Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 01, 2024, DOI 10.54209/infosains.v14i01
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

Potential of rooftop solar electric energy on campus buildings high school of technology Sinar Husni using helioscope software

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Article Info

Keywords:
Photovoltaic system,
Helioscope,
Solar Panel,
Energy Potential

ABSTRACT

This research is directed at analyzing the potential of electrical energy from Rooftop Solar Power Plants in the Sinar Husni College of Technology Campus Building, with the utilization of Helioscope software. This research is the basis for understanding the extent of solar energy potential that can be generated by solar power plants in the STT Sinar Husni campus building. The method used involves reviewing literature related to solar energy, Solar Power Plants, and the use of Helioscope as analysis software. The location of this research is the Sinar Husni College of Technology Campus Building. The process of retrieving solar radiation data for one year from the meteonorm website was carried out by accessing the meteonorm web platform. In this study, a monocrystalline solar module with a capacity of 320 Wp was used. By utilizing the Google Earth application, information was generated that the area available for the installation of solar modules is 270 m2. To determine the right number of PV modules according to the desired design, Helioscope software was used. The calculation results show that the building can accommodate the installation of 77 solar panels. Solar Radiation / Irradiance: The solar radiation received at this location, expressed in kWh/m2, reached 1,466.3 kWh/m2 in one year. Power Generated by Solar Panels: The solar panel type Trina Solar, model TSM-PD14 320 (May16) (320W) in one year reached 31,248.5 kWh.

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INTRODUCTION

The utilization of solar energy as an environmentally friendly renewable energy source is increasingly becoming a focus in the development of energy technology.(Ridwan et al., 2021)One of the solutions presented is the Solar Power Plant which can generate electricity through solar cells. Indonesia, as a country located in the equatorial region, has great potential in the utilization of solar energy. Indonesia's geographical condition consisting of thousands of islands makes PLN electricity impossible in many remote areas. As a tropical country, Indonesia has intense solar energy potential, with an average daily radiation (sunlight) of 4.5 kWh/m^2/day. The utilization of Solar Power Plant technology as

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a potential utilization of solar energy at that location is a good solution.(Shrestha, A. K., Thapa, A., & Gautam, 2019; Zakri, A. A., Rosma, I. H., & Simanullang, 2018)

Rooftop solar power plants are solar power plants installed on the roofs of buildings, both residential and commercial.(Anjarani et al., 2023) Although it has a smaller capacity, rooftop solar power plants have several advantages, including that the existing land can also be used to reduce costs on land investment. Another advantage is that it is easier and cheaper to connect to the existing electricity system.(Tarigan, 2022) The basic characteristic of rooftop solar power plants is that power generation is only done during the daytime. Therefore, the development of rooftop solar technology is expected to contribute to meeting electricity demand, especially in remote areas.(Shaher et al., 2023)

This research will discuss the potential use of an on-grid solar power system by utilizing Helioscope software in the Sinar Husni College of Technology Campus Building. The main focus is to identify the extent of sustainability and energy efficiency that can be achieved through the implementation of this technology.(Li et al., 2020) In addition, this research will also detail the solar cell array scheme and perform Simulating Report calculations using Helioscope software to gain an in-depth understanding of the potential power generated by the solar power system, especially on the rooftop of the Sinar Husni College of Technology Campus Building.

Polines is located in the city of Semarang which has an astronomical location7.0521006° Lat and 110.4353347° Long. The potential of rooftop solar power plants at the Semarang State Polytechnic Mechanical Engineering Workshop. The study focuses on the angle of inclination of the solar panels and its impact on the power and energy produced by solar cells. The research utilized Helioscope software to simulate the optimal angle of inclination for the solar panels on the rooftop PLTS at the Semarang State Polytechnic Machinery Workshop Building.

The results indicated that the optimal angle of inclination is 10°, with a radiation received of 1773.7 kWh/m^2 and a total energy production of 13577.8 kWh. The study aims to optimize the utilization of solar energy as an alternative energy source. The findings of this research provide valuable insights for future studies on rooftop solar power plants, particularly in the context of the Semarang State Polytechnic Mechanical Engineering Workshop. (Sugiono et al., 2022)

Research on the design and simulation of On-Grid Rooftop Solar Power Plant system in Riau University campus building. This study aims to provide a panorama of current knowledge and identify gaps in existing research. The main objectives of this study are to present the On-Grid Rooftop Solar PV system, the integration of clean energy sources with the existing electricity system, the importance of clean energy sources in a sustainable sustainable energy system, a review of On-Grid Rooftop Solar PV systems in various buildings, and the development and testing of solar energy systems.

