Study of potential energy at Sport Field Using PV Syst

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***Abstract*— Escalating global power consumption requires an urgent shift toward renewable energy technologies. This study analyzes the potential of a solar power plant (PLTS) at the Sport Field of Universitas Muhammadiyah Semarang. The researchers utilized PVsyst software to simulate an off-grid system design with a capacity of 12.65 kWp. The simulation evaluated five tilt angle variations ranging from 15° to 35° using Neosun 550 Wp modules. The analysis identifies the 15° tilt angle as the most optimal configuration. This specific setup generates 18.603 MWh of electrical energy annually. The system records maximum production in August and minimum production in January. The research confirms the feasibility of implementing this off-grid system to support facility operations.**

Keywords—renewable energy, PVsyst, off-grid, the Sport Field

I. INTRODUCTION

Energy consumption is inextricably linked to human economic activity, with electricity driving nearly every aspect of daily life, from industrial machinery to household appliances. However, this surging demand has precipitated a global energy crisis. The continuous rise in electricity consumption increases the workload on power generators, primarily leading to the accelerated depletion of fossil fuel resources such as oil, natural gas, and coal. Most of the global population still relies heavily on these non-renewable resources to meet their energy needs, a dependency that is unsustainable in the long term due to the finite nature of fossil reserves[1].

Beyond the issue of scarcity, the combustion of fossil fuels is the primary driver of anthropogenic climate change. To mitigate the environmental impact of carbon emissions and ensure energy security, there is a global consensus on the urgent need to transition toward New and Renewable Energy (NRE). Renewable energy technologies offer a critical pathway to reducing greenhouse gas emissions and diminishing the carbon footprint associated with conventional power generation. Among these technologies, solar photovoltaic (PV) systems have emerged as a leading solution due to their clean energy profile and the ubiquity of sunlight. Solar power innovation plays a crucial role in addressing global warming while simultaneously fulfilling future energy requirements without the ecological degradation associated with fossil fuel extraction[2][3].

Indonesia, as a tropical archipelago situated along the equator, possesses immense potential for harnessing solar energy. The country receives a relatively high and consistent intensity of solar radiation throughout the year, making it an ideal candidate for the widespread implementation of solar power plants (PLTS). Despite this abundance, the growth in national electricity loads often outpaces the supply, leading to potential disruptions or blackouts in certain regions if generation capacity is not expanded sustainably[4][5].

Recognizing this potential and the looming threat of fossil fuel depletion—data from the Agency for the Assessment and Application of Technology (BPPT) indicates that Indonesia's fossil reserves are insufficient for long-term needs—the Indonesian government has enacted proactive regulatory frameworks[6][7]. Specifically, under regulations established in 2014 (Policy No. 79) and the National Electricity Supply Business Plan (RUPTL), the government has set an ambitious target: 23% of the nation's energy must be sourced from New and Renewable Energy by the year 2025[8][9]. This policy aims to enhance local energy security, improve regional air quality, and prevent energy scarcity driven by ever-increasing demand.

One of the most effective strategies for increasing renewable energy penetration in densely populated or land-constrained areas is the deployment of Rooftop Solar Power Plants. This approach utilizes the existing surfaces of buildings—such as roofs and walls—to install photovoltaic modules, thereby avoiding the need for large-scale land acquisition often required for ground-mounted solar farms. The installation of rooftop solar PV systems has proven to be a highly effective means of delivering social, economic, and environmental benefits[10].

In Indonesia, the regulatory environment now supports the concept of "prosumers"—entities that both consume and produce electricity. Rooftop solar systems allow customers to remain connected to the local utility grid (PLN) through On-Grid configurations. Uniquely, this allows for the export and import of electricity; excess energy generated during peak sunlight hours can be exported to the grid, while electricity can be imported when solar generation is low. This exchange is monitored via kWh meters, where exported energy is converted into economic value to reduce monthly electricity bills. This mechanism not only incentivizes renewable adoption but also helps alleviate stress on the central electrical grid[11].

While the potential for solar energy in Indonesia is vast, the actual power produced by a solar power plant is directly proportional to the intensity of solar radiation received by the panels. Therefore, to maximize electrical power production, the physical and electrical design of the system must be rigorously optimized. Two critical factors influence the efficiency of a PV system: the geometric orientation (tilt and azimuth) and the electrical circuit configuration (series and parallel connections)[12][13].

