THE INFLUENCE OF THE TILT ANGLE OF 120 WP SOLAR PANELS ON LIGHT INTENSITY AND GENERATED ELECTRICAL POWER

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Abstract: In designing solar panel devices, generally the tilt angle of the panel surface is designed with a static design and this greatly influences the results of the electricity source generated. The design of the tool is intended to be in coordinates that are perpendicular to the direction of the sunlight rays so that it receives maximum solar radiation. This research aims to determine the relationship between the tilt angle of the solar panels and the light intensity and electrical power generated and to determine the optimal tilt angle of the solar panels based on the values of light intensity and electrical power. The indicators measured consist of light intensity, voltage, current and electrical power by varying the tilt angle of the solar panel. The results of this research show that the tilt angle of the solar panel greatly influences the measured light intensity value so that the greater the light intensity obtained, the higher the output voltage of the solar panel. The most optimal tilt angle is at an angle of 105º and 120º with the greatest light intensity so that the resulting output power is correspondingly greater.

Keywords: tilt angle; light intensity; electrical power; solar panel

Abstrak: Dalam merancang alat panel surya, pada umumnya posisi kemiringan dari permukaan panel dirancang dengan desain statis sangat mempengaruhi hasil dari sumber listrik yang dihasilkan. Rancangan alat diupayakan berada di koordinat yang tegak lurus dengan arah pancaran cahaya matahari agar menerima radiasi matahari yang maksimal. Penelitian ini bertujuan untuk mengetahui hubungan posisi kemiringan panel surya terhadap intensitas cahaya dan daya listrik yang dihasilkan serta mengetahui posisi kemiringan panel surya yang optimal berdasarkan nilai intensitas cahaya dan daya listriknya. Indikator yang diukur terdiri dari intensitas cahaya, tegangan, arus, dan daya listrik dengan memvariasikan posisi kemiringan dari panel surya. Hasil penelitian ini menunjukkan posisi kemiringan sebuah panel surya sangat mempengaruhi nilai intensitas cahaya yang diukur sehingga semakin besar intensitas cahaya yang didapat maka tegangan keluaran panel surya mengalami kenaikan. Posisi kemiringan yang paling optimal pada sudut 105º dan 120º dengan intensitas cahaya yang didapat terbesar sehingga daya keluaran yang dihasilkan sejalan yaitu semakin besar pula.

Kata kunci : Posisi kemiringan; intensitas cahaya; daya listrik; panel surya

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Introduction

The use of solar panels is widely used as an alternative source of electricity generation (Laksana et al., 2021) because it has advantages such as sustainable solar energy in very large quantities (Syahputra & Soesanti, 2021). Solar panels make solar energy (Widodo et al., 2020) a future energy that can be utilized to overcome the scarcity of conventional energy (Anoi et al., 2020) which continues to decrease (Kurniawan et al., 2022). This is also supported by its environmentally friendly nature and does not damage the environment if used continuously (Iqtimal & Devi, 2018).

One indicator that greatly influences the performance of solar cells is the tilt angle of the solar panels (Hariningrum, 2021). Determining the tilt angle of the panel is intended to maximize the intensity of the sun received by the solar panel (Shufat et al., 2019). In designing solar panel devices (Hasanah et al., 2019), generally, the tilt angle of the panel surface is designed with a static design so that it greatly influences the results of the electricity source produced (Pido et al., 2022).

Apart from the position of solar panels, another significant factor influencing their performance is the ambient temperature (Ummah et al., 2021), sunlight intensity, and weather conditions affecting the voltage, current, and power generated by solar cells (Pido et al., 2022). The voltage and current generated by solar panels (Listyalina et al., 2021) directly correlate with the amount of solar energy received by the panels (Hariningrum, 2021), and as the solar energy radiation increases (Qosim & Hariyati, 2021), it also affects the surface temperature of the solar panels (Basrah Pulungan et al., 2021).

The design of the tool is intended to be in coordinates that are perpendicular to the direction of the sunlight rays so that it receives maximum solar radiation (Umurani et al., 2023). In physics, two types of angles are factors in installing solar panels (Hidayat et al., 2019),such as the angle of inclination of the solar panel to a flat plane which is called the slope and the azimuth angle which is an angle measured in the south direction (Mamun et al., 2022).

Starting from this problem, the author conducts this research to find out the relationship between the tilt angle of the solar panel and the light intensity and electrical power produced and to find out the optimal tilt angle of the solar panel based on the values of light intensity and electrical power. The indicators measured consist of light intensity, voltage, current and electrical power by varying the tilt angle of the solar panel (Hariyati et al., 2019).