The methods used include HelioScope simulations to evaluate the design and performance of the On-Grid Rooftop Solar PV system. (Khan et al., n.d.; Umar et al., 2018)The results of this simulation are used to determine the potential electrical energy that can be generated by the On-Grid Rooftop Solar PV system and compare it with the annual electrical load requirements of the Riau University campus buildings. In addition, this research also discusses the data analysis of the simulation and the comparison of the energy generated by the On-Grid Rooftop PLTS system with the annual electricity load requirements of the Riau University campus buildings. Overall, this research provides a comprehensive understanding of the design and simulation of On-Grid Rooftop Solar Power Plant systems in Riau University campus buildings.(Yakin et al., 2020)

METHODS

This research is directed at analyzing the potential of electrical energy from Rooftop Solar Power Plants in the Sinar Husni College of Technology Campus Building, with the utilization of Helioscope software. This research is the basis for understanding the extent of the potential of solar energy that can be generated by PLTS in the STT Sinar Husni campus building.

The importance of this research lies in the contribution of PLTS Rooftop to supply the electrical load on the campus building, especially during the day. By optimizing the use of renewable natural resources, this research aims to create an efficient and sustainable energy source. The selection of Helioscope as the analysis software is the main consideration due to its ability to present the results of the PLTS planning in detail, including shadow analysis, component efficiency, and solar panel layout optimization.(Rahmaniar et al., 2023)

The results of this study are expected to provide a clear picture of the potential of Rooftop Solar Power Plant in STT Sinar Husni campus building. The data obtained from the analysis using Helioscope is expected to be a reference for decision making regarding the implementation of PLTS, which in turn can be a significant step towards reducing dependence on conventional energy sources.

Figure 1. The rooftop location of Sinar Husni College of Technology

The results of this study are expected to provide a clear picture of the potential of Rooftop Solar PV in the STT Sinar Husni campus building. The data obtained from the analysis using Helioscope is expected to be a reference for decision-making regarding the

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implementation of PLTS, which in turn can be a significant step towards reducing dependence on conventional energy sources.

During the day, solar radiation is captured by solar modules to be converted into electrical energy. Electrical energy from the solar module circuit is channeled to the DC protection box. From the DC protection box, it is channeled to the inverter, the DC electrical input is converted into AC output by the inverter. The output electrical energy from the inverter is channeled to the AC protection and kwh meter which is then channeled to the distribution panel.

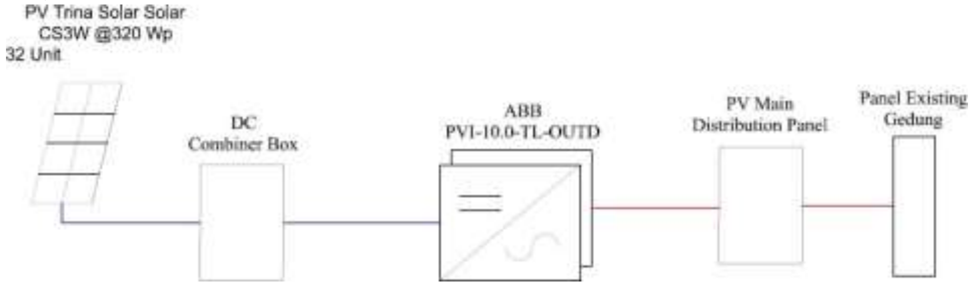

Figure 2. Block Diagram

Determining Component Specifications

In planning the Off-Grid Solar Power Plant at the Sinar Husni College of Technology Campus Building, an important step is to determine the type of solar panels and inverters to be used. The determination of the specifications of these components will be based on the Helioscope simulation results.

By understanding the information obtained through the simulation, we can more precisely determine the type and specifications of solar panels and inverters that best suit the characteristics and energy needs of the building. This step is key to ensuring the optimal performance and efficiency of the Off-Grid Solar PV system to be implemented, so that it can provide maximum benefits in supplying the energy needs of the Sinar Husni College of Technology Campus Building. (Konneh et al., 2021; Mohanty et al., 2016)

In determining the type of solar panel, energy conversion efficiency, tolerance to shadows, and space utilization efficiency are the main considerations. Inverter selection must also consider the ability to generate power in accordance with the building's electrical load and high energy conversion efficiency.(Peng et al., n.d.)

