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The Effect of Light Intensity on Electrical Energy Produced by Polycrystalline Solar Panels

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Abstract: *This study analyzes the effect of sunlight intensity on the electrical energy generated by polycrystalline solar panels. The solar power plant system was designed simply and measurements were taken over three days using a lux meter, thermometer, ampere meter, and power meter. Data were analyzed using SPSS through correlation tests and multiple linear regression. The results show that light intensity (lux) has a dominant influence with an average contribution of 68.2% to electrical power. The maximum power recorded was 76 Watts on May 18, 83.3 Watts on June 1, and 85 Watts on June 27, 2025. Other environmental variables such as panel surface temperature, ambient temperature, and humidity also have an influence but on a smaller scale. In conclusion, light intensity plays a significant role in solar panel performance and is a major factor in solar power plant system planning.*

Keywords: *Light intensity, Linear regression, PLTS, Solar panel, Renewal energy*

INTRODUCTION

Electrical energy has become a basic human need in supporting various daily activities. From the household to the industrial sector, electricity plays an important role in maintaining productivity and comfort. The depletion of fossil energy sources for power generation and the resulting environmental problems are also serious challenges in maintaining long-term energy sustainability. As a solution to this problem is the utilization of new renewable energy such as solar energy, wind or wind energy, geothermal energy, water energy and biomass energy. Solar energy is an abundant, environmentally friendly and freely available source of energy from the sun. Utilization of solar energy can be done by using solar panel technology that converts sunlight into electricity. The use of solar energy as a household power plant can be one of the solutions for alternative energy and backup when electricity from PLN is disrupted. Alternative energy is very useful so that households can produce their own energy and can reduce dependence on conventional electricity.

Utilization of solar light is the utilization of new renewable energy sources and sustainable (A. F. Simanullang et al ,2024). Abundant sunlight throughout the year for tropical countries like indonesia can be an alternative solution as a power plant where sunlight as an energy source is converted into electrical energy through solar cells (photovoltaic cells) (Maulana et al ,2024) A solar power plant installation is a power plant that utilizes the radiated solar light absorbed by solar cells, and the solar cells convert the absorbed light into electrical energy (Rochimawati, I. ,2019). The electrical energy produced will be controlled by the solar charge controller and stored in the battery in the form of DC current and will be converted into alternating electricity by a DC to AC inverter and then distributed to the electricity load. This research focuses on policrystalline solar panels that convert solar radiation into electrical energy through the photovoltaic effect(Setyawan, A., & Ulinuha, A.,2022). Factors such as light intensity, temperature, and humidity affect the efficiency of this conversion. This study aims to examine the extent to which light intensity affects the performance of polycrystalline panels through experimental observations.

RESEARCH METHOD

The research began with Theme Selection, literature study, selection of tools and materials, PLTS Assembly, PLTS testing , data retrieval and report preparation ended..

