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ANALYSIS OF SOLAR ENERGY POTENTIAL IN THE PT. SUMEDANG TELEVISI UTAMA BUILDING AS AN ALTERNATIVE ENERGY SOURCE

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ABSTRACT

Indonesia is a tropical region with significant solar energy potential, where the average daily sunlight reaches 4.5 - 4.8 kWh/m²/day. This makes solar energy one of the promising forms of renewable energy worthy of development. The instability of electricity supply from the national grid (PLN) is a prevalent issue across various regions. PT. Sumedang Televisi Utama (SMTV), a television broadcasting company, frequently encounters disruptions in TV broadcasts due to power supply issues originating from PLN. Hence, this research holds the urgency to explore alternatives that can provide electricity supply during interruptions in the PLN power distribution. The contribution of this study lies in the development of a practical and applicable Photovoltaic Solar Power Plant (PLTS) module. With the implementation of this module, it is anticipated that PT. Sumedang Televisi Utama (SMTV) and other entities can have a backup electricity supply source, mitigating the impact of power supply disturbances from PLN. Suggestions for further research include delving deeper into the efficiency and performance assessment of the designed PLTS module under various environmental conditions and weather patterns that are typical in Indonesia. Furthermore, subsequent research could focus on integrating a more effective energy storage system with the PLTS module, thereby maximizing solar energy utilization even during periods of limited sunlight. This endeavor would enhance the resilience and availability of alternative power supply during instances of disruptions in the national grid (PLN) distribution.

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INTRODUCTION

Indonesia is a tropical region with significant solar energy potential, where the average daily sunlight ranges from 4.5 to 4.8 kWh/m²/day. This condition positions solar energy as an appealing form of renewable energy for development. Solar energy is not only naturally abundant but also possesses environmentally friendly characteristics. The abundant solar energy resource does not pollute the environment, even though its potential and benefits are often overlooked. In efforts to harness this energy source, Photovoltaic Solar Power Plants (PLTS) technology has emerged as an innovative and eco-friendly solution [1], [2].

This study aims to design and create a practical module for Photovoltaic Solar Power Plants (PLTS) with key components including a 30Wp Solar Panel, Solar Charge Controller, Battery (Accumulator), DC to AC Inverter, and Lamp as an example of output load. The experimental method (trial) is employed to gather necessary data [3]. However, the unstable electricity supply from the national power company (PLN) has become a recurring issue in many regions, including at PT. Sumedang Televisi Utama (SMTV), a television broadcasting company. Disruptions in the power supply from PLN often lead to broadcast interruptions that affect SMTV's operations. Therefore, this study holds the urgency to explore alternatives that can provide electricity supply during PLN power outages. An interesting option is the utilization of solar energy, which is not only limitless but also environmentally friendly [4].

Currently, all activities at SMTV rely entirely on the electricity supply from PLN, encompassing television broadcasting, video editing, local news recording, and the operation of the Master Control Room (MCR). However, during power outages, all operations at SMTV come to a halt due to the lack of an alternative energy source. The aim of this research is to provide a solution to this issue by integrating solar energy as an alternative power source during electricity outages. Thus, it is anticipated that the operational processes at SMTV can run more smoothly and effectively. Through the compilation of a report titled "Analysis of Solar Energy Potential in PT. Sumedang Televisi Utama building as an alternative energy source," the author intends to address operational disruptions caused by power failures and enhance the company's operational sustainability [5].