Designing these systems requires precise forecasting to ensure economic and technical feasibility before physical installation. To this end, simulation software such as PVsyst has become the industry standard for modeling solar power plants. PVsyst allows researchers to simulate daily sunlight data, input geographical coordinates, and model specific

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ISSN 0216-8685 (print); 2528-6889 (online)

hardware components (modules and inverters) to estimate annual energy production[11][14][15]. The software requires parameters such as tilt, azimuth, component specifications, and shading profiles as input variables to process and output the most optimal system model. By simulating various scenarios—such as different tilt angles or string designs, planners can predict monthly fluctuations and total annual yield (MWh) with high accuracy[16].

In the context of Muhammadiyah University Semarang, the institution has many students and staff, along with supporting facilities such as sport fields, classrooms, laboratories, cafeterias, mosques, libraries, and more. All these facilities require a stable supply of electricity, and power outages can disrupt all activities. Therefore, one way to ensure the smooth operation of activities in the sport field or sport center and other facilities during power outages is to install a Solar Power Plant (PLTS) as the primary source of electricity and use batteries as backup power.

II. METHODS

The data collection and analysis methods in this PLTS system research are as follows:

1. Conducting direct field observations to Sport Field of Universitas Muhammadiyah Semarang to observe the possibility of implementing the PLTS system.
2. Collecting supporting research data, as follows:

a. Position of the PLTS component placement if in the future the Rooftop PLTS can be applied to the building.

b. Estimated installed load on the Sport Field.

3. Calculating the potential of the PLTS through simulation using PVsyst software.
4. Carrying out variations in the tilt angle of 15°, 20°, 25°, 30°, 35° in the installation of the PLTS system.
5. Conducting a comparative analysis of the PLTS performance based on production data from the PVsyst simulation with the estimated installed load.
6. Drawing conclusions.

Belmahdi and El Bouardi (2020) state that the PvSyst software utilizes key parameters as essential input variables. This simulation process identifies the most optimal model for solar power generation. The simulation examines three distinct scenarios for power generation systems. The data collection method begins with the selection of the power plant design. Users choose between on-grid, off-grid, or pumping designs.

This research employs an off-grid design. The study focuses on Sport Field for the implementation of renewable energy in public facilities. The next step involves the selection of a specific geographic site within the Sport Field area. The PvSyst application displays the research position at latitude -7.02° and longitude 110.46 ° (see Figure 1).

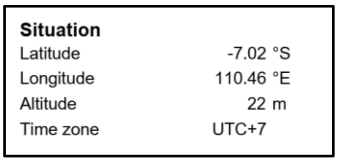

Fig. 1. Geographical Coordinates

This study does not incorporate variations in azimuth. The research utilizes slope values of 15°, 20°, 25°, 30°, or 35°. The researchers fix the azimuth value at 0°. The location contains no trees or structures that obstruct sunlight. The next phase involves the input of the planned power value. The researcher inputs an estimated power requirement of 12.65 kWp into PvSyst.

This study uses a PV module with the specification Neosun NS-550M-144-M8. Where this module has a monocrystalline type and is capable of producing power of 550 Wp on each module (see figure 2).

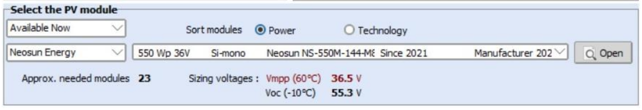

Fig. 2. PV Module

This study focuses on the variation of determining the angle of inclination of the PV module to the horizontal plane by changing the variation from 15° then changing it to 20° and the last one is changed to 35°, the next step is to run a simulation on PvSyst. In the simulation results, it will be sought which variation produces the most optimal electrical energy production.

III. RESULTS AND DISCUSSION

The PVSyst simulation results indicate the optimal potential of the solar power plant at the Sport Field of Universitas Muhammadiyah Semarang. The configuration connects 1 module in series and 23 modules in parallel. The system utilizes 23 solar modules of the Neosun NS-550M-144-M8 type. Figure 3 displays the complete simulation results for this configuration.

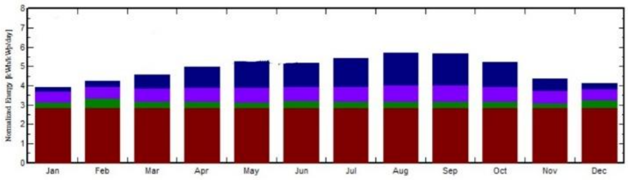

Fig. 3. Energy Production At 15° Slope

The PVsyst simulation indicates the energy production levels. The design utilizes a solar panel tilt of 15°. This configuration generates 18.603 MWh of electrical energy per year. The solar power plant exhibits fluctuating output results each month. The system achieves the highest electricity production in August. Conversely, the system records the lowest electricity production in January.