Method

In this research, the author made a tool by utilizing solar panels as a source of electrical power and performed tests in the form of measurements on whether the tool was able to work well or not. These parameters were measured continuously for 3 consecutive days starting from July 25th to 27th, 2023, located in the Tuntungan area of Medan, in an open venue.

The equipment used consists of a multimeter Merk Sanwa, soldering iron, digital thermometer and lux meter. The materials used consist of a 120 Wp solar panel, battery VRLA 12 Volt 100 Ah, SCC (solar charge controller MPPT 12V/24V), and inverter 1000 Watt Pure Sine Wine. The overall design of the tool can be seen in Figure 1.

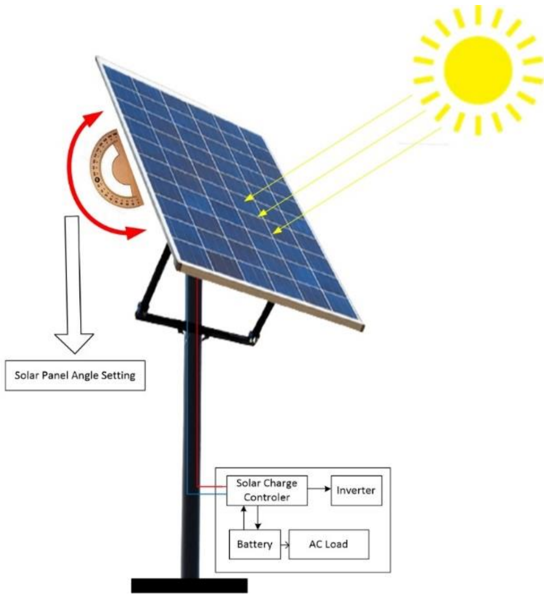

Figure 1. Design of the solar panel

The design of solar panel system tool with tilt angle settings is designed for the entire system, which starts with the connection process between the required system components, such as connecting the solar panel with the SSC module or Solar Charger Controller which functions to control/regulate the DC and then connect it to the battery. From this SSC module, the excess battery charging process or overcharging can be controlled automatically so that the battery can still work properly. The battery which functions as a storage source for electrical energy obtained from the solar panels will continue to the inverter module which is used to convert DC to AC. Next, this will handle the AC load. To optimize the work of solar panels by getting maximum sunlight, there is a flexible system for adjusting the angle of the solar panels so that the angle of the solar panels can be adjusted manually. This aims to position the solar panels in the direction of maximum sunlight.

The measurement parameters are obtained based on the values read on the solar panel which is connected to a multimeter by adjusting the tilt angle. This measurement uses an arc with varying angles from 15^o to 180^o of the position of the solar panel in the direction of incoming sunlight. The parameters measured consist of light intensity (Lux), voltage (Volt), current (Ampere) and electrical power (Watt). The data from these parameters will be processed and analyzed.

Result and Discussion

The implementation of the overall device design resulted in a tool capable of functioning effectively, as evidenced by the measured parameters on the solar panel equipped with tilt adjustment. The measured parameters include tilt angle adjustment, light intensity, voltage, and current on the solar panel. The tilt adjustment system is manually operated using a protractor, allowing for variations in angle from 15° to 180° relative to the direction of incoming sunlight.

Testing of solar panels with tilt angle settings is conducted by varying the angle starting from 15° to 180° with the parameters measured consisting of light intensity, solar panel voltage, solar panel current, electrical power and looking at weather conditions. The test was performed when the sunlight was perpendicular (above the head) or from 12.00 to 14.00 Western Indonesian Time. These parameter measurements were conducted for 3 consecutive days and the test data can be seen in Tables 1; 2; and 3.

Table 1. Data for day 1 of measurements on solar panels

Tilt angle (°)	The amount of light (Lux)	Voltage of solar panels (Volt)	Current in solar panels (Ampere)	Electrical power (Watt)	Weather condition
15	9331	20.8	4.15	86.32	Sunny
30	9438	20.9	3.96	82.76	Sunny
45	9596	20.9	4.03	84.22	Sunny
60	9108	20.5	2.95	60.47	Sunny
75	9322	20.6	2.78	57.26	Sunny
90	9122	20	1.83	36.60	Sunny
105	9605	21	4.30	90.30	Sunny
120	9277	20.5	3.37	69.08	Sunny
135	8473	20.2	2.60	52.52	Sunny
150	8649	20.1	1.64	32.96	Sunny
165	8396	19.4	0.93	18.05	Sunny
180	8382	19.4	0.80	15.52	Sunny
Average	9058.25	20.35	2.77	57.17	-

Based on Table 1, setting the tilt angle of the solar panel affects the results of measuring voltage, current on the solar panel and light intensity. On the first day, the average value obtained from measurements for solar panel voltage was 20.35 Volts, current was 2.77 Amperes and light intensity was 9058.25 Lux. Apart from these measurements, calculations were also conducted to obtain an electrical power value of 57.17 Watts and the weather conditions at the time of measurement were sunny.

