

## Electricity Productivity Analysis of Thin Solar Panels

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**ABSTRACT**

The requirement for electrical energy is anticipated to witness a 70% increase between the years 2000 and 2030, owing to the inevitable population growth that will consequently lead to a surge in electricity demand. To ensure an adequate supply of electrical energy, one can harness the potential of abundant energy sources, such as solar energy, which can be converted into electrical energy. Solar energy offers numerous advantages, including its environmentally friendly and clean nature, as well as its ability to avoid air pollution. The prevailing types of solar panels, namely polycrystalline and monocrystalline, are widely utilized, despite their considerable weight. However, in the future, the development of thin solar panels is expected, primarily due to their lightweight nature, which renders them suitable for a wide range of electronic devices. The objective of this study is to analyze the power productivity generated by thin solar panels. During sunny weather, the first thin solar panel generated power ranging from 0.87 watts to 15.60 watts, with the lowest value recorded as the minimum and the highest value documented as the maximum. Furthermore, under both sunny and cloudy weather conditions, the power generated ranged from 0.52 watts to 11.17 watts, with the lowest and highest values representing the minimum and maximum power outputs, respectively. Finally, during cloudy and rainy weather, the power generated ranged from 0.21 watts to 4.72 watts, with the lowest and highest values representing the minimum and maximum power outputs, respectively. This discrepancy can be attributed to the optimal absorption of power by thin solar panels under sunny weather conditions.

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**Keywords:** Electricity demand, Solar energy, Power productivity, Thin solar panels

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### 1. Introduction

The demand for electrical energy is predicted to increase by 70% between 2000 and 2030, along with the development of the times the demand for electrical energy is increasing rapidly [2] [3]. This increase is influenced by the growth or to anticipate the shortage of electrical energy, planning is needed to be able to meet the needs of electrical energy in the future [1]. In planning to meet the needs of electrical energy we can utilize one of the abundant energy sources such as solar energy where this solar energy can be converted into electrical energy, so that electrical energy needs can be met. This solar energy has many advantages such as being environmentally friendly, clean and does not cause air pollution and can be obtained for free [3-8]. Currently, the panels that are often used are polycrystalline and monocrystalline types. Polycrystalline has a good efficiency of 8.47% - 12.22% and monocrystalline has an efficiency of 15.32% - 20.87%. While the thin solar panel type has an efficiency of 5.78% - 6.13% [9].

This type of polycrystalline and monocrystalline has good efficiency, then there is a new type developed, namely thin solar panels. Thin solar panels have the advantage of being thinner and lighter than polycrystalline and

monocrystalline weights thicker, but thin solar panels are not widely used, because they still have low efficiency [10-12]. This low efficiency is caused by several things such as the materials used are not as good as polycrystalline and monocrystalline, the optimization control used is not good and the cost is expensive [14], [19]. Hopefully in the future thin solar panels can develop and have higher efficiency so that it becomes one of the choices that is feasible to use in various fields. This is supported by the advantages of thin solar panels, which have a thin weight so that they can be applied to electronic goods such as televisions, calculators, streetlights and so on [13], [15-18].

Based on the description above, the research aims to analyze the power productivity generated by thin solar panels. This research is assisted by a tool that can determine the power productivity of thin solar panels to know the amount of power when the weather is not sunny and sunny weather. It takes the right time at the time of absorption of solar energy on thin solar panels such as during pick sun hour or peak sun hours. As well as comparing the power results obtained during sunny, cloudy, and rainy weather. Furthermore, it is explained in research that energy productivity testing is only done by testing the constituent material properties of the panel, so no one has tested the productivity of thin solar panels.

## 2. Research method

This research is a qualitative study with a laboratory experimental method on thin solar panels with a capacity of 100 wp to determine the maximum energy and the current produced. In this study, thin solar panels were used to analyze the productivity of electricity produced. Through measurement of current-voltage (V-I) variables produced by solar panels. From [18], [19] the variables that have been measured, it will be seen the productivity of the electricity produced by the two types of panels. The electrical power generated by solar panels can be defined as follows,

$$P_{out} = Voc * I_{sc} * FF \quad (1)$$

Where  $P_{out}$  is the power generated by the solar cell (watts),  $Voc$  is the open circuit voltage on the solar cell (volts),  $I_{sc}$  is the short circuit current on the solar cell (amperes), and  $FF$  is the fill factor generated by the solar cell. The fill factor is the ratio value of voltage and current at the maximum power state and open circuit voltage ( $Voc$ ) and short circuit current ( $I_{sc}$ ).