By using Helioscope as an application to plan the potential of electrical energy, Helisocope provides a suitable device for use, namely:

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1. Solar panel module

   The solar panel modules used are as follows:

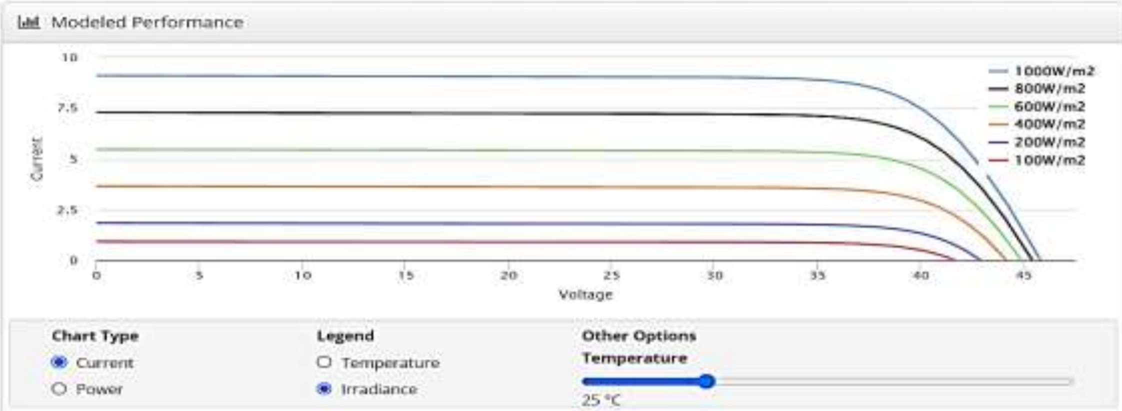
Module Model	
Name	TSM-PD14 320 (May16)
Manufacturer	Trina Solar
Power	320.0 W
Technology	Si-Poly (72 cells)
Source	Photon DB
Uploaded By	HelioScope

Module Characterization	
Power	320.0 W
V_{mp}	37.100V
V_{oc}	45.800V
I_{sc}	9.100A
I_{mp}	8.630A
Dimensions	0.992m x 1.956m
Temp Coefficient P_{max}	-0.410%/°C
Temp Coefficient V_{oc}	-0.320%/°C
Temp Coefficient I_{sc}	0.05000%/°C
Last Update	2/15/18 4:19 AM

Figure 3. Solar Panel models and characteristics

Spec Sheet Characterization (PAN)

From spec sheet. Methodology based on module ideality (gamma) and series resistance jointly optimized to match I/V curves to Vmp, Imp, Voc, and Isc



Irradiance (W/m²)	I_{SC}	V_{OC}	I_{MP}	V_{MP}	Power	dP_{mp}/dT	dV_{mp}/dT	dV_{oc}/dT
1000	9.10	45.8	8.56	37.4	320.4	-0.41%	-0.43%	-0.34%
800	7.28	45.4	6.84	37.6	257.1	-0.41%	-0.43%	-0.35%
600	5.46	44.9	5.12	37.6	192.6	-0.41%	-0.43%	-0.36%
400	3.64	44.1	3.40	37.4	127.5	-0.42%	-0.44%	-0.37%
200	1.82	42.9	1.69	36.8	62.2	-0.43%	-0.46%	-0.39%
100	0.91	41.6	0.84	35.8	30.0	-0.44%	-0.48%	-0.41%

Figure 4. Current Characteristics of Solar Radiation

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2. Inverter module

   The inverter module used in the helioscope is as follows:

Spec Sheet	
Name	Sunny Tripower 24000TL-US
Manufacturer	SMA
Max Power	24.1 kW
Min Power	0
Max Voltage	1,000V
Max MPPT Voltage	800V
Min MPPT Voltage	150V
Min Voltage	150V
Source	CEC
Uploaded By	HelioScope
Last Update	

Figure 5. Inverter Specification Data

Figure 6. Inverter Performance Graph

Efficiency Table

Power	Voltage			
	150	450	712	800
2,410	95.5%	96.1%	97.5%	96.9%
4,820	95.5%	97.4%	98.3%	98.0%
7,230	95.5%	97.4%	98.5%	98.2%
12,050	95.5%	97.3%	98.5%	98.2%
18,075	95.5%	97.1%	98.4%	98.1%
24,100	95.5%	96.9%	98.3%	97.9%

Figure 7. Inverter efficiency

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RESULTS AND DISCUSSION

Solar Power Plant Planning

When analyzing the planning needs of Off-Grid Solar PV, the first step is to thoroughly understand the underlying data in the building. The information obtained from this data will be the basis for detailing the construction plan of the grid-connected solar power plant.

