Planning of Solar Generation for Renewable Energy Development in the Evironment of Univeritas Siliwangi, Campus II Mugasari

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***Abstract*— The utilization of renewable energy, particularly solar energy, is becoming increasingly crucial in efforts to reduce dependence on fossil fuels and mitigate the impacts of climate change. Higher education institutions play a vital role in adopting and promoting clean energy technologies. This research aims to plan the implementation of a solar power generation system (PLTS) at Siliwangi University Campus II Mugasari using Helioscope software-based simulation.The research methodology includes topographical analysis of the location, evaluation of solar energy potential, and optimization of system design to maximize efficiency and energy output. Helioscope was chosen for its ability to model photovoltaic systems by considering critical variables such as solar radiation, panel configuration, and specific location characteristics. Simulation results indicate that the designed PLTS system has significant potential in generating electrical energy and contributing to the reduction of greenhouse gas emissions. Quantitative analysis includes estimates of energy production capacity, optimal configuration of photovoltaic arrays, and long-term system performance projections. This research provides a comprehensive blueprint for developing renewable energy infrastructure in the campus environment. Additionally, this study contributes to the body of knowledge related to the integration of solar technology in academic contexts and can serve as a replicable model for other higher education institutions in transitioning towards more sustainable and environmentally friendly campuses.**

Keywords*— renewable energy, helioscope, pv solar power plant, universitas siliwangi

I. Introduction

The drastic decline in the availability of fossil fuels, coupled with growing concerns about climate change, has pushed the world toward a critical juncture in energy transition [3]. Conventional fuels such as gasoline, oil, gas, and coal are depleting rapidly, posing significant environmental challenges [4]. The increasing environmental awareness in recent years has prompted governments to integrate renewable energy generation into national power grids to meet overall electricity demand [5] [6] [7]. Globally, the rapid growth in energy demand has led to issues of reliability and security in energy supply. Renewable energy sources have emerged as a viable solution to meet these energy needs [8]. In Indonesia, energy demand continues to rise alongside economic and population growth. As a developing country with a population of approximately 250 million spread across more than 17,000 islands [9] [10], Indonesia requires a substantial electricity supply. The availability of electricity is crucial as it determines the quality of life in a country [11]. The selection of new energy systems must consider local energy productivity, energy efficiency, and energy stability in a multidimensional manner [12]

Solar energy is one of the most promising renewable energy sources in the world today. In Indonesia, the utilization of solar energy is increasing in response to the need to reduce dependence on environmentally unfriendly fossil energy sources. Located on the equator, Indonesia has a vast solar energy potential, with an average solar radiation intensity of 4.5 kWh/m²/day, making it one of the countries with the largest solar energy potential in the world [1] [2]. The utilization of solar energy in Indonesia can play a crucial role in the deep decarbonization planned for 2060 or as early as 2050, with at least 88% of installed power capacity expected to come from solar energy [2]. However, despite this immense potential, the utilization of solar energy in Indonesia remains relatively low compared to its potential, primarily due to challenges in financing, infrastructure, and regulation [2]. Solar energy offers numerous advantages, including reducing greenhouse gas emissions, saving energy costs, and enhancing energy resilience. The use of solar panels can decrease reliance on electricity from the general grid, which often depends on fossil fuels. Additionally, solar energy is a clean and sustainable energy source that can help mitigate negative environmental impacts and support global efforts to combat climate change.

Universities serve as centers for urban development and are integral components of modern metropolises. Today's campus landscapes almost invariably include parks, forests, and one of the most promising concepts, the "Green Campus" initiative. This concept involves the construction of environmentally friendly buildings, the availability of waste separation and recycling facilities, and the use of "zero emission of heat" buildings and landscaped areas. Universitas Siliwangi, Campus II Mugasari, has significant potential to implement a solar power generation system as part of its renewable energy development initiatives [14]. By harnessing abundant solar energy potential, the university can reduce operational energy costs and enhance its image as an environmentally conscious institution. The development of solar energy at Universitas Siliwangi, Campus II Mugasari, is a strategic step to support the transition to renewable energy use. With its vast potential and appropriate policy support, solar energy can become an effective solution to meet sustainable and environmentally friendly energy needs in Indonesia.

II. Methods

This research aims to plan and analyze the Solar Power Generation System (PLTS) within the environment of Universitas Siliwangi, Campus II Mugasari, using Helioscope simulation software. This method will assist in determining the optimal system design based on solar irradiance data and the energy needs of the location. The planning is conducted in the Electrical Engineering Program Building using an on-grid system that utilizes the rooftop.