METODE PENELITIAN

Research Approach

This research employs a quantitative approach to gather and analyze solar energy potential data on PT. Sumedang Televisi Utama building. The quantitative method is a research approach aimed at collecting and analyzing data in the form of numbers or quantitative measurements. This approach is widely used to address various research questions that can be measured using numerical data, allowing for in-depth statistical analysis and facilitating the ability to generalize findings more broadly. Based on a strong scientific foundation, the quantitative method enables researchers to design and conduct studies with clear structures, obtaining results that are objectively measurable.By implementing structured data collection instruments such as questionnaires or systematic observations, quantitative data can be efficiently and consistently collected for further processing through meticulous statistical analysis. The goal is to reveal significant relationships, patterns, and differences within the data. The outcomes of the quantitative method not only provide information about the research sample but also serve as a robust basis for making generalizations about the phenomena under investigation in a broader population [6]

Research Methodology

This research is conducted by following a series of structured steps to analyze the solar energy potential of the PT. Sumedang Televisi Utama building. The following are the stages carried out in this study:

Objective Identification: The initial stage involves identifying the research objectives, which are to analyze the solar energy potential of the PT. Sumedang Televisi Utama building and design a suitable Solar Power Generation System (SPGS) module. Data Collection: Solar energy potential data is collected through measurements of solar radiation intensity, weather observations, and building characteristics. This data is crucial for understanding the extent of solar energy potential that can be harnessed. Solar Panel Efficiency Analysis: The efficiency of the solar panels used in the building is analyzed, including the efficiency of converting sunlight into electrical energy. This entails testing and measuring the performance of the solar panels under real conditions.

Energy Potential Calculation: Using solar radiation data and solar panel efficiency, calculations are performed to determine the potential energy that can be generated by the SPGS in the building. SPGS Framework Development: Based on the analysis and calculations, a SPGS framework is developed, encompassing key components such as solar panels, solar charge controller, and battery, DC to AC inverter, and lamps as an example of output load. Simulation and Testing: The developed SPGS framework is subjected to computer simulations and field testing. This aims to validate the performance of the SPGS in effectively harnessing solar energy.

Data Analysis and Interpretation: Data collected from measurements and testing are analyzed using statistical methods and other analytical techniques. The results of the analysis are used to interpret the efficiency and performance of the SPGS. Conclusion and Recommendations: Based on the analysis and interpretation of data, the research concludes the solar energy potential that can be utilized in the PT. Sumedang Televisi Utama building. Recommendations are also provided for future development and optimization of the SPGS. The SPGS framework in this research is based on the integration of the aforementioned key components. Solar panels collect solar radiation and convert it into electrical energy. The solar charge controller regulates the charging process of the battery with the accumulated solar energy. The battery stores solar energy for use when needed, such as during nighttime. The DC to AC inverter converts the direct current (DC) from the solar panels into alternating current (AC) that can be used by conventional electrical devices. Lamps, as an example of output load, represent the utilization of solar energy for lighting purposes [7], [8]. This SPGS framework is designed to optimize the utilization of solar energy and provide alternative electricity supply when required. By integrating these components into a unified system, the SPGS can work efficiently and effectively in generating and storing solar energy [9].

RESULTS AND DISCUSSION

Solar Energy Concept

The Solar Energy Concept refers to the understanding of the energy resource derived from sunlight and its utilization as an eco-friendly alternative energy source. Solar energy is obtained through the process of converting sunlight into usable energy in the form of heat or electricity. This concept involves knowledge about the principles of operation and components involved in the collection, conversion, and utilization of solar energy [1].

Basic Principles of Solar Energy

Solar energy is based on the fundamental concept that sunlight contains energy that can be converted into other forms of energy, such as heat or electricity. When sunlight reaches the Earth's surface, a portion of it is absorbed by objects or surfaces exposed to the sun. This absorption process involves the energy being absorbed at the atomic or molecular level, leading to an increase in temperature or separation of electric charges. This effect enables the collection and conversion of solar energy [10], [11].

Components of Solar Energy Systems

Solar energy systems consist of several main components that play a role in the collection and conversion of solar energy. These components include Specify the components in this section, or you can provide a summary of what those components are [12].

Solar Panel

Figure 1 Solar Panel

The Solar Panel is the main component of the Photovoltaic Solar Power Plant (PLTS). It is a collection of solar cells arranged in such a way to effectively absorb sunlight. The solar cells are responsible for absorbing sunlight and are composed of various photovoltaic components that can convert light into electricity. Typically, solar cells consist of semiconductor silicon layers, metals, anti-reflective coatings, and metal conductor strips. Generally, solar modules do not require routine maintenance like generators [13][14].

