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THE INFLUENCE OF WEATHER CONDITIONS ON ELECTRICITY PRODUCTION FROM A RESIDENTIAL PHOTOVOLTAIC SYSTEM

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Abstract Photovoltaic (PV) systems are an important source of renewable energy, and their electricity production is influenced strongly by the weather conditions. The aim of this study was to investigate the influence of global solar irradiance, air temperature and cloud cover on electricity production from a residential photovoltaic system during a seven-day observation period. Electricity production data obtained from the SolarEdge Monitoring Platform were compared with meteorological data provided by the Slovenian Environment Agency (ARSO), and the results were analysed using Tables and graphs created in Microsoft Excel. The analysis showed that global solar irradiance had the greatest influence on PV electricity production, while cloud cover reduced the energy output and the air temperature had a smaller effect. The findings improve the understanding of how weather conditions influence electricity production from residential photovoltaic systems, and highlight the importance of solar irradiance for PV performance.

Keywords

photovoltaic system,
weather, production,
solar irradiance,
electricity production,
renewable energy

1 Introduction

Renewable energy sources are becoming increasingly important, because they help reduce greenhouse gas emissions and decrease the dependence on fossil fuels. Among the renewable energy technologies, photovoltaic (PV) systems are one of the fastest-growing methods of electricity generation. According to the International Energy Agency (International Energy Agency, 2024) the global use of solar energy continues to increase, due to its environmental and economic benefits.

The analysed residential photovoltaic system is monitored using the SolarEdge Monitoring Platform, which provides detailed information about electricity production throughout the day (SolarEdge Technologies, 2026). The weather data used in this study were obtained from the Slovenian Environment Agency (ARSO), which provides reliable meteorological measurements, including global solar irradiance and air temperature (Slovenian Environment Agency, 2026).

The electricity production of a photovoltaic system depends strongly on the weather conditions. Messenger and Ventre (Messenger & Ventre, 2010) explained that the amount of electricity generated is determined primarily by the intensity of the incoming solar radiation, while environmental factors such as air temperature and cloud cover also influence the performance of photovoltaic modules. Furthermore, Dubey et al. (Dubey et al., 2013) highlighted the importance of environmental conditions when evaluating the performance of PV systems. Their findings support the need to analyse weather conditions when assessing PV system performance.

The aim of this study was to investigate the influence of weather conditions on electricity production from a residential photovoltaic system. Electricity production data collected from the PV system were compared with meteorological data, including global solar irradiance and air temperature, over a seven-day observation period. The results were analysed, to determine how changes in the weather conditions affected the electricity production of the residential PV system.

2 Materials and Methods

The analysed photovoltaic system is installed on a residential building in Slovenia. The basic technical characteristics of the analysed PV system are presented in the following Table.

Table 1: Basic technical characteristics of the analysed PV system

Installed capacity - PV modules peak power (kWp)	Module orientation - Azimuth (°)	Tilt (°)	Inverter/ system configuration	Shading
15.725	129 (for 36 modules) 309 (for 1 module)	28	3-phase 16 kW inverter, with 19 optimisers, 37 monocrystalline 425 W PV modules, one string	two chimneys

The distance between the PV installation and the ARSO meteorological station is approximately 2.14 km. The limitation of the study is also the global irradiance measured at a meteorological station rather than irradiance in the plane of the PV modules.

The air temperature was used as an available meteorological parameter. However, it should be noted that the air temperature does not represent the PV module temperature directly, which is the parameter related more directly to temperature-induced changes in PV efficiency.

The electricity production data were obtained from the SolarEdge monitoring platform. The PV production data had a temporal resolution of 15 minutes, while the meteorological data obtained from the ARSO weather station were recorded at 10-minute intervals. The datasets were aligned according to their date and time information for comparison. No missing data were identified in either dataset during the analysed seven-day period. The analysed period covered seven consecutive days, from 15 June to 21 June, 2026. The selected period included both clear and cloudy days, allowing the influence of different weather conditions to be evaluated on PV electricity production.

The meteorological data were obtained from the nearest ARSO weather station, which is located in the village of Šmartno pri Slovenj Gradcu. Two weather parameters were selected for the analysis: global solar irradiance (W/m^2) and air temperature ($^{\circ}\text{C}$). These parameters were selected because they are relevant meteorological factors affecting photovoltaic electricity production and were available for the analysed period.

The electricity production and weather data were organised and processed using Microsoft Excel. Graphs were created to compare the changes in PV electricity production with the changes in solar irradiance and air temperature throughout each day.