It is important to consider various aspects in this planning. One of the crucial things is the proper calculation of the power required in the solar system. By performing accurate calculations, we can optimize the capacity and output of the solar power plant to match the desired energy needs.

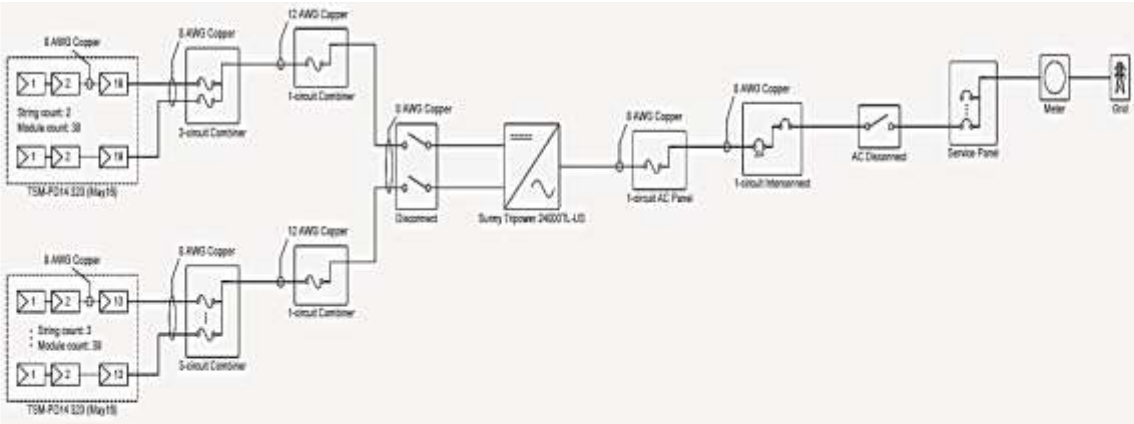

Figure 8. Single Line Diagram of Solar Power Plant

In planning grid-connected solar power plants, an in-depth understanding of the electrical load characteristics in buildings is necessary. Data such as daily energy consumption, types of electrical equipment, and electricity usage patterns are important factors that need to be taken into account.

In addition, the selection of solar technology and components that suit the building's needs is also an integral part of the planning. These components involve the selection of the type of solar panels, inverters, and energy storage systems that can provide optimal performance according to the characteristics of the energy demand in the building.

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Solar Radiation Data

	Global horizontal irradiation kWh/m²/mth	Horizontal diffuse irradiation kWh/m²/mth	Temperature °C	Wind Velocity m/s	Linke turbidity [-]	Relative humidity %
January	142.0	72.2	26.9	1.70	3.891	83.1
February	150.8	78.5	27.3	1.80	4.451	81.2
March	162.8	86.1	27.8	1.79	4.112	80.3
April	163.7	82.5	27.6	1.61	3.774	83.1
May	151.7	71.0	28.0	1.71	3.711	82.3
June	142.5	68.4	27.7	1.70	3.901	81.8
July	149.2	74.8	27.7	1.70	3.743	80.4
August	147.2	85.1	27.5	1.69	4.020	81.7
September	135.6	72.6	26.7	1.70	3.975	85.0
October	128.7	73.4	26.9	1.59	4.087	84.2
November	129.0	67.5	26.6	1.69	3.618	86.1
December	117.4	70.1	26.8	1.69	3.604	84.9
Year	**1720.6**	**902.2**	**27.3**	**1.7**	**3.907**	**82.8**

Figure 9. Monthly Solar Radiation Data

The process of retrieving solar radiation data for one year from the METEONORM website is done by accessing the METEONORM web platform. This step is necessary to ensure that the data accessed is accurate and reliable in solar energy analysis. METEONORM is a trusted data source that provides information on solar radiation, including its variability for a full year.