Inverter DC to AC

Figure 2 Inverter AC to DC

The Sungrow SG20KTL inverter is one type of three-phase inverter produced by Sungrow Power Supply Co., Ltd. This inverter has a capacity of 20 kW, which means it can convert electrical energy of up to 20 kilowatts (kW) into alternating current (AC) used in the solar power system [15]. Below are some features and common characteristics of the Sungrow SG20KTL inverter:

a. Capacity: This inverter has an output capacity of 20 kW. This capacity indicates how much electrical power can be converted into AC current.
a. Three-Phase: The inverter is designed for use in three-phase systems. Three-phase systems are used to transmit electrical power more efficiently and can handle larger loads compared to single-phase systems.
b. High Efficiency: The Sungrow SG20KTL inverter has high efficiency, meaning it can convert electrical energy with minimal loss or wastage of power. Inverter efficiency is often measured in percentage, and the Sungrow SG20KTL inverter generally has an efficiency of over 98%.
c. Protection and Reliability: The inverter is equipped with protection features such as surge protection, overcurrent protection, short circuit protection, and over temperature protection. These features help maintain the performance and extend the lifespan of the inverter by reducing the risk of damage from undesirable situations.
d. Monitoring and Communication: The Sungrow SG20KTL inverter is typically equipped with a monitoring and communication system that allows users to monitor the inverter's performance in real-time and collect useful data such as energy production, efficiency, and operational conditions.
e. Integrated Design: The inverter is designed in an integrated manner with essential components packaged into one device. This simplifies installation, maintenance, and reduces system complexity [12].

Battery

Figure 3 Battery

The battery is an energy storage device charged by the direct current (DC) flow from the solar panels. Besides storing DC power, the battery also converts chemical energy into electrical current. The battery serves two important purposes in the photovoltaic system: providing electrical power to the system when power is not provided by the solar panel array, and storing excess power generated by the panels whenever the power exceeds the load. The battery undergoes a cyclical process of storing and releasing, depending on the presence or absence of sunlight. During sunny periods, the solar panel array generates electrical power. Unused power is then used to charge the battery. During periods without sunlight, the demand for electrical power is met by the battery, which discharges the stored power [7].

Calculation for how long the battery can back up the load:

P = V x I
V = P/I
I = P/V
Where:
I = Current (Amperes)
P = Power (Watts)
V = Voltage (Volts)

The battery used is a Sodium-Nickel Chloride (NaNiCl) battery, which uses sodium chloride as an electrolyte. They have advantages in terms of high energy density, long lifespan, and the ability to handle high currents. However, they are still in development and not yet fully commercially available [15].

Solar Charge Controller

Figure 4 Solar Charge Controller

The Solar Charge Controller is a device that regulates the flow of electric current from the solar panels to the battery and vice versa. When the battery charge remains between 20% to 30%, the controller will disconnect with the load. The battery regulator also controls excess charging and excess voltage from the solar panels. The benefit of this device is to avoid full discharge and overloading, as well as monitor battery temperature. Excess voltage and charging can reduce the battery's lifespan. This controller is equipped with diode protection that prevents DC current from the battery from entering the solar panels again [7]. Some detailed functions of the solar charge controller are as follows:

a. Regulating the current for charging the battery, avoiding overcharging, and overvoltage.
b. Controlling the discharge/withdrawal of the battery to prevent full discharge and overloading.
c. Monitoring battery temperature.

Automatic Transfer Switch (ATS)

An Automatic Transfer Switch (ATS) is a device used in electrical systems to automatically switch the power supply from the main power source, which is the utility grid (PLN electricity), to the backup power source, which is the Photovoltaic Solar Power Plant (PLTS), in the event of a power outage or disruption in the main power supply. The ATS ensures a stable and uninterrupted power supply to the loads connected to the system [10].