Table 2. Data for day 2 of measurements on solar panels

Tilt angle (º)	The amount of light (Lux)	Voltage of solar panels (Volt)	Current in solar panels (Ampere)	Electrical power (Watt)	Weather condition
15	9682	19.1	1.33	25.40	Sunny
30	9850	20.7	3.07	63.54	Sunny
45	9940	20.3	2.76	56.03	Sunny
60	9869	20.7	2.94	60.58	Sunny
75	9701	20.6	4.02	90.84	Sunny
90	9758	20.5	4.33	88.76	Sunny
105	9702	20.4	3.74	76.29	Sunny
120	10210	20.3	4.41	89.52	Sunny
135	9627	20.2	2.95	59.59	Sunny
150	9554	19.5	0.98	19.11	Sunny
165	10640	19.1	0.97	18.52	Sunny
180	9166	19.6	0.92	18.03	Sunny
Average	9808.25	20.08	2.70	55.52	-

Based on Table 2, the measurements for the second day with the average values obtained for the solar panel voltage were 20.08 Volts, the current was 2.70 Amperes, the battery voltage was 12.65 Volts and the light intensity was 9808.25 Lux. Apart from these measurements, calculations were also conducted to obtain an electrical power value of 55.52 Watts and the weather conditions at the time of the measurement were sunny. When comparing the measurement results between the first day, the second day has greater measurement results seen from the higher intensity values based on the data in Table 1. When comparing the measurement data between the first and second days, the second day shows higher intensity values, as indicated in Table 1. This is attributed to the fact that the sunlight conditions on the second day were more intense compared to the first day. Therefore, on the second day, the solar panel received a higher intensity of sunlight (Hariningrum, 2021).

Table 3. Data for day 3 of measurements on solar panels

Tilt angle (º)	The amount of light (Lux)	Voltage of solar panels (Volt)	Current in solar panels (Ampere)	Electrical power (Watt)	Weather condition
15	14450	19.83	3.17	62.86	Sunny
30	15330	20.20	3.90	78.78	Sunny
45	15460	20.20	4.26	86.05	Sunny
60	15620	20.90	4.33	90.50	Sunny
75	15670	20.70	4.43	91.70	Sunny
90	16700	20.20	3.78	76.35	Sunny
105	16960	20.70	3.22	66.65	Sunny
120	18670	20.10	4.64	93.26	Sunny
135	16160	19.59	1.08	21.15	Sunny

Tilt angle (°)	The amount of light (Lux)	Voltage of solar panels (Volt)	Current in solar panels (Ampere)	Electrical power (Watt)	Weather condition
150	15980	19.30	0.98	18.91	Sunny
165	15810	19.20	0.80	15.36	Sunny
180	16100	19.00	0.63	11.97	Sunny
Average	16075.83	19.99	2.93	59.46	-

Based on Table 3, the measurements for the third day with the average values obtained for the solar panel voltage were 19.99 Volts, current was 2.93 Ampere, and light intensity was 16075.83 Lux. Apart from these measurements, calculations were also conducted to obtain an electrical power value of 59.46 Watts and the weather conditions at the time of the measurement were sunny. If we compare the measurement results from the first and second days, the second day has greater measurement results in terms of the average values of solar panel voltage, electrical power and battery voltage. Meanwhile, for the highest average light intensity on the third day, the change in measurement values was not that significant. This is due to environmental influences, especially weather conditions and the tilt angle of the solar panels.