$$FF = \frac{(Voc - In (Voc + 0,72))}{(Voc + 1)} \quad (2)$$

The efficiency that occurs in solar cells is the ratio of the power that can be compared by solar cells to the input energy obtained from solar irradiance.

$$n = \frac{output}{input} \times 100\% \quad (3)$$

Furthermore, to calculate the PHS value, the process to obtain the Peak Sun Hour (PSH) value can be done by using the nominal peak power equation, the PSH value can be determined by substituting the peak power value into the equation,

$$P_{pv} = \frac{P_{total}}{PHS \cdot \eta_{sistem}} \quad (4)$$

Several factors affect the output power of solar panels produced in solar panel systems, including the influence of solar radiation on solar panels. Then the influence of temperature, the amount of temperature received by solar panels is inversely proportional to the amount of output power produced by solar panels [20-23]. Furthermore, partial shading conditions can cause a loss of solar module output power [24]. In addition to these factors, other factors that affect the productivity of solar panels are the effects of latitude and longitude, the effect of sunlight intensity is determined by the region on the earth's surface [25].

### 2.1. Subdivision - numbered sections (11 pt, Sentence case)

In testing the electrical productivity of solar panels using a testing circuit as shown in Figure 1, the testing circuit is used to facilitate the process of taking test data. In the test circuit there is a Thin Solar Panel with a peak power specification generated by 100 Wp, which is connected in series with a current measuring instrument and connected in parallel with a voltage measuring instrument.

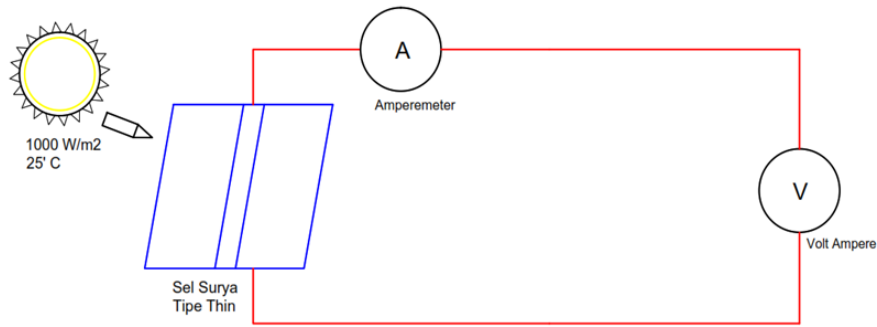


Figure 1. Condition circuit testing

### 3. Results and discussion

The results of this study are the amount of voltage, current and power produced by thin solar panels with different intensity and temperature of the sun. In the test, the current and voltage measurements produced by each panel are carried out, to know the electrical productivity of the Thin Solar Panel reaching the maximum point of current and power that can be generated, based on intensity. The data collection time starts from 08:00 to 16:00 with the panel position only facing straight vertically upwards. The solar panel used in this study is a thin solar panel which has specifications as shown in Table 1.

Table 1. Solar panel specifications

Thin Solar Panel	
Pmax	100 W
Voc	23.05 V
Isc	6.78 A
Vmp	17.98 V
Imp	5.57 A
Dimensi	920x678

#### 3.1. Energy productivity during sunny

In measuring thin solar panels in sunny weather conditions, measurements were taken for 9 hours starting from 08.00 - 16.00 WIB. In sunny weather, the power generated generally ranges in the range of 4.55 watts - 12.85 watts. The lowest power generated during sunny weather is 0.87 watts. While the highest power obtained during sunny weather is 15.60 watts.