The primary function of ATS is to detect failures in the main power supply and quickly switch the power source to the available backup source. When the main power supply is interrupted or the voltage drops below the specified threshold, the ATS will work automatically to connect the circuit to the backup power source, such as a generator. This allows for a fast and seamless transition in providing power without any disruption to the connected loads [6].

ATS is equipped with several essential components, including circuit breakers that control the flow of electricity, relays that detect power supply failures, and control mechanisms that manage the automatic operation of power source switching. ATS is often equipped with monitoring and supervision systems to provide information about the power supply status and ATS operational conditions [16].

The use of ATS is very common in various applications, such as commercial buildings, industrial facilities, data centers, hospitals, and other critical facilities where reliable power supply is crucial. With ATS, the switching of power sources can be done automatically and instantaneously, reducing recovery time and maintaining critical operational continuity for the connected loads [17].

SMTV Building Load Specifications

The SMTV building has a building electrical power of 23,000 VA, based on the data below. Therefore, we design the capacity of the PLTS to be approximately 15 kWp.

Table 1. SMTV Building Load Specifications

SMTV Building Load Specifications					
No	**Types of Electrical Loads**	**Amount (unit)**	**Loads (watt)**	**Usage (jam/hari)**	**Power (kWh/hari)**
1	Kamera	2	70	4 jam	0,56
2	Monitor	4	25	5 jam	0,5
3	Mixer Audio	2	70	4 jam	0,56
4	Mixer Video	2	100	4 jam	0,8
5	Switcher Video	1	80	1 jam	0.08
6	Rooter Wifi	2	18	24 jam	0,864
7	CPU	4	90	5 jam	1,8
8	Lampu	12	15	12 jam	2,16
9	Lampu Studio	5	300	1 jam	1,5
10	Kulkas	1	100	24 jam	2,4
11	Monitor + CPU MCR	1	200	24 jam	4,8
		Amount			16,024

Adding Photovoltaic Solar Power Plant (PLTS) as an Alternative Energy Source in PT. Sumedang Televisi Utama Building

In the television broadcasting industry, the continuity of power supply is of utmost importance to ensure the seamless airing of films or other television programs. To prevent broadcasting disruptions caused by power outages, an alternative electrical energy source is employed as a backup supply. Efforts to meet uninterrupted power needs have resulted in the integration of the main utility grid (PLN electricity) with Photovoltaic Solar Power Plants (PLTS) as backup power sources. The combination of these two electrical sources can be optimized using an Automatic Transfer Switch (ATS) system.

The ATS serves as an automated system that switches the power source from PLN to the backup power source in the event of a power outage. It consists of a contactor connected to both power sources, capable of conducting or disconnecting electrical current. The MK2P relay acts as an inverter switch, while the MCB functions as a component protector. The switching process from PLN to PLTS is based on the presence or absence of current flowing through the relay coil when connected to the PLN power source, indicating a power outage. In this scenario, the MK2P relay is in its normal state, and the inverter switch connected to the Normally Closed (NC) relay is activated, thus turning on the inverter.

The output from solar panels can be directly used for loads that require direct current (DC) voltage with low current consumption. However, to utilize generated electrical energy during conditions without sunlight, such as at night, the output from the solar panels must be connected to an energy storage medium, which is a battery in this case. However, this connection is not direct; it passes through a Solar Charge Controller (SCC) circuit, regulating the direct current charged to and discharged from the battery towards the loads. The solar charge controller manages the charging process and prevents overcharging when the battery is full, as well as regulates excess voltage from the solar panels.

PLTS, which is capable of producing direct current (DC) electricity, needs to be connected to an electronic circuit/module called the DC-AC Inverter. The DC-AC Inverter functions to convert direct current (DC) into alternating current (AC). Once the direct current is transformed into alternating current, the AC output can be directly used to power electrical and electronic equipment requiring alternating current (AC). The magnitude of the output voltage and power that can be utilized for loads should match the capacity of the inverter used and the storage system size (measured in ampere-hours or AH) of the battery.

