured in CO2 equivalent units. Fossil fuel-based energy generation has a carbon footprint of about 1,000 g CO2eq/kWh of electricity generated, while solar energy generation produces only 10-100 g CO2eq/kWh, as shown in Figure 1 [4].

As a member of the G-20, Indonesia has ratified international agreements in the field of environmental protection, particularly in reducing CO2 emissions. Indonesia has committed to reducing greenhouse gas emissions by 29% by 2030, or by 41% with assistance from developed countries. The government acknowledges that coal combustion produces significant greenhouse gas (GHG) emissions, necessitating efforts to reduce emissions from coal-fired power plants [5], [6].

Indonesia has substantial renewable energy potential to achieve its primary energy mix target. This potential includes 94.3 GW of hydropower, 28.5 GW of geothermal, 207.8 GWp of solar, 60.6 GW of wind, and 17.9 GW of ocean energy [7], [8]. The National Energy Policy (KEN), based on Government Regulation No. 79 of 2014, targets a primary energy mix by 2025 of 23% renewable energy, less than 25% oil, at least 30% coal, and at least 22% natural gas. By 2050, the targets are 31% renewable energy, less than 20% oil, at least 25% coal, and at least 24% natural gas [9].

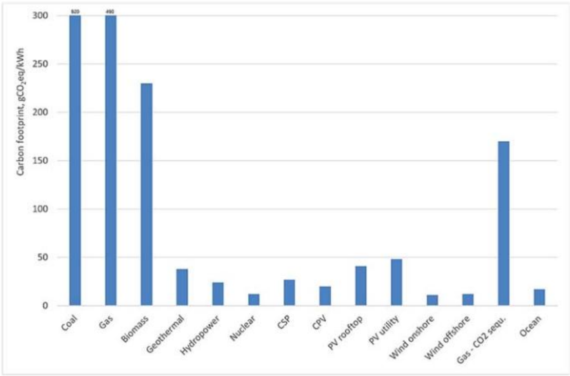

Figure 1. CO2 equivalent carbon footprint for some energy conversion technologies [4].

Renewable energy resources are becoming very popular and commonly used today. An example of a clean renewable energy resource is energy generated using photovoltaic (PV) systems. Over time, renewable energy sources are attracting more attention due to fossil fuel depletion, awareness of energy security, increased electricity demand, and growing concerns over environmental issues [10]. Solar power has become an important renewable resource for energy production worldwide. Technological advances in solar power generation have the potential to affect various stakeholders, such as power generators, power companies, equipment manufacturers, and investors [11].

Solar power offers a clean, environmentally friendly, and unlimited source of energy compared to conventional energy sources. However, it is not necessarily a completely green energy source, as there are potential environmental and socio-economic impacts associated with solar power that cannot be ignored. The successful implementation of rooftop photovoltaic systems in a country is greatly influenced by various factors, including technical aspects and policy or regulatory frameworks [12].

This research was conducted to assess the potential of solar energy in advancing the green campus concept. A green campus is characterized by the implementation of environmental conservation activities, energy efficiency measures, and the provision of comfortable conditions that support learning and working activities. Renewable energy harvesting is one of several approaches toward achieving a sustainable campus. This research analyzes the non-technical feasibility of a solar power plant in the campus area.

2. Research Methods

a. Research Location

The research was conducted in the Faculty of Engineering building complex at Riau University, located at a latitude of 0.479994°, a longitude of 101.376736°, and an altitude of 26 meters. Figure 2 shows the location of the Faculty of Engineering, Riau University, through the Google Earth application. The campus area of the Faculty of Engineering at Riau University is approximately 84,200 m².

Figure 2. Location of Riau University Faculty of Engineering building complex (Source: Google Earth)

b. Data Gathering

Solar energy characteristic data is measured using an Automatic Weather Station (AWS). AWS measures and records meteorological parameters automatically. Figure 3 shows the AWS at the Electrical Machinery Laboratory, Department of Electrical Engineering, Faculty of Engineering, Riau University.