Fig. 1. Research Location

Figure 1 showing the Electrical Engineering Department building of Universitas Siliwangi, located at Mugarsari, Tamansari District, Tasikmalaya Regency, West Java, with coordinates 7°22'46" S, 108°15'09" E.

A. Data Collection

The data required for this research includes:

- Irradiance Data: Using historical solar irradiance data from nearby meteorological stations or satellite data to obtain information about solar energy potential at the location.
- Energy Consumption Data:Gathering information on energy usage on campus, including the time and types of equipment used.

B. Research Flowchart

Here are the research steps that will be conducted:

- Determining Research Location: Selecting an area in Campus II Mugasari to install solar panels.
- Data Collection: Gathering energy consumption data from each building. And collecting solar irradiance data for the location.
- Energy Needs Analysis: Calculating the total daily and annual energy requirements.
- Modeling with Helioscope: Inputting location data, panel type, and system configuration into Helioscope. Running simulations to determine the potential energy that can be generated.
- Performance Analysis: Calculating the system performance ratio and estimating energy savings. And analyzing costs and potential return on investment.
- Environmental Impact Evaluation: Assessing the environmental impact of implementing the PV system.

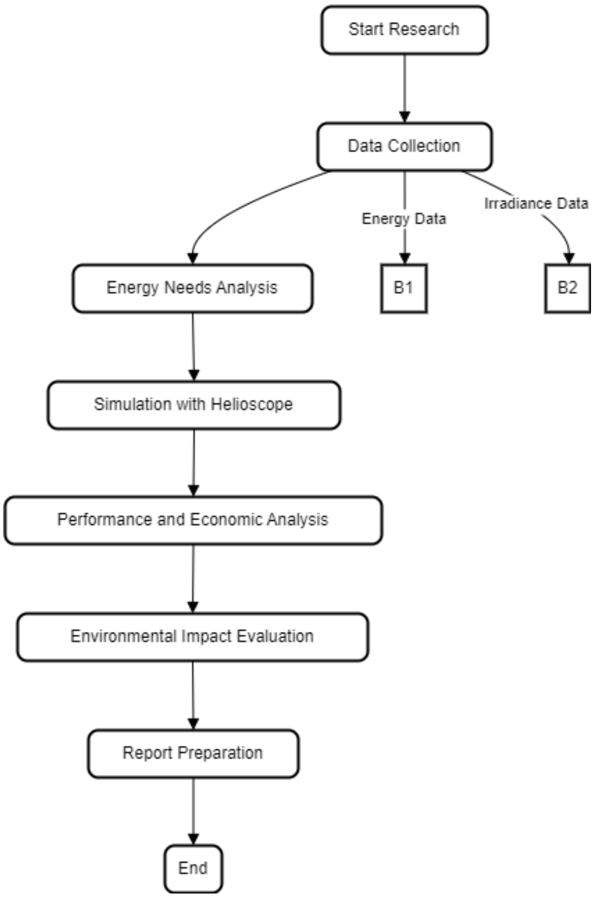


Fig. 2. Research Flowchart

III. Results and Discussion

A. Load Profile

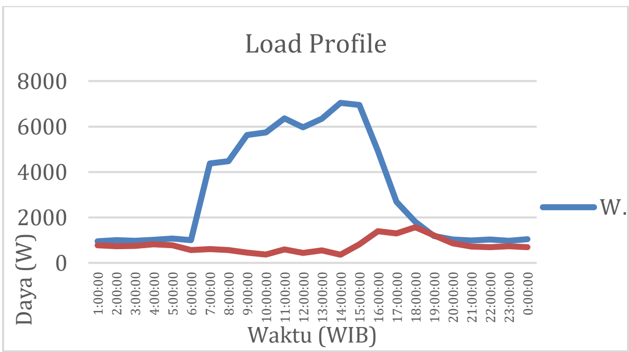


Fig. 3. Load Profile

Figure show The load profile graph shows a comparison of power consumption between weekdays and weekends in watts over a 24-hour period. On weekdays, power consumption rises sharply from early morning and peaks around 7000 watts between 10:00 AM and 12:00 PM, reflecting high activity in offices or industries. After the peak, the load gradually decreases until the evening. In contrast, on weekends, power consumption is more stable and lower, with a gradual increase from the morning to a peak of around 1800 watts during the day, before slowly decreasing towards the evening. This pattern indicates a significant difference in energy usage between weekdays and weekends, which can be used to plan for more efficient energy management.