Overall Block Diagram

The diagram below represents the ATS design in the system.

a. PLN serves as the main energy source used in this research.
b. PLTS acts as the backup energy source in case of sudden power outages or other malfunctions.
c. ATS plays a role in controlling the switching of power supply from the main energy source, PLN, to the backup energy source, PLTS, automatically. ATS is composed of several components such as EWIG SN-21 Contactor, MK2P Relay, and a single-phase MCB.

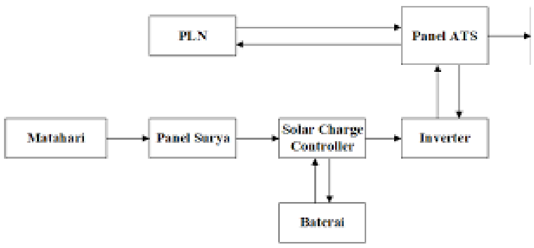

Figure 5 Block Diagram

System Design

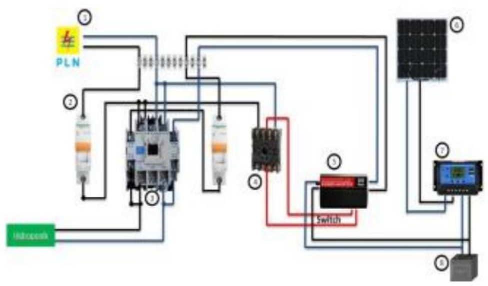

Figure 6 System Design

Wiring Diagram (PLN in the started state)

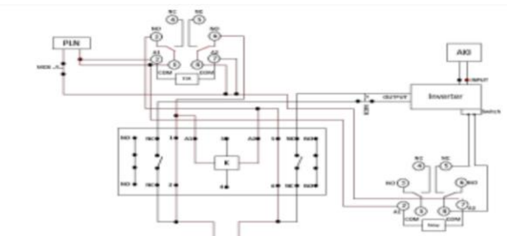

Figure 7 Wiring Diagram (PLN in the Stated State)

Explanation of the Wiring Diagram:

In this diagram, you can observe the wiring layout of the ATS (Automatic Transfer Switch) when PLN is in an active state. The main electrical source originates from PLN and is connected to a time-delay relay set for a 5-second delay to prevent sudden changes in the power source. Subsequently, the electrical current enters the coil (A1 and A2) of the contactor, activating it and causing the Normally Open (NO) circuit to close while the Normally Closed (NC) circuit disconnects. The PLN electrical current is also directed to input 1 and 5 of the contactor, flowing to output 2 and 6, thus powering the electrical devices within the building that are connected to the contactor. In this wiring diagram, the inverter remains inactive as the inverter switch is linked to the Normally Closed (NC) position of the MK2P relay. This is due to the PLN current flowing through the relay coil (A1 and A2), activating the relay and transforming the Normally Closed (NC) position into an open state, while the Normally Open (NO) position becomes connected. Within this wiring diagram of the system, no current originates from the inverter because the inverter switch is in the inactive state.

Wiring Diagram (PLTS in the started state)

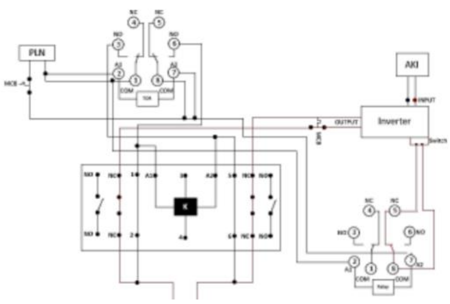

Figure 8 Wiring Diagram (PLTS in the Started State)

Explanation of the Wiring Diagram:

The illustration depicts the wiring arrangement of the ATS (Automatic Transfer Switch) when the Photovoltaic Solar Power Plant (PLTS) is operational or when the main utility grid (PLN) is in an inactive state. When the PLTS is active, the primary electrical source is derived from the inverter. This situation occurs due to the MK2P relay being in its normal state or when there is no current flowing from the PLN into the coil of the relay (A1 and A2). This condition causes the inverter switch connected to the Normally Closed (NC) relay to become connected, thereby activating the inverter.