Figure 3. Automatic Weather Station Electrical Machinery Laboratory Electrical Engineering Department Faculty of Engineering Riau University. (Source: Iswadi HR, 2020)

The AWS records meteorological data from the measurement area at intervals that can be adjusted as needed. In this research, the AWS records data on radiation, temperature, humidity, and other parameters every 5 minutes, resulting in 12 data points per hour. The radiation recorded by the AWS is the Global Horizontal Irradiation (GHI), which is the total amount of shortwave irradiation captured from above by a horizontal surface on a flat plane. This value is important for rooftop PV designs that do not use large solar irradiance tracking devices. GHI includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI) values.

Additionally, the AWS captures ambient temperature data and the humidity of the surrounding environment.

3. Research Result

Figure 4 shows that the lowest irradiation on the measurement day of August 01, 2020, was 805.9 W/m². The total energy for that day was 4,240.1 Wh/m²/day, or 4.24 kWh/m²/day.

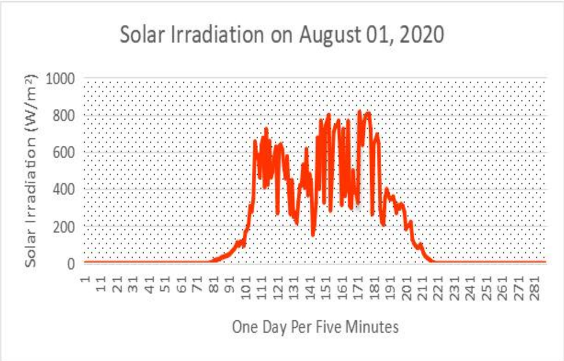

Figure 4. Graph of solar irradiation fluctuations during August 01, 2020.

Figure 5 shows that the highest irradiation on the measurement day of February 26, 2020, reached 896.4 W/m². The total energy for that day was 5,142.8 Wh/m²/day, or 5.14 kWh/m²/day.

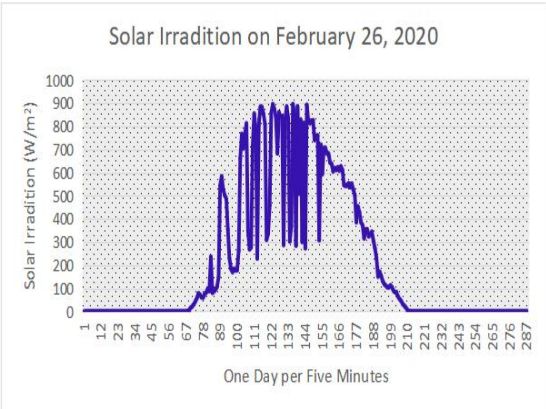

Figure 5. Graph of solar irradiation fluctuations during February 26, 2020.

Figure 6 shows that the monthly average solar irradiation is affected by seasonal changes, from January to December 2020. The highest irradiation of 132.25 kWh/m²/month occurred in May, with a daily energy of 4.24 kWh/m²/day. Meanwhile, the lowest irradiation reached 102.48 kWh/m²/month in November, with a daily energy of 3.42 kWh/m²/day. Throughout 2020, the total average solar irradiation was 3.88 kWh/m²/day. It is evident that solar irradiance is higher in the summer and lower during the rainy season.

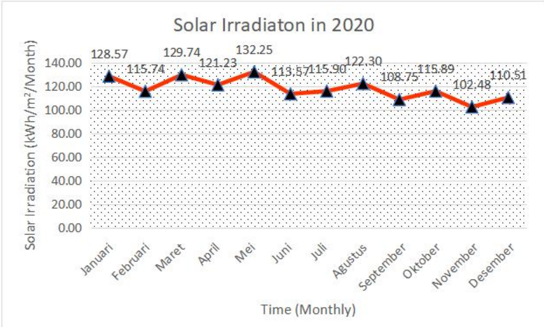

Figure 6. Solar irradiation fluctuation graph from January to December 2020.

4. Conclusion and Suggestion

This paper analyzes the characteristics of solar irradiation for the planning of rooftop photovoltaic installations. The characteristic curve obtained shows that throughout 2020, the total average solar irradiation reached 3.88 kWh/m²/day. Irradiation is affected by seasonal changes, with the highest irradiation occurring in May during the summer and the lowest in November during the rainy season. The solar energy resources at the location of the Faculty of Engineering building, Riau University, are shown to be adequate and very feasible for solar power generation. However, building orientation and shadows significantly affect the power output of solar power plants. These factors must be considered in planning solar power plants to ensure their performance meets theoretical and technical feasibility standards.

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