B. Planning of PV

The energy consumption data for the Electrical Engineering Study Program building at Universitas Siliwangi from 07:00 to 17:00 is 64,277 kWh. To meet this demand, the following equation is used: The peak load consumption data for the Electrical Engineering Study Program building at Universitas Siliwangi is 70,000 kWh. To meet this demand, the following equation is used :

$$PV_{area} = \frac{E_L}{G_{av} \times \eta_{PV} \times TCF \times \eta_{In}} \quad (1)$$

$$PV_{area} = \frac{70000}{4{,}52 \times 0{,}213 \times 0{,}9398 \times 0{,}98}$$

$$PV_{area} = 78{,}994\ m^2$$

Next, to determine the capacity of the solar power plant, use the following equation

$$P_{PV} = PV_{area} \times Ir_{STC} \times \eta_{Pv} \quad (2)$$

$$P_{PV} = 78{,}994 \times 1000 \times 0.213$$

$$P_{PV} = 16{,}925{,}72\ Wp$$

Next, the power output of the solar power plant (PLTS) is divided by the capacity of one solar module, which is 550 Wp, using the following equation:

$$P_{PV} = P_{MPP} \times N \quad (1)$$

$$N = \frac{16{,}925{,}72}{550}$$

$$N = 30{,}77 \approx 30$$

$$P_{PV} = 550 \times 30$$

$$P_{PV} = 16{,}500\ Wp$$

The required solar power capacity to meet the load of the Electrical Engineering program building at Siliwangi University is 16,500 Wp.

C. System Simulation

The planning of a Solar Power Plant (PLTS) system with a capacity of 16.5 kWp is carried out to optimize the use of renewable energy at Universitas Siliwangi, Campus II Mugasari. This simulation uses Helioscope software to evaluate the potential energy production, system efficiency, and economic feasibility of the installation. Three array conditions are tested: using a roof facing northwest, southeast, and using both roofs.

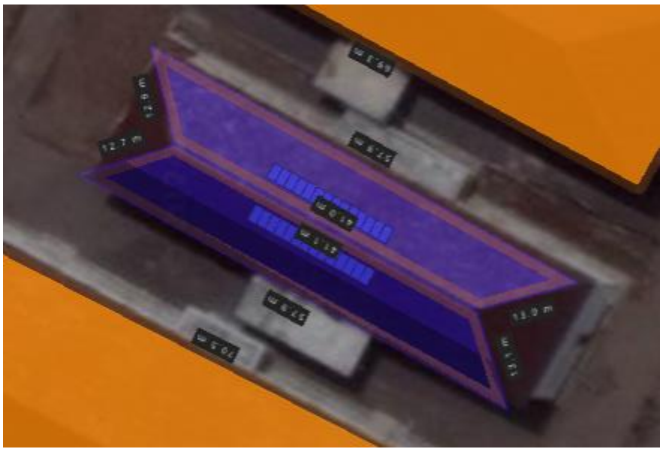


Fig. 4. Condition of the Second Roof Array

Fig 4. shows the array and capacity of solar panels in each segment. Both sides have a power capacity of 8.8 kWp with JAM72S30550/MR modules. The type of mounting is Flush Mount Racking (sloped roof), with a height of 8.9 meters and a tilt angle of 30°. The only difference between the two segments is the azimuth value (roof direction); the western side has an azimuth value of 299°, while the eastern side has an azimuth value of 119°

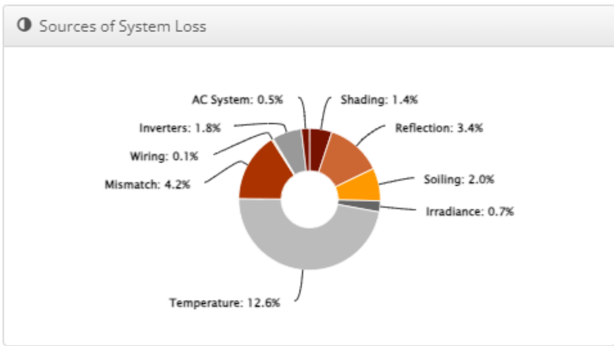
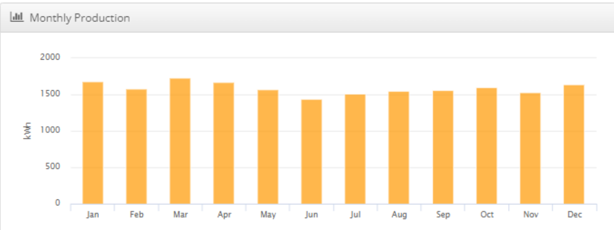