The voltage from the 12V battery is then converted by the inverter to 220V. The current from the inverter flows to the Normally Closed (NC) contactor, which is a component of the contactor assembly. When the PLN is inactive, the contactor returns to its normal state with the Normally Closed (NC) position connected. This configuration allows the current from the inverter to flow through the contactor, providing power to the electrical devices in the building. In other words, when the PLN is not supplying power, the inverter plays the role of the primary electrical source. The 12V battery voltage is transformed to 220V by the inverter, and the current from the inverter flows through the contactor to supply power to the electrical devices in the building.

Web Global Solar Atlas

The Web Global Solar Atlas is an online platform that serves as a comprehensive resource providing valuable information about solar energy potential on a global scale. Developed by the World Bank, this platform is designed to grant easy access to a wide array of data collected from diverse and credible sources, encompassing satellite imagery, solar irradiance data, and sophisticated simulation models [18].

The primary objective behind the creation of the Web Global Solar Atlas is to support solar energy project developers, stakeholders, and the general public in obtaining detailed insights into the solar energy potential at various locations around the world. By harnessing the capabilities of this platform, users are empowered to:

View Solar Radiation Maps

The platform offers an interactive interface that presents users with comprehensive maps showcasing the levels of solar radiation across different geographical regions. Users have the flexibility to explore and analyze solar irradiance data, ranging from average annual and monthly figures to daily and even hourly measurements. This wealth of data facilitates a deep understanding of the availability of sunlight and its variations over time [19].

Access Numerical Data

Beyond the visual aids provided through maps, the platform provides direct access to a rich repository of numerical data associated with solar energy potential at specific locations. This encompassing dataset includes essential information such as solar irradiance levels, ambient air temperature, temperature of solar modules, and estimations of solar energy production.

Evaluating Project Potential:

Leveraging the information furnished by the platform, solar energy project developers are empowered to perform in-depth potential analyses and make informed decisions regarding the selection of optimal project sites. Data related to solar irradiance, anticipated energy production, and various other influencing factors contribute to enhanced project planning and decision-making processes.

Obtain Technical Information

The Web Global Solar Atlas also serves as a valuable resource for obtaining technical details. It offers supplementary information such as the methodologies employed for measuring solar irradiance, the simulation models utilized for calculations, and other relevant data sources that can be harnessed for further advanced research and analysis. This aspect supports professionals and researchers in expanding their understanding of solar energy dynamics and making well-informed conclusions based on accurate technical insights.

Rooftop Configuration

PV Out Information

PV Out Map: In Figure, there is information depicting the power output level (PV Out) in the Rooftop configuration. The range of PV Out values is between 1400 kWh/kWp and 1600 kWh/kWp. This indicates the amount of electrical energy generated by each installed power unit of the rooftop solar panel system. In other words, each kilowatt peak (kWp) of solar panel capacity on the roof is capable of producing approximately 1400 to 1600 kilowatt-hours (kWh) of electrical energy during a specific period, such as a year. This quantity provides a further insight into the potential performance of the solar panel system and its effectiveness in generating solar energy.

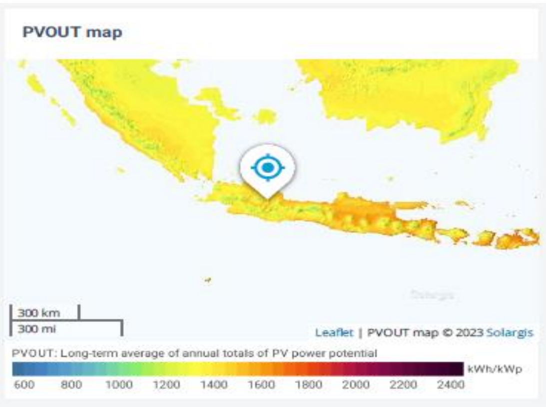

Figure 9 Rooffop PV Out Map

Average Monthly PV Out: The average PV Out per month can be seen in the image below.