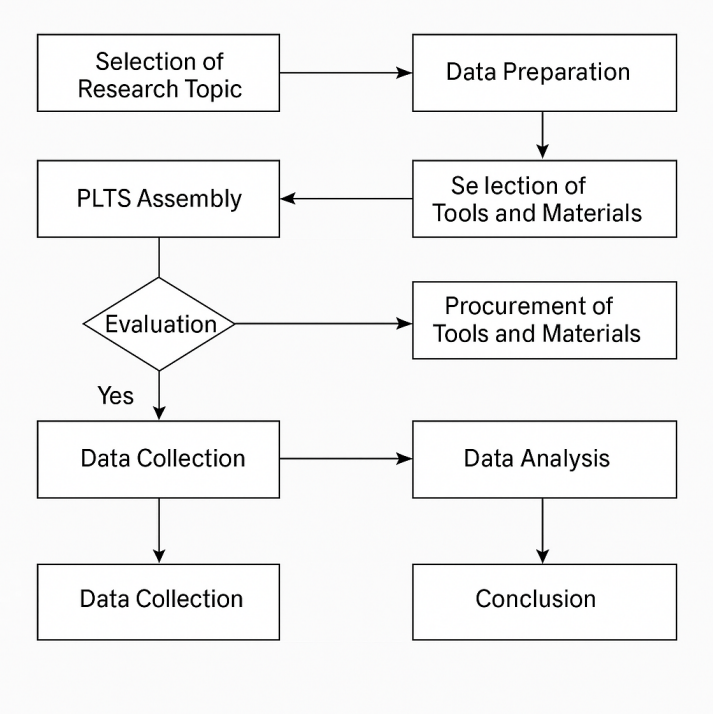

Figure 1. Research flow table

The initial stage of the research started from the selection of themes and literature studies and knowing the theoretical foundations and applications of solar power plant system installation ranging from solar panels, solar charge controllers, batteries, DC to ac inverters to loads. The next step is the selection of tools and materials to be used, for the tools used are polycrystalline solar panels with a capacity of 100wp, 30a solar charge controller, 45 Ah VRLA battery, dc to ac inverter. The measuring instrument used is a dc power meter to measure the current and power that goes from the solar panel to the battery and that comes out of the battery to the load. Ac Power meter to evaporate the current and power used by the load. Other uktu tools used are lux meters to measure light intensity, infra red thermo meters to measure the surface temperature of solar panels and thermohygro meters to measure ambient temperature and humidity. Polycrystalline Solar Panel Solar panels are devices used to convert photon energy from the sun into electrical energy (Samsurizal et al, 2021). Solar panels are made of a semiconductor material that is a certain number of P-n diodes . Solar panel arrays generally consist of a number of cells arranged in Series or parallel, and generally amount to 36 or 72 cells (Hidayat, W., & Rizaldi, R. ,2024).

This type is made of crystalline silicon with an efficiency level of between 12% - 15% (R. P. S. T. ,2022) . this type is the most suitable type used in indonesia, because indonesia is a country in the equator area and has two seasons, namely summer and rainy season, so this type still has a pretty good efficiency when in the rainy season and when cloudy conditions.

Figure 2. PLTS plan

Figure 3. Front view of PLTS design

Solar Charge Controller

Solar Charge Controller is a device that serves to regulate the electricity generated by solar panels to be stored in the battery so that the battery is not overcharged (Kosasih, D. P.,2018). This device is needed to ensure the performance of plts runs well and makes the maximum performance and battery life.

VRLA Battery

In solar power systems, batteries are used to store electrical energy generated by solar panels. A battery or accumulator is an electrochemical device that works on the principle of converting chemical energy into electrical energy (Yanayatry et al, 2024). Valve regulated lead acid is one type of sealed acid battery that is most suitable for storing electrical energy in solar power plants (Putra, S., & Rangkuti, C., 2016), because this type is a deep cycle type that has the character of issuing constant power for a long time

Inverter DC to AC

Inverter has an important role in PLTS (Khatima, H., et al.,2024) which serves to convert direct electric current into alternating electric current (Apriani, Y., & Barlian, T.,2018) so that the bias is used for equipment that generally uses AC electric current . The working principle of the inverter can be described using four switches (Sinaga, Y. A et al, 2017) . When switches S1 and S2 are in the on State, DC current will flow through the load R from left to right direction. Conversely, if switches S3 and S4 are active, DC current will flow through the load R from the right to left direction (Amin, M. S. et al, 2022). DC to ac inverters are distinguished from the type of wave produced, there are 3 types of waves, namely pure sine wave, modified sine wave and square wave (Sri, N., et al.,2022). This pure sine wave wave is a sine wave like an AC power wave and this inverter is the best and most suitable type for a variety of electronic devices **.**

SPSS Application

SPSS application is an application used for data analysis and statistics (Rusdi, I. ,2023) and for data analysis, researchers use some features that exist in SPSS, namely, correlation, regression Correlation is a reciprocal relationship in which changes in one variable will affect other variables (Rozak, A., & Hidayati, W. S.,2020). There are three correlation relationships, namely negative correlation relationship, zero correlation relationship and positive correlation relationship. Regression is the relationship between the bound variable

and the independent variable. The Output of regression models include summary, Anova and coefficient

Testing equipment

In this study the researchers used 4 measuring instruments, namely lux meter to measure light intensity , thermohygro meter to measure ambient temperature and humidity, infrared thermometer to measure the temperature of solar panels, and dc power meter to measure the current and power that goes into the battery.