	Global horizontal irradiation kWh/m²/day	Horizontal diffuse irradiation kWh/m²/day	Temperature °C	Wind Velocity m/s	Linke turbidity [-]	Relative humidity %
January	4.58	2.33	26.9	1.70	3.891	83.1
February	5.39	2.80	27.3	1.80	4.451	81.2
March	5.25	2.78	27.8	1.79	4.112	80.3
April	5.46	2.75	27.6	1.61	3.774	83.1
May	4.89	2.29	28.0	1.71	3.711	82.3
June	4.75	2.28	27.7	1.70	3.901	81.8
July	4.81	2.41	27.7	1.70	3.743	80.4
August	4.75	2.75	27.5	1.69	4.020	81.7
September	4.52	2.42	26.7	1.70	3.975	85.0
October	4.15	2.37	26.9	1.59	4.087	84.2
November	4.30	2.25	26.6	1.69	3.618	86.1
December	3.79	2.26	26.8	1.69	3.604	84.9
Year	**4.71**	**2.47**	**27.3**	**1.7**	**3.907**	**82.8**

Figure 10. Solar Radiation Data per day

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Table 1. Load on campus buildings

No	Electronic Components	Power (W/Watt)	Number of components	Usage Time (Hours)	Total (Wh)
1	AC	350	14	4	19.600
2	TV	350	2	2	1.400
3	PC	240	9	3	6.480
4	Power Outlets	50	12	3	1.800
5	Dispenser	210	2	8	3.360
6	Lamps	32	84	5	13.440
	Total daily electricity demand				46.080

By accessing the METEONORM website, researchers can obtain location-specific solar radiation data. This data includes information on daily, monthly and annual solar radiation intensity. This in-depth understanding of solar radiation patterns is key in planning and analyzing solar power generation systems. Through accessing the METEONORM web, researchers can gain a comprehensive understanding of the level of solar radiation at the location under study. This accurate data will be the basis for proper calculations and simulations in designing the solar power system.

The calculation of the electrical load on the Sinar Husni College of Technology building is a crucial step in planning the construction of the solar power plant. This process begins with analyzing and recording the daily energy consumption, including the use of electrical appliances, lighting, and other electrical needs in the building.

Determining the Solar Module

In this planning stage, a monocrystalline Csun type solar module with a capacity of 320 Wp was used. By utilizing the Google Earth application, information was generated that the area available for the installation of solar modules was 270 m2.

To determine the right number of PV modules according to the desired design, Helioscope software was used. By using Helioscope, an accurate and optimal calculation can be made to determine the number of PV modules in accordance with the available area and the capacity of each solar module. This step is important in ensuring that the solar PV design can be optimized and provide the best performance according to the environmental characteristics and energy needs of the location.

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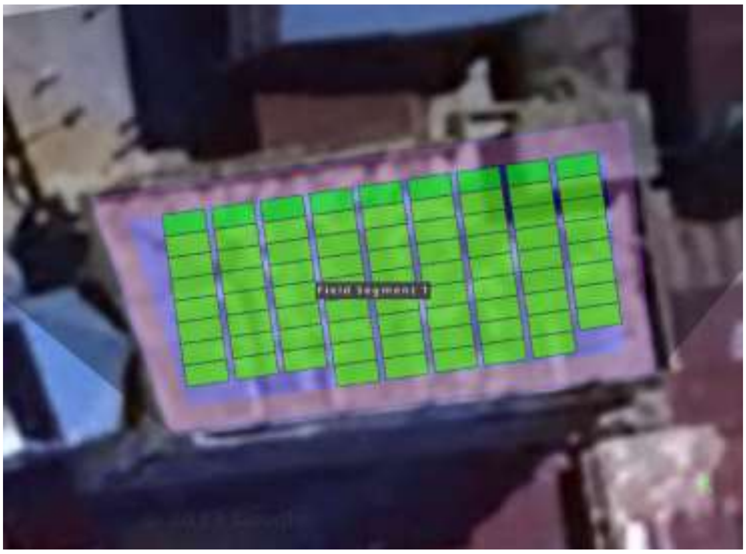

Figure 11. Shading Array with Helioscope Application

Total Energy Generated by Solar Power Plant

Judging from the solar radiation data in the area around the Sinar Husni College of Technology Campus Building. In the figure below the simulation of the energy produced by solar panels using average solar radiation (using Helioscope software):