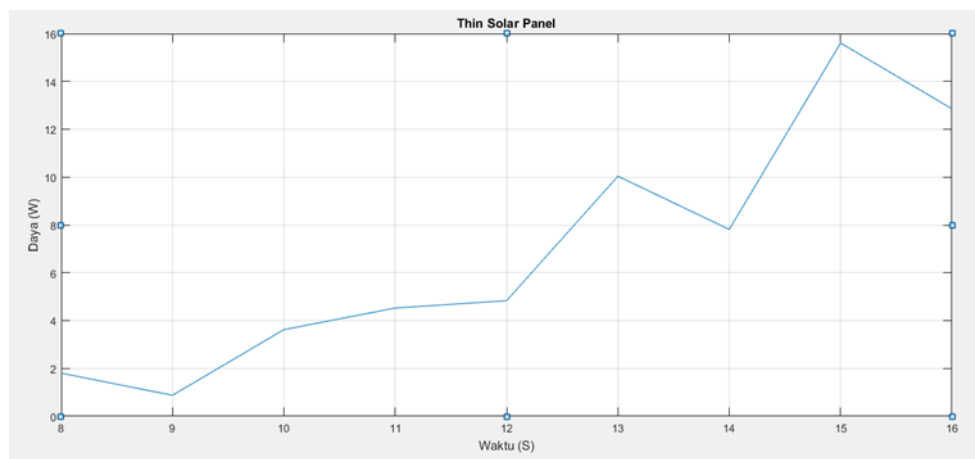


Figure 2. The energy produced by thin solar panels during sunny weather

It can be seen in Figure 2, at 08.00 to 09.00 the graph drops slightly, then at 09.00 to 13.00 the graph increases quite high because the power generated is increasing, but at 13.00 - 14.00 the graph starts to drop and the graph rises again until 15.00, where this is the peak power obtained during sunny conditions, then the graph drops again at 16.00 WIB. In measurements taken from 08:00 to 16:00 Thin Panels in sunny conditions, the average current generated is 0.275 A and the average power is 6.885 Watt. Several things affect the rise and fall of the graph, namely weather conditions. In this sunny weather, the absorption of power on the panel can be done optimally.

### 3.2. Energy productivity during cloudy

Measurements on thin solar panels in cloudy, sunny, and then cloudy conditions again, where these measurements were carried out for 9 hours starting at 08.00 - 16.00 WIB. From 08.00 to 10.00 the power generated was 0.60 watts to 2.18 watts. Furthermore, in sunny conditions at 11:00 to 13:00 the power increased to 3.66 watts. Then the power decreased because the weather was cloudy again and the power produced was quite good, up to 11.17 watts.

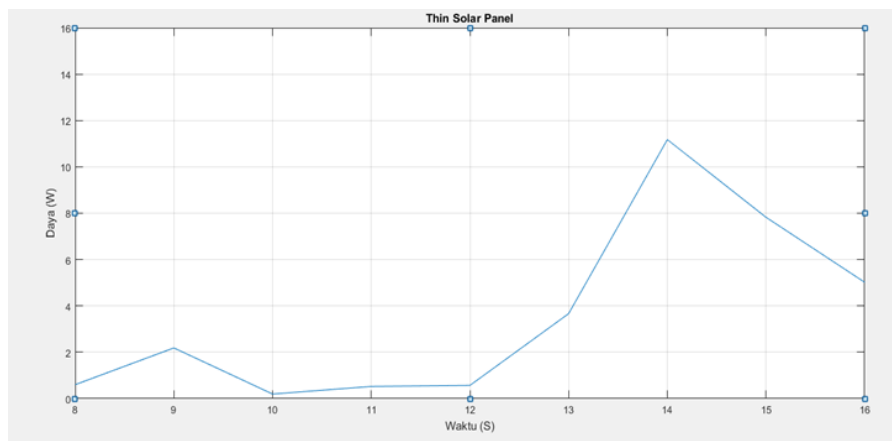


Figure 3. The energy produced by thin solar panels during sunny-cloudy weather

As shown in Figure 3, from 08.00 to 09.00 it increased, then dropped again until 10:00, from 10.00 the graph increased due to sunny weather until 13.00, but the graph continued to increase until 14:00 even though conditions had begun to cloudy and this time also the highest power was generated, then the graph began to fall back until 16.00. In measurements starting from 08.00 to 16.00 Thin Panels in sunny and cloudy conditions, the average current generated was 0.139 A and the average power was 3.529 Watts.