RESULT AND DISCUSSION

The results of observations made on the intensity of sunlight, ambient temperature, PV panel temperature, stored power and current entering the battery.

Table 1. Days submersible solar panel testing

DATE	HOUR	LUX	PV TEMP	ENVIRONMENT TEMP	HUMIDITY	AMPERE	WATT	BATTERY VOLTAGE	ENVIRONMENT CONDITION
18 Mei 2025	07.00	28.200	35,6	28,8	68%	1,17	13,3	12,62	SUNNY
18 Mei 2025	08.00	68.100	41,1	30,4	66%	2,59	33,0	12,84	SUNNY
18 Mei 2025	09.00	108.900	41,6	37,0	45%	4,29	58,5	12,92	SUNNY
18 Mei 2025	10.00	125.300	56,9	41,0	36%	4,72	64,3	13,21	SUNNY
18 Mei 2025	11.00	142.800	59,6	43,2	34%	5,05	75,5	13,84	SUNNY
18 Mei 2025	12.00	30.100	40,4	37,5	44%	1,23	24,0	13,25	CLOUDY
18 Mei 2025	13.00	2.400	40,7	41,0	34%	0,0	0,0	13,13	CLOUDY
18 Mei 2025	14.00	9.530	50,1	38,0	37%	0,20	1,5	13,17	CLOUDY
18 Mei 2025	15.00	89.300	51,1	43,2	28%	3,10	42,2	13,77	SUNNY
18 Mei 2025	16.00	8.000	31,4	32,8	53%	0,0	0,0	13,06	CLOUDY
18 Mei 2025	17.00	6590	28,6	29,8	58%	0,0	0,0	13,1	CLOUDY
1 juni 2025	07.00	10.150	32,9	26,6	79%	0,33	4,4	12.33	SUNNY
1 juni 2025	08.00	46.300	36,9	31,3	67%	0,62	8,5	12,49	SUNNY
1 juni 2025	09.00	57.100	31,0	30,0	62%	2,02	25,6	12,68	SUNNY
1 juni 2025	10.00	77.800	46,7	38,8	36%	3,92	30,2	12,93	SUNNY
1 juni 2025	11.00	32.300	41,0	37,9	38%	1,28	16,7	12,89	CLOUDY
1 juni 2025	12.00	20.600	34.1	33,0	47%	0,89	11,6	12,89	CLOUDY
1 juni 2025	13.00	25.400	34,2	31,0	53%	1,13	14,7	12,95	CLOUDY