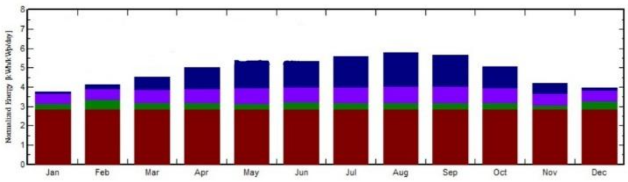

Fig. 4. Energy Production At 20° Slope

The PVsyst simulation indicates the energy production levels. The design utilizes a solar panel tilt of 20°. This configuration generates 18.501 MWh of electrical energy per year. The solar power plant exhibits fluctuating output results each month. The system achieves the highest electricity production in August. Conversely, the system records the lowest electricity production in January.

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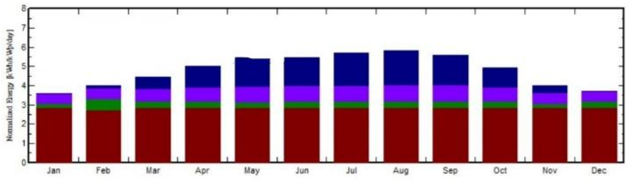

Fig. 5. Energy Production At 25° Slope

The PVsyst simulation indicates the energy production levels. The design utilizes a solar panel tilt of 25°. This configuration generates 18.285 MWh of electrical energy per year. The solar power plant exhibits fluctuating output results each month. The system achieves the highest electricity production in August. Conversely, the system records the lowest electricity production in January.

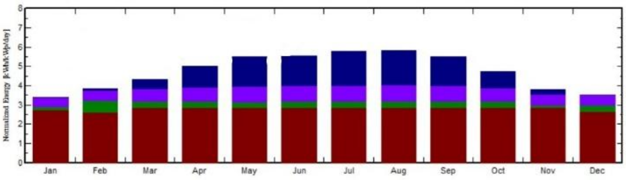

Fig. 6. Energy Production At 30° Slope

The PVsyst simulation predicts an annual energy output of 17.961 MWh. This calculation utilizes a solar panel tilt design of 30°. The solar power plant exhibits monthly fluctuations in electrical energy generation. The system achieved its highest electricity production in August. Conversely, the facility recorded the lowest energy output in January.

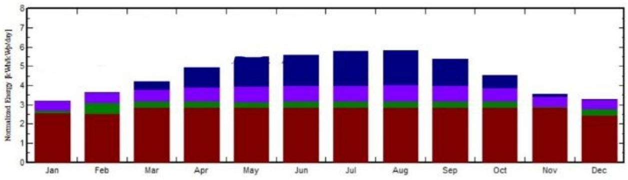

Fig. 7. Energy Production At 35° Slope

Meanwhile, based on the results of the PVSyst simulation with a 35° solar panel tilt design, the solar power generation system has the optimal potential to produce 17.525 MWh of electrical energy per year. In the study with a 35° solar panel tilt design, the largest electricity production results were obtained in July and the smallest electricity production in January.

TABLE 1 COMPILATION TILT ANGLE PLTS SYSTEM

TILT ANGLE	Energy Production (MWh)
15°	18.603
20°	18.501
25°	18.285
30°	17.961
35°	17.525

Table 1 presents the energy production comparison across different placement angles. The system achieves the most optimal energy production at a 15° angle. This configuration generates 18.603 MWh of energy. The design utilizes a series of 23 solar panel modules.

IV. CONCLUSION

The research analysis confirms the feasibility of an off-grid 12.65 kWp solar power generation system on the Sport Field at Muhammadiyah University of Semarang. The selection of the installation tilt angle directly affects the resulting energy production. The solar power plant generates electrical energy with monthly fluctuations. The system achieved its highest electricity production in August. Conversely, it recorded the lowest production in January. A 15° tilt angle yielded the most optimal energy production. This configuration produced 18.603 MWh using a series of 23 solar panel modules. An increase in connected modules boosts energy generation. However, the installation plan must consider the available area for the solar panels.

ACKNOWLEDGMENT

This work was supported by electrical engineering department, Universitas Muhammadiyah Semarang.

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