Table 2 Energy Data Generated for a Year

Shading by Field Segment

Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Field Segment 1	10.0°	351.7°	77	24.6 kWp	1,550.7kWh/m²	31.2 MWh[1]	98.9%	95.7%	94.7%
Totals, weighted by kWp			**77**	**24.6 kWp**	**1,550.7kWh/m²**	**31.2 MWh**	**98.9%**	**95.7%**	**94.7%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,638.0kWh/m² at 5.1° tilt and 182.6° azimuth

Figure 12. Energy Data Generated for a Year

Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Field Segment 1	99%	99%	98%	95%	91%	91%	90%	94%	98%	99%	99%	99%
Solar Access, weighted by kWp	**98.9%**	**99.0%**	**98.1%**	**95.0%**	**91.3%**	**90.8%**	**90.4%**	**93.8%**	**97.5%**	**99.0%**	**99.0%**	**98.9%**
AC Power (kWh)	**2,387.2**	**2,479.7**	**3,014.2**	**2,731.2**	**2,729.7**	**2,610.5**	**2,805.5**	**2,752.0**	**2,526.3**	**2,774.4**	**2,305.2**	**2,132.7**

Figure 13. Energy data generated monthly

From the results of the Helioscope Simulation Report, the potential that can be generated by solar power plants in the Sinar Husni College of Technology campus building is obtained:

1. Solar Panel Installation Area: At the initial stage of planning for the utilization of solar energy in the Sinar Husni College of Technology building, it is necessary to know that the area available for the installation of solar panels reaches 270 m^2. This area is a significant potential for generating electrical energy through the utilization of sunlight.

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2. Number of Solar Panels that Can Be Installed: By utilizing an area of 270 m^2, the calculation results show that the building can accommodate the installation of 77 solar panels. This number reflects an effort to maximize the potential of solar energy that can be converted into electrical power efficiently.
3. Power Generated by Solar Panels: The Trina Solar type solar panel, model TSM-PD14 320 (May16) (320W), is expected to generate 24.6 kW of power. This figure details the reliable power capacity of a given set of solar panels, serving as the basis in calculating the total capacity of the solar power generation system.
4. Solar Radiation / Irradiance: The solar radiation received at this site, expressed in kWh/m^2, reached 1,466.3 kWh/m^2 in one year. This information gives an idea of the intensity of sunlight that can be utilized by the solar panels, which is an important parameter in measuring the potential energy that can be generated.
5. Electric Energy Generated in One Year: With the selected solar panel configuration and the available solar radiation, the total electrical energy that can be generated by the solar power generation system in one year is 31,248.5 kWh. This amount reflects the significant contribution of the solar power plant to sustainably meet the building's electricity demand.

Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	127.7	119.8	118.5	2,745.0	2,387.2
February	131.1	124.6	123.4	2,871.0	2,479.7
March	156.1	154.0	151.0	3,530.2	3,014.2
April	140.6	142.5	135.5	3,163.9	2,731.2
May	142.2	148.1	135.2	3,159.6	2,729.7
June	135.2	142.0	128.9	3,014.2	2,610.5
July	146.6	153.4	138.6	3,244.2	2,805.5
August	141.8	145.1	136.1	3,177.9	2,752.0
September	128.1	127.9	124.8	2,909.5	2,526.3
October	144.9	139.5	138.1	3,219.2	2,774.4
November	123.5	115.8	114.7	2,662.4	2,305.2
December	115.4	107.3	106.1	2,452.2	2,132.7

Figure 14. Graph of Energy generated every month

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CONCLUSION

The implementation of the Off-Grid Solar Power Plant (PLTS) at the Sinar Husnis College of Technology Campus Building involved meticulous planning and construction, with the Helioscope application playing a crucial role in determining the specifications of the components. Through this technology, the project aimed to optimize the efficiency of the solar power system. A key aspect of the initiative was the selection of monocrystalline Csun-type solar modules with a capacity of 320 Wp. The determination of the required number of modules was carried out using both Google Earth and Helioscope, showcasing the integration of advanced tools for precise planning. According to the Helioscope simulation, the Off-Grid Solar PV system in the campus building has the potential to generate an impressive electrical energy output of 31,248.5 kWh per year. Beyond its energy efficiency, the project is positioned as a positive stride towards supporting broader environmental goals. The implementation of this sustainable energy solution is expected not only to provide maximum benefits but also to set an inspiring example for the Sinar Husni College of Technology Campus Building and similar institutions aiming for a greener and more sustainable future.

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