DATE	HOUR	LUX	PV TEMP	ENVIRONMENT TEMP	HUMIDITY	AMPERE	WATT	BATTERY VOLTAGE	ENVIRONMENT CONDITION
1 juni 2025	14.00	12.990	32,4	30,4	56%	0,69	9,0	12,95	CLOUDY
1 juni 2025	15.00	5.600	31,6	30,2	59%	0,65	8,5	12,95	CLOUDY
1 juni 2025	16.00	4.160	31,6	30,0	60%	0,46	6,1	12,95	CLOUDY
1 juni 2025	17.00	3.130	27,6	28,5	66%	0,14	1,9	12,89	CLOUDY
26 Juni 2025	07.00	9.150	25,5	25,2	79%	0,35	4,3	12,16	CLOUDY
26 Juni 2025	08.00	19.210	27,4	26	77%	0,57	7,1	12,38	CLOUDY
26 Juni 2025	09.00	64.400	38,8	29,3	69%	2,27	28,9	12,56	CLOUDY
26 Juni 2025	10.00	74.400	39,5	31,8	63%	2,77	35,8	12,75	CLOUDY
26 Juni 2025	11.00	93.300	51	33,9	54%	3,89	51,4	12,91	CLOUDY
26 Juni 2025	12.00	73.700	50,1	32,7	56%	2,69	35,4	12,95	CLOUDY
26 Juni 2025	13.00	83.200	48,3	42,5	38%	3,13	41,6	13	CLOUDY
26 Juni 2025	14.00	31.400	39,8	38,6	39%	1,27	16,7	13,02	CLOUDY
26 Juni 2025	15.00	12.640	35,7	35	47%	0,4	5,2	12,93	CLOUDY
26 Juni 2025	16.00	1.643	31,1	31	55%	0	0	12,73	CLOUDY
26 Juni 2025	17.00	3.630	28,6	29	61%	0,15	1,5	12,73	CLOUDY

Data obtained on June 18, 2025 the smallest Lux intensity was 6590 at 17.00 without power and stored current, and the largest lux was 142000 at 11.00 with current and stored power of 5.05 amperes and 75.5 Watts

Data obtained on June 1, 2025, the smallest Lux intensity was 3130 at 17.00 with power and stored current of 0.14 amperes and 1.9 Watts, and the largest lux was 77800 at 10.00 with current and stored power of 3.92 amperes and 30.2 Watts.

Data obtained on June 27, 2025, the smallest Lux intensity was 3630 at 17.00 with power and stored current of 0.15 amperes and 2.0 Watts, and the largest lux was 93300 at 11.00 with current and stored power of 3.89 amperes and 51.4 Watts.Tabel 2. Korelasi SPSS

Table 2 . Correlation

Correlations

		KELEMBABAN	LUX	SUHU PV	SUHU LINGKUNGAN
WATT	Pearson Correlation	-.410*	.979**	.795**	.563**
	Sig. (2-tailed)	.018	.000	.000	.001
	N	33	33	33	33

The above results show a strong correlation between the variable light intensity with Watts and amperes, between lux with Watts of 0.979 with a significance of 0.00.

Table 3. Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.980[a]	.961	.955	4.3732

Summary table shows there is a strong linear relationship between 98.0 percent of the combination of independent variables with variable wattage, 96.1 percent of the effect of the increase in wattage can be explained by the existing free variables.

Table 4. Anova table

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13043.529	4	3260.882	170.505	.000[b]
	Residual	535.497	28	19.125		
	Total	13579.025	32			

The results of the anova showed statistically significant with a value of 0.000, this shows a significant relationship between lux and Watts. Large regression and small residual.

Table 5. Coefficient

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	28.823	31.416		.917	.367
	LUX	.001	.000	.995	14.134	.000
	SUHU PV	.004	.213	.002	.017	.987
	SUHU LINGKUNGAN	-.541	.673	-.136	-.803	.428
	KELEMBABAN	-.221	.210	-.151	-1.053	.301

a. Dependent Variable: WATT

Overall the regression model is very significant for the light intensity with significance values of 0.000 and R2 0.961, although partially the value of the independent variable varies

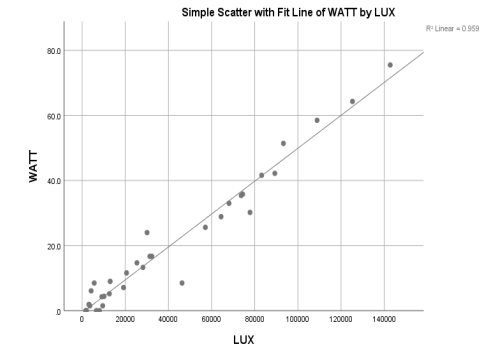

Figure 4. Scatters Diagram

The graph shows the higher the lux or intensity of sunlight, the electrical power (Watts) tends to increase. Here's a graph of the average intensity of light and incoming power in 3 days.