### 3.3. Energy productivity during cloudy and rainy

In measuring thin solar panels in cloudy to rainy weather, measurements were taken for 9 hours starting from 08.00 - 16.00. The power generated when it is cloudy and even rainy is not too high, where starting from 08.00 to 14.00 the lowest power generated is 1.68 watts while the highest power generated is 5.04 watts at 09.00. Then, the power generated during rainy weather is 0.21 watts and 0.66 watts at 15.00 to 16.00.

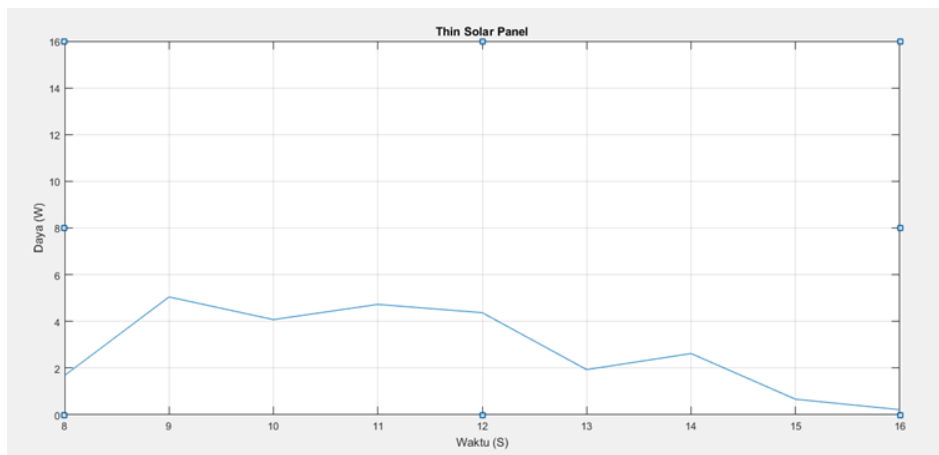


Figure 4. The energy produced by thin solar panels during cloudy-rainy weather

From Figure 4, at 08.00 to 09.00 the graph increases because this peak power is obtained during cloudy and rainy conditions. Furthermore, from 09.00 until 12.00 it also increased, then fell at 13.00, rose again at 14.00, and then fell until 16.00 WIB. In cloudy to rainy conditions, the graph often experiences ups and downs, but the power generated is also quite good. In measurements taken from 08:00 to 16:00 Thin Panels in cloudy and rainy conditions, the average current generated is 0.115 A and the average power is 2.817 Watt.

#### 4. Conclusions

The power generated on the first thin solar panel during sunny weather, the lowest power is 0.87 watts while the highest power is 15.60 watts. Furthermore, during sunny and cloudy weather, the lowest power generated is 0.52 watts while the highest power generated is 11.17 watts. Finally, the power generated during cloudy and rainy weather, the lowest power obtained is 0.21 watts while the highest power obtained is 4.72 watts.