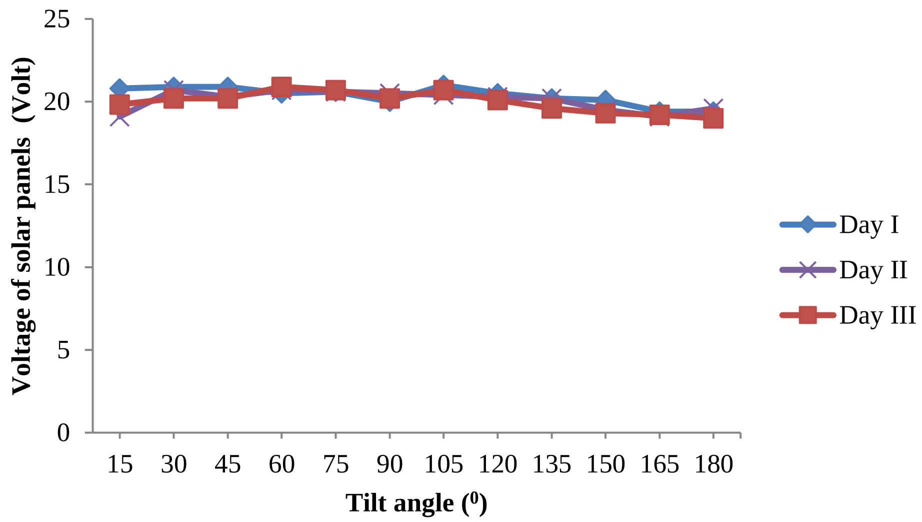

Figure 2. Graph of solar panel voltage on tilt angle

In Figure 2, there is a graph of the relationship between solar panel voltage and tilt angle. From this graph, the solar panel voltage value is obtained for 3 days. Based on the graph of the solar panel voltage values, it was found to be more stable above 20 Volts at a tilt angle of 15^o to 150^o and at a tilt angle of 165^o to 180^o there was a decrease in the voltage value on the solar panel. However, this decline was not that far. This decrease in voltage value is due to the influence of the tilt angle where the solar panels face away from sunlight.

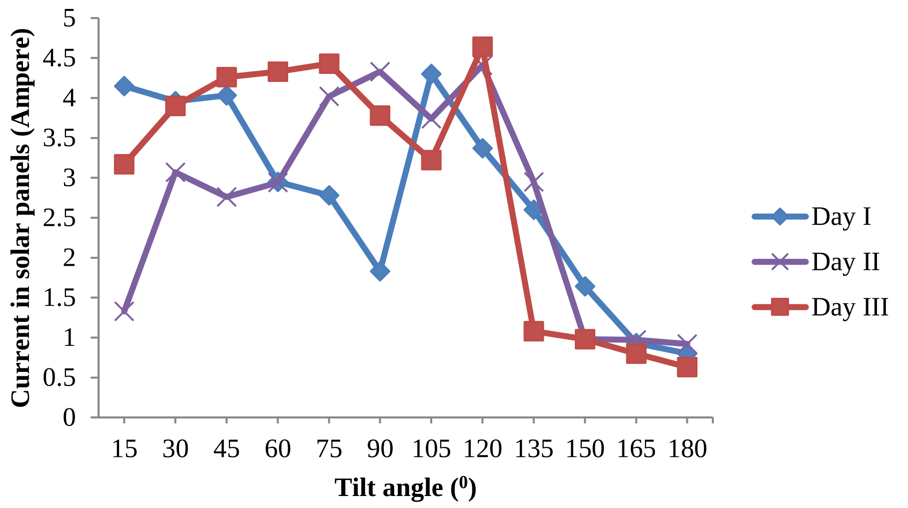

Figure 3. Graph of solar panel current and tilt angle

Figure 3 is a graph of the relationship between solar panel current and tilt angle. From this graph, the solar panel current value is obtained for 3 days. Based on the graph, the current value of the solar panel fluctuates so that it is less stable. This is due to the light intensity factor and the tilt angle where the solar panels face away from sunlight.