Fig. 5. Losses of the 16.5 kWp PV

The analysis shows that temperature factors contribute the most to energy losses, accounting for 12.6%, followed by module mismatch causing 4.2% losses and light reflection at 3.4%. These factors highlight the importance of considering efficiency reductions due to heat and module characteristic variations in system design. Although shading, soiling, and inverter conversion also contribute to losses, their impacts are relatively smaller, at 1.4%, 2.0%, and 1.8%, respectively. Energy losses from wiring and AC distribution are almost negligible, indicating that the cable and electrical distribution system have been well-designed. Overall, this analysis emphasizes the need for optimizing thermal and electrical aspects to maximize the efficiency of the PV system, as well as the importance of routine maintenance to reduce losses due to dirt and shading.



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	153.8	144.4	142.5	2,077.3	1,675.3
February	145.7	135.6	133.7	1,953.0	1,578.8
March	160.0	149.0	147.0	2,148.3	1,727.2
April	152.8	142.8	140.8	2,053.2	1,665.1
May	144.6	135.0	133.3	1,941.4	1,574.6
June	130.4	121.8	120.2	1,749.6	1,436.0
July	138.0	128.1	126.5	1,843.5	1,513.8
August	141.5	131.7	129.8	1,892.1	1,552.9
September	142.0	133.5	131.6	1,918.3	1,560.5
October	148.3	138.0	135.9	1,983.0	1,604.0
November	142.0	131.7	129.8	1,893.9	1,530.8
December	151.6	141.5	139.5	2,036.1	1,642.1

Fig. 6. Monthly Energy Production

Monthly Energy Production from the 16.5 kWp PV system with arrays on both sides of the roof shows stable performance throughout the year, despite seasonal variations in solar radiation and shading. The system achieves its highest energy production in March and its lowest in June, reflecting the impact of global horizontal irradiance (GHI) and shading on system performance. Although there is some energy loss due to shading and slightly reduced efficiency during months with lower radiation, the system continues to provide consistent and efficient output. Overall, this analysis indicates that the PV system is well-designed and effective in utilizing solar resources at the Universitas Siliwangi environment, with adequate energy production potential throughout the year

The economic analysis of the 16.5 kWp on-grid PV system begins with calculating the initial capital cost of installation, which amounts to IDR 185,000,000.00. The annual operational and maintenance (O&M) costs are estimated at IDR 3,000,000.00, so the total O&M cost over 20 years is estimated to be IDR 34,500,000.00. The Life Cycle Cost (LCC), which includes the initial capital and O&M costs over the 20-year project lifespan, is projected to be IDR 275,000,000.00. With an estimated annual energy production of 19,393 kWh and an electricity tariff for the B-3/TM category at IDR 1,114.75 per kWh, the annual electricity cost savings can be calculated based on this energy production.

For emission analysis, after determining the electricity generated by the PV system, the reduction in carbon emissions can be calculated. With an annual energy output of 19,393 MWh and an average emission factor of 1.05 kg/kWh, the carbon emissions produced amount to approximately 20.362.65 tons of CO_2 per year. Thus, the installation of the 16.5 kWp on-grid PV system at the Electrical Engineering Program Building of Universitas Siliwangi can reduce carbon emissions by up to 20,362.65 tons of CO_2 over its operational lifetime, which represents a significant contribution to the university's carbon footprint reduction efforts.

IV. Conclusion

Based on the economic and emissions evaluation conducted, it can be concluded that the installation of a 16.5 kWp on-grid solar photovoltaic (PV) system at the Electrical Engineering Department building of Universitas Siliwangi is a significant investment. The initial capital cost amounts to Rp 185,000,000.00, while the total operational and maintenance costs over 20 years are estimated at Rp 34,500,000.00. With a total life cycle cost (LCC) of Rp 275,000,000.00, the system is projected to generate approximately 19,393 kWh of energy per year, offering substantial electricity cost savings, especially considering the current electricity tariff at the university. From an environmental perspective, this PV system has the potential to significantly reduce carbon emissions. With an estimated annual energy production, the system can reduce emissions by up to 20,362.65 tons of CO_2 over its lifespan, thus making a substantial contribution to reducing Universitas Siliwangi's carbon footprint. Therefore, the implementation of this PV system not only provides long-term economic benefits through electricity cost savings but also supports the university's environmental sustainability initiatives by significantly reducing carbon emissions.

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