3 Results

3.1 Daily analysis of PV production

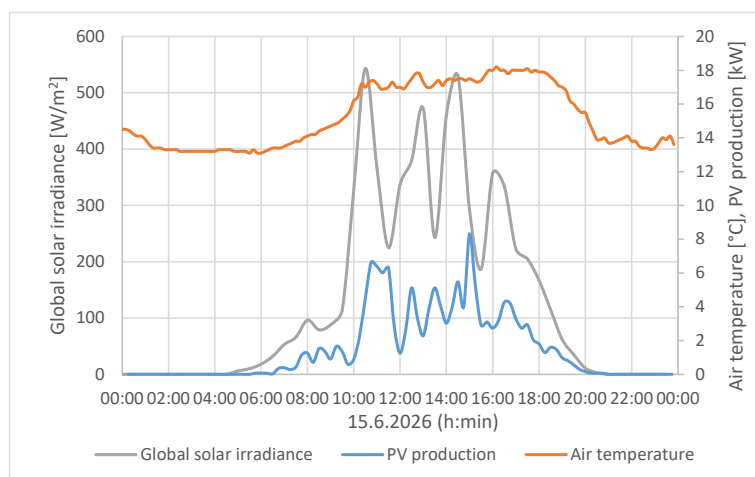


Figure 1: Relationship between the weather conditions and PV power production on 15 June, 2026

Figure 1 shows the relationship between the global solar irradiance, air temperature and PV power production on 15 June, 2026. The global solar irradiance increased during the morning and reached its maximum around midday. The PV system responded similarly, although several short-term drops in power production

occurred due to temporary reductions in solar irradiance, caused most likely by passing clouds. The air temperature increased steadily throughout the day and reached its highest value in the afternoon. The results indicate that the solar irradiance had the greatest influence on PV power production.

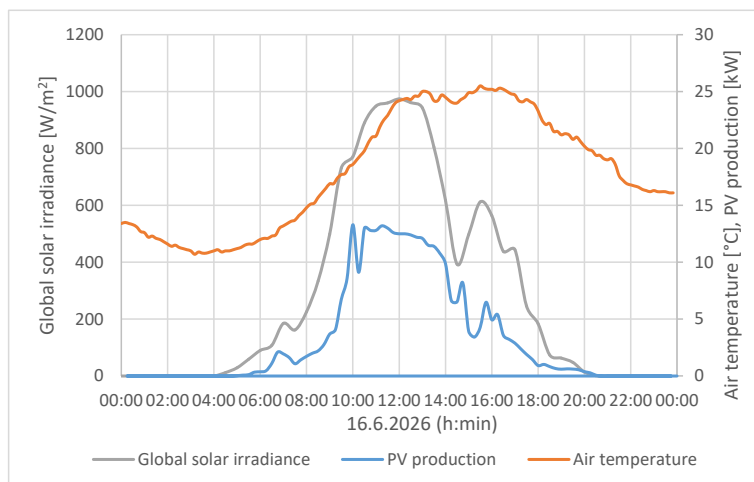


Figure 2: Relationship between the weather conditions and PV power production on 16 June, 2026

Figure 2 presents the weather conditions and PV power production on 16 June, 2026. The solar irradiance increased rapidly during the morning and remained relatively high until the afternoon. These changes were reflected in the PV production, which followed the irradiance pattern closely. The air temperature increased gradually during the day and remained high for several hours. The strong similarity between the irradiance and PV production confirms that solar radiation was the dominant factor affecting power generation.

Figure 3 illustrates the weather conditions and power production on 17 June, 2026. Compared with the previous day, the global solar irradiance showed more frequent fluctuations, indicating variable cloud cover. Consequently, the PV system produced power less steadily, with several noticeable decreases during the day. The air temperature increased continuously and reached its maximum in the afternoon. The results suggest that the changing cloud conditions affected the power production significantly.

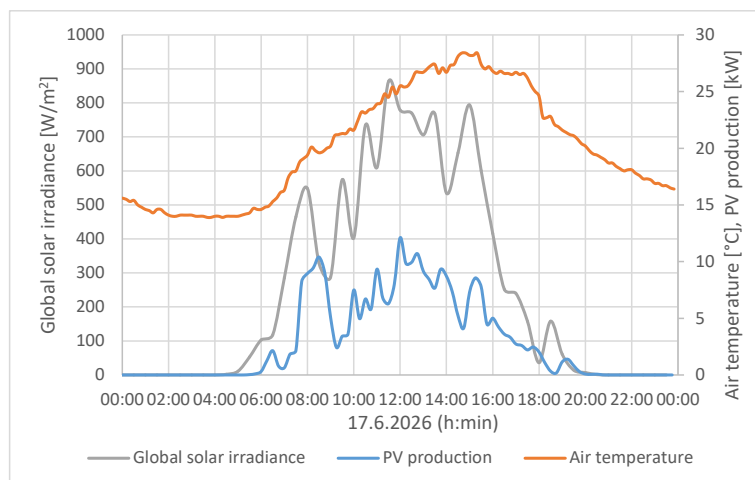


Figure 3: Relationship between the weather conditions and PV power production on 17 June, 2026