#### References

- [1]. Abderrahim, T., Abdelwahed, T. and Radouane, M. (2020) 'Improved strategy of an MPPT based on the sliding mode control for a PV system', *International Journal of Electrical and Computer Engineering*, 10(3), pp. 3074–3085.
- [2]. Ady Pratama, D. and Herlamba Siregar, I. (2018) 'Uji Kinerja Panel Surya Tipe Polycrystalline 100Wp', *Jptm*, 6(3), pp. 79–85.
- [3]. Agne, E.B.P., Hastuti, R. and Khabibi (2010) 'Jurnal Kimia Sains dan Aplikasi', *Jurnal Kimia Sains dan Aplikasi*, 13(2), pp. 51–56.
- [4]. Ali, M.H.M. et al. (2022) 'Comparison between P&O and SSO techniques based MPPT algorithm for photovoltaic systems', *International Journal of Electrical and Computer Engineering*, 12(1), pp. 32–40.
- [5]. Asrori Harahap, M. Zusriansyah Fahrudin, A.H. (2022) 'Perbandingan Performansi Panel Surya Tipe Amorphous dan', *Jurnal Riset dan Konseptual*, 7(November), pp. 1091–1103.
- [6]. Asyadi, T.M., Sara, I.D. and Suriadi, S. (2021) 'Metode Maximum Power Point Tracking (MPPT) dan Boost Converter Menggunakan Fuzzy Logic Controller (FLC) pada Modul Surya', *Jurnal Rekayasa ElektriKa*, 17(1), pp. 1–6.
- [7]. Berisha, X., Zeqiri, A. and Meha, D. (2018) 'Determining the optimum tilt angles to maximize the incident solar radiation-case of study Pristina', *International Journal of Renewable Energy Development*, 7(2), pp. 123–130.
- [8]. Budiyanto, B. and Setiawan, H. (2021) 'Analisa Perbandingan Kinerja Panel Surya Vertikal Dengan Panel Surya Fleksibel Pada Jenis Monocrystalline', *Resistor (Elektronika Kendali Telekomunikasi Tenaga Listrik Komputer)*, 4(1), p. 77.
- [9]. Hamoodi, S.A., Al-Karakchi, A.A.A. and Hamoodi, A.N. (2022) 'Studying performance evaluation of hybrid e-bike using solar photovoltaic system', *Bulletin of Electrical Engineering and Informatics*, 11(1), pp. 59–67.
- [10]. Hamrouni, N., Jraidi, M. and Chérif, a (2008) 'Solar radiation and ambient temperature effects on the performances of a PV pumping system', *Revue des Energies Renouvelables*, 11(March 2008), pp. 1–95.
- [11]. Harahap, P. (2020) 'Pengaruh Temperatur Permukaan Panel Surya Terhadap Daya Yang Dihasilkan Dari Berbagai Jenis Sel Surya', pp. 73–80.
- [12]. Hie Khwee, K. (2013) 'Pengaruh Temperatur Terhadap Kapasitas Daya Panel Surya (Studi Kasus: Pontianak)', *Jurnal ELKHA*, 5(2), pp. 23–26.
- [13]. Iswahyudi, S. et al. (no date) 'Peningkatan Produktivitas Sel Surya Dengan Memanfaatkan Parabola Sebagai Konsentrator'.
- [14]. Kaban, S.A. and Jafri, M. (2020) 'Optimalisasi Penerimaan Intensitas Cahaya Matahari Pada Permukaan Panel Surya ( Solar Cell ) Menggunakan Cermin', 5(2), pp. 108–117.
- [15]. Killam, A.C. et al. (2021) 'Monitoring of Photovoltaic System Performance Using Outdoor Suns-VOC', *Joule*, 5(1), pp. 210–227.
- [16]. Megantoro, P. et al. (2022) 'Effect of peak sun hour on energy productivity of solar photovoltaic power system', *Bulletin of Electrical Engineering and Informatics*, 11(5), pp. 2442–2449.

- [17]. Purwoto, B.H. et al. (2018) 'Efisiensi Penggunaan Panel Surya sebagai Sumber Energi Alternatif', Emitor: Jurnal Teknik Elektro, 18(1), pp. 10–14.
- [18]. Ramadani, K. (2021) 'Pengaruh Lama Waktu Penyemprotan Sistem Pendingin Water Spray Terhadap Kinerja Panel Surya', pp. 1–53.
- [19]. Ramansyah, G. (2021) 'Perancangan Panel Surya Sebagai Sumber Energi Lampu'.
- [20]. Reza pahlevi, Hasyim Asy'ari, A.B. (2014) 'Pengujian Karakteristik Panel Surya Berdasarkan Intensitas Tenaga Surya'.
- [21]. Safitri, N. (2019) Buku Teknologi Photovoltaic. Edited by K.Y. Putri. YayasanPuga Aceh Riset Redaksi:
- [22]. Setyaningrum, Y. (2017a) 'Pengukuran Efisiensi Panel Surya Tipe Monokristalin Dan Karakterisasi Struktur Material Penyusunnya', Its [Preprint].
- [23]. Setyaningrum, Y. (2017b) 'Pengukuran Efisiensi Panel Surya Tipe Monokristalin Dan Karakterisasi Struktur Material Penyusunnya', Institut Teknologi Sepuluh Nopember, 75.
- [24]. Shodiq, J. (2017) 'Simulasi Performa Photovoltaics Berbahan Nanokristalin SnO<sub>2</sub>', pp. 1–60.
- [25]. Suryana, D. (2016) 'Pengaruh Temperatur/Suhu Terhadap Tegangan Yang Dihasilkan Panel Surya Jenis Monokristalin (Studi Kasus: Baristand Industri Surabaya)', Jurnal Teknologi Proses dan Inovasi Industri, 1(2), pp. 5–8.