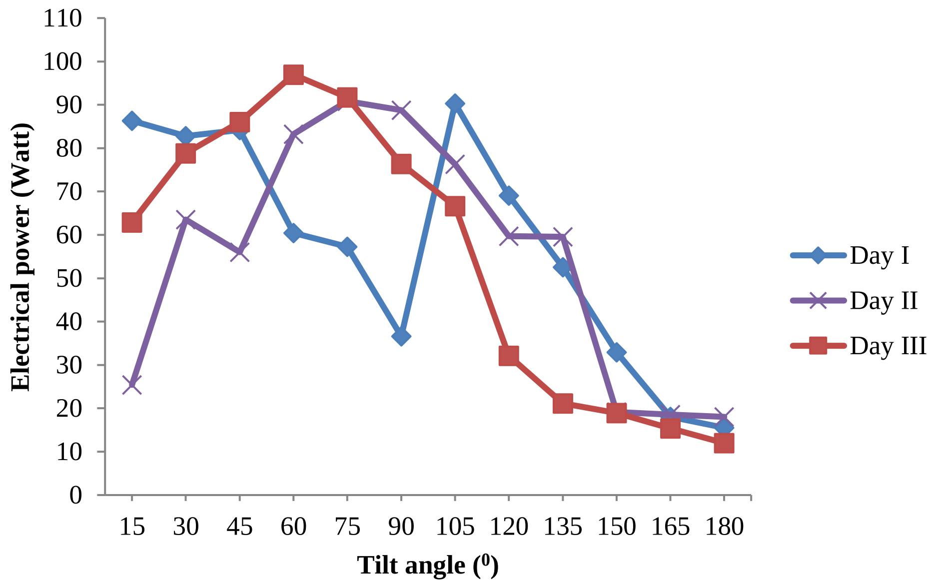

Figure 4. Graph of solar panel electrical power and tilt angle

Figure 4 shows a graph of the relationship between solar panel output power and tilt angle. These results show that the output power value is greatly influenced by the light intensity, where the greater the light intensity obtained, the higher the output voltage of the solar panel. In contrast to the current value of solar panels, the value obtained still fluctuates. The change in value is not constant due to the influence of the tilt angle of the solar panels.

From all the tests that have been performed, the optimal tilt angle for the first day is 105º with a light intensity value of 9605 Lux and a power of 90.30 Watts. The second day was at a 120º tilt angle with a light intensity value of 10210 Lux and a power of 89.52 Watts. The third day was at a 120º tilt angle with a light intensity value of 18670 Lux and a power of 93.26 Watts. These results show that the most optimal tilt angle is at an angle of 105º and 120º with the greatest light intensity so that the resulting output power is also greater.

From all the conducted tests, the optimal tilt angles were determined as follows on the first day, the optimal tilt angle was 105°, resulting in a light intensity of 9605 Lux and a power output of 90.30 Watts. On the second day, the optimal tilt angle was 120°, with a light intensity of 10210 Lux and a power output of 89.52 Watts. On the third day, the optimal tilt angle was also 120°, yielding a light intensity of 18670 Lux and a power output of 93.26 Watts. These results indicate that the most optimal tilt angles were found to be 105° and 120°, resulting in the highest light intensities and consequently higher power outputs. When compared to previous research by Hariningrum (2021), significant differences in results are observed. This disparity can be attributed to the utilization of a 100 Wp solar panel in the previous study, with data measurement conducted over a single day and tilt angle variations ranging from 0° to 80°. In that study, the optimal tilt angle was found to be 40°, resulting in a light intensity of 37800 Lux and a power output of 10.2 Watts (Hariningrum, 2021).

Conclusion

The results of this research show that the tilt angle of a solar panel greatly influences the measured light intensity value so that the greater the light intensity obtained, the higher the output voltage of the solar panel. The most optimal tilt angle is at an angle of 105º and 120º with the greatest light intensity so that the resulting output power is also greater. The most optimal tilt angles at angles of 105° and 120° with the greatest received light intensity, thus resulting in increasing output power. From this research, several factors affect the operation and measurement results of solar panels, namely the size of the peak power of the solar panel used, the tilt angle of the solar panel, and weather conditions.

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References

Anoi, Y. H., Yani, A., & W, Y. (2020). Analisis sudut panel solar cell terhadap daya output dan efisiensi yang dihasilkan. *Turbo : Jurnal Program Studi Teknik Mesin*, *8*(2), 0–5. https://doi.org/10.24127/trb.v8i2.1051

Basrah Pulungan, A., Elvanny Myori, D., Elmubdi, F., Hasannuddin, T., & Padang, N. (2021). Real-Time Monitoring System on Solar Panel Orientation Control Using Visual Basic. *Journal of Applied Engineering and Technological Science*, *2*(2), 112–124.

Hariningrum, R. (2021). Analisa Pengaruh Sudut Kemiringan Panel Surya100 WP Terhadap Daya Listrik. *Marine Science and Technology Journal*, *1*(2), 67–76. http://e-journal.ivet.ac.id/index.php/maristec%0ACover

Hariyati, R., Qosim, M. N., & Hasanah, A. W. (2019). Energi dan Kelistrikan : Jurnal Ilmiah Konsep Fotovoltaik Terintegrasi On Grid dengan Gedung STT-PLN Energi dan Kelistrikan : Jurnal Ilmiah. *Energi Dan Kelistrikan: Jurnal Ilmiah*, *11*(1).