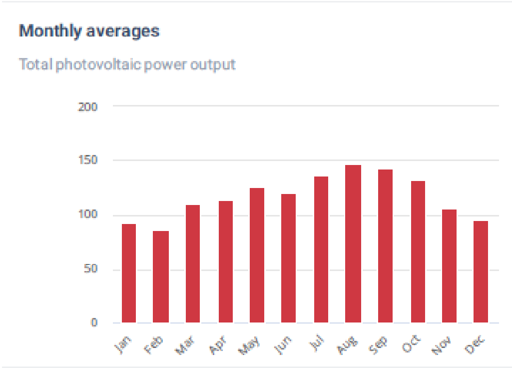

Figure 10 Average Rooftop PV Out per month in 2023

Radiation Information

The information on the potential radiation levels in Sumedang Regency is displayed in the image below.

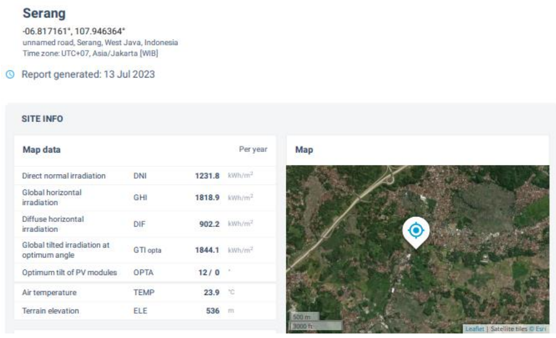

Figure 11 Radiation Information

Solar Altitude

Information regarding the elevation angle of the Rooftop in Sumedang Regency can be found in the Figure. From the illustration, it can be inferred that the optimal orientation for solar panels is facing North at an inclination angle of approximately 12 degrees. By orienting the solar panels towards the North, the solar panel system will receive more even sunlight throughout the day, as the sun mostly moves across the southern sky. The 12-degree inclination angle also represents an angle that can maximize sun exposure throughout the year, optimizing solar energy production under varying weather conditions. Therefore, adjusting the angle and orientation of the solar panels towards the North with a 12-degree inclination can enhance the efficiency and performance of the solar panel system at that location.

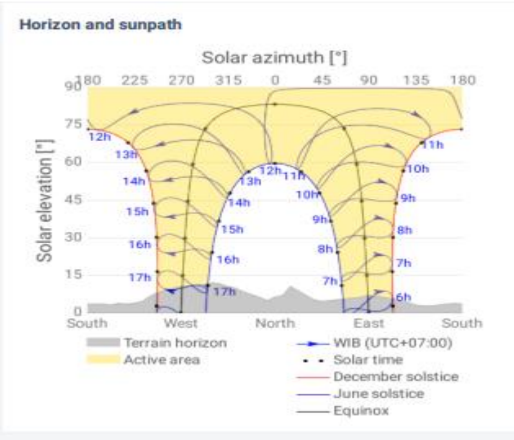

Figure 12 Solar Altitude

CONCLUSION

This research underscores the significance of uninterrupted power supply in the television broadcasting industry to ensure seamless broadcasting operations. Power outages can disrupt broadcasts, hence the use of alternative electrical energy sources as backups. The integration of the main utility grid (PLN) with Photovoltaic Solar Power Plants (PLTS) as backup sources is the adopted solution to meet uninterrupted power needs. The utilization of the Automatic Transfer Switch (ATS) system optimizes the transition between these two power sources.

The implication of this research is the provision of a solution to enhance the reliability of power supply in television broadcasting operations through the integration of PLN and PLTS with the assistance of ATS. However, this research has several limitations, including its focus on the context of the television broadcasting industry, which may not directly apply to other scenarios. Furthermore, this study may not comprehensively address the environmental and economic impacts. To further develop this research, several suggestions can be considered. The research can involve a deeper analysis of the environmental and economic impacts of implementing the integration of PLN and PLTS with ATS

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