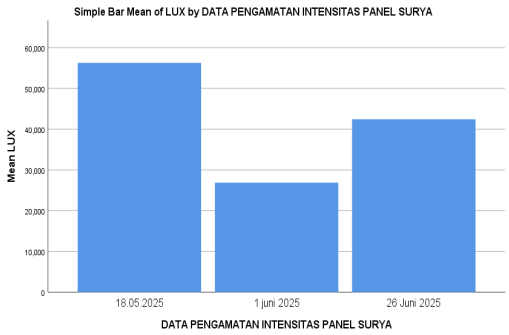

Figure 5. Average intensity of sunlight for 3 days

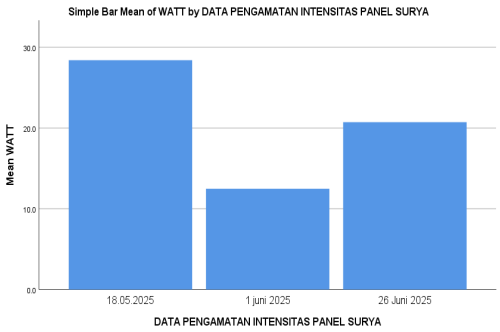

Figure 6. Average incoming power for 3 days

From the graph of the average light intensity and power generated above visible linearity between light intensity and power generated and this shows the variable light intensity is very influential with the electrical power generated. Here is Table 6 is the percentage of influence of the dependent variable (Watt) with independent variables, namely lux, humidity, ambient temperature and surface temperature of the solar panel.

Table 6. Influence of percentage of other variables on watts

Variabel	Beta (Standardized)	Persentase Pengaruh (%)
LUX	0,995	77,49
Suhu Lingkungan	0,136	10,59
Kelembaban	0,151	11,76
Suhu Permukaan PV	0,002	0,16
Total	1,284	100,00

Here is the pie diagram

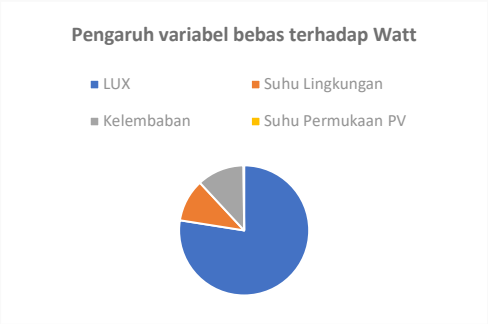

Figure 7. Percentage diagram of the influence of other variables on Watts

From Table 6 and Figure 7 shows the light intensity contributes to the increase in power produced by solar panels by 77.49 percent

CONCLUSION

From observations that have been carried out for three days there were conducted on May 18, 2025, June 1, 2025 and June 27, 2025, the following conclusions were obtained:

1. The observations showed that on May 18, 2025 the maximum power generated reached about 75.5 Watts at a light intensity of 142800 on June 1, 2025 the maximum power was recorded at 30.2 Watts with an intensity of 77800 lux, and on June 27, 2025 the maximum power was recorded at 51.4 Watts when the intensity reached 93300 lux. This shows a consistent trend between increased light intensity and increased power.
2. Solar light intensity (lux) has a very significant influence on the electrical power (watts) generated by solar panels. This is evidenced by the results of regression and correlation analysis on all three days of observation, which showed a very high correlation value (R) and coefficient of determination (R2), as well as a valid significance value. Based on the analysis of the value of standardized coefficients

(Beta), the average effect of light intensity on the wattage of the three days of observation was 77.49%.

3. Variable panel surface temperature, ambient temperature, and humidity also affect the electrical power generated, but their contribution is lower than the light intensity. Lux is the most dominant variable based on the value of standardized coefficients (Beta) in the regression model.
4. The effect of light intensity on electrical power output is linear and consistent, meaning that the higher the intensity of sunlight, the greater the electrical power produced.

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