Hasanah, A. W., Hariyati, R., & Qosim, M. N. (2019). Konsep Fotovoltaik Terintegrasi On Grid dengan Gedung STT-PLN. *Energi & Kelistrikan*, *11*(1). https://doi.org/10.33322/energi.v11i1.394

Hidayat, S., Hariyanto, A., & Yasser, R. (2019). Pengaruh Kemiringan Posisi Modul Surya Prototipe 200 WP Dengan Tracking System Terhadap Energi Listrik Yang Dihasilkan. *Kilat*, *8*(2), 168–179. https://doi.org/10.33322/kilat.v8i2.436

Iqtimal, Z., & Devi, I. (2018). Aplikasi Sistem Tenaga Surya Sebagai Sumber Tenaga Listrik Pompa Air. *Kitektro*, *3*(1), 1–8.

Kurniawan, I., Ichwani, R., Fionasari, R., Batubara, A., & Huda, A. (2022). Indonesia's Renewable Energy Outlook: What to Expect in The Future Renewable Energy of Indonesia. A Brief Review. *Elkawnie*, *8*(2), 298. https://doi.org/10.22373/ekw.v8i2.18738

Laksana, E. P., Prabowo, Y., Sujono, S., Sirait, R., Fath, N., Priyadi, A., & Purnomo, M. H. (2021). Potential Usage of Solar Energy as a Renewable Energy Source in Petukangan Utara, South Jakarta. *Jurnal Rekayasa Elektrika*, *17*(4). https://doi.org/10.17529/jre.v17i4.22538

Listyalina, L., Susilo, E., Lusiana Utari, E., & Buyung, I. (2021). Pengaruh Tegangan dan Arus di Pengambilan Data Waktu Cahaya Matahari pada Perancangan Kontrol Intensitas Lampu Jalan Otomatis Tenaga Surya. *Jurnal Teknologi Informasi*, *3*.

Mamun, M. A. A., Islam, M. M., Hasanuzzaman, M., & Selvaraj, J. (2022). Effect of tilt angle on the performance and electrical parameters of a PV module: Comparative indoor and outdoor experimental investigation. *Energy and Built Environment*, *3*(3), 278–290. https://doi.org/10.1016/j.enbenv.2021.02.001

Pido, R., Hidayat Boli, R., Rifal, M., Rauf, W., Shanti Dera, N., & Rianto Day, R. (2022). Analisis Pengaruh Variasi Sudut Kemiringan Terhadap Optimasi Daya Panel Surya. *Radial*, *10*(2), 234–240. https://doi.org/10.37971/radial.v10i2.287

Qosim, M. N., & Hariyati, R. (2021). Kajian Kelayakan Finansial Fotovoltaik Terintegrasi On Grid Dengan Kapasitas 20 kWp. *Kilat*, *10*(1), 1–9. https://doi.org/10.33322/kilat.v10i1.544

Shufat, S. A. A., Kurt, E., & Hancerlioğulları, A. (2019). Modeling and design of azimuth-altitude dual axis solar tracker for maximum solar energy generation. *International Journal of Renewable Energy Development*, *8*(1), 7–13. https://doi.org/10.14710/ijred.8.1.7-13

Syahputra, R., & Soesanti, I. (2021). Renewable energy systems based on micro-hydro and solar photovoltaic for rural areas: A case study in Yogyakarta, Indonesia. *Energy Reports*, *7*, 472–490. https://doi.org/10.1016/j.egyr.2021.01.015

Ummah, H. F., Setiati, R., Dadi, Y. B. V., Ariq, M. N., & Malinda, M. T. (2021). Solar energy as natural resource utilization in urban areas: Solar energy efficiency literature review. *IOP Conference Series: Earth and Environmental Science*, *780*(1). https://doi.org/10.1088/1755-1315/780/1/012007

Umurani, K., Abdullah, Putri, M., & Juli. (2023). System Implementation of Solar Panel Optimization by Adjustment of Tilt Degrees and Cooling System Integrated Internet of Things. In *International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)* (Vol. 10).

Widodo, D. A., Purwanto, P., & Hermawan, H. (2020). Potential of solar energy in residential rooftop surface area in Semarang City, Indonesia. *Advances in Science, Technology and Engineering Systems*, *5*(4), 397–404. https://doi.org/10.25046/aj050446