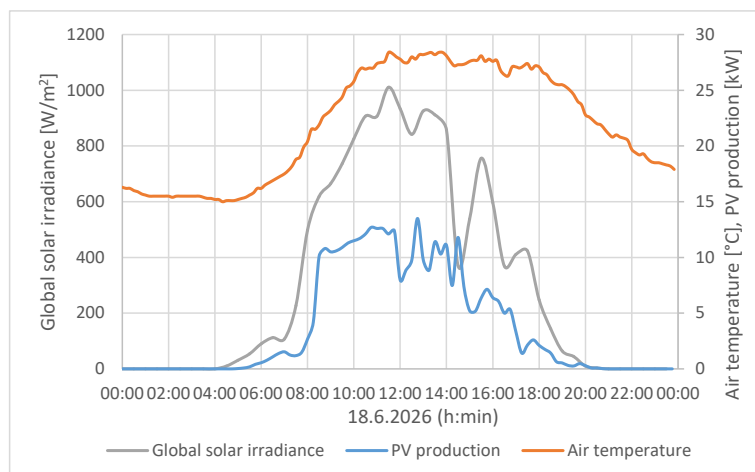


Figure 4: Relationship between the weather conditions and PV power production on 18 June, 2026

Figure 4 shows relatively favourable weather conditions throughout most of the day. The global solar irradiance reached high values during the late morning and early afternoon, resulting in stable power production by the PV system. Short-term reductions in irradiance were reflected immediately in lower power production. The air temperature remained high during the afternoon, but did not produce sudden

changes in PV output. This confirms that solar irradiance had a more direct influence on power production than air temperature.

Figure 5 represents one of the most stable days during the observation period. The global solar irradiance followed a smooth daily pattern with only minor fluctuations, resulting in relatively constant PV power production. The air temperature increased gradually and reached approximately 30 °C during the afternoon. Because the cloud cover was limited, the PV system operated under favourable conditions and produced power continuously throughout the day.

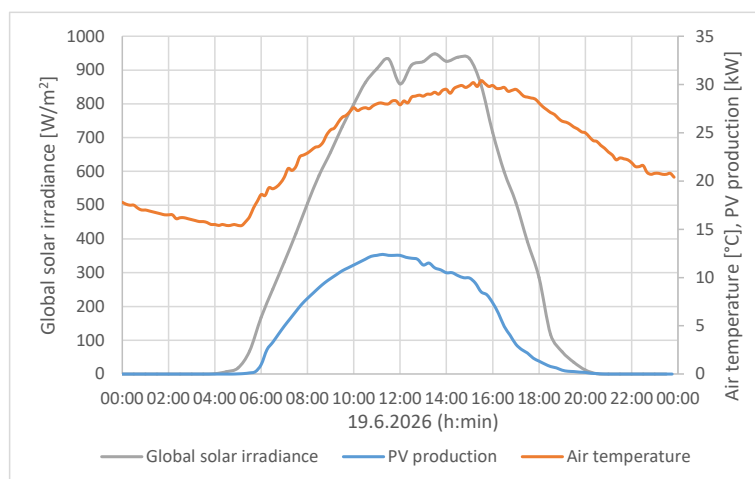


Figure 5: Relationship between the weather conditions and PV power production on 19 June, 2026

Figure 6 differs from the previous days because the power production decreased sharply during the afternoon at relatively high air temperatures. This reduction corresponded to a rapid decline in the global solar irradiance, indicating increased cloud cover or changing weather conditions. As a result, the PV production dropped significantly within a short period. The graph again demonstrates that solar irradiance has a much stronger influence on power production than air temperature alone.

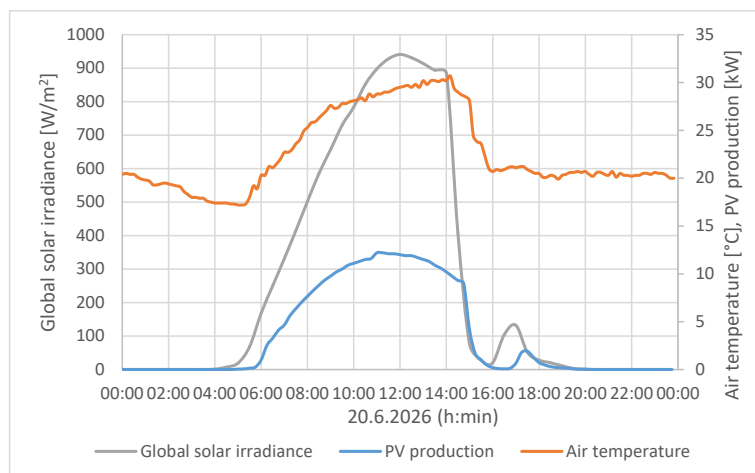


Figure 6: Relationship between the weather conditions and PV power production on 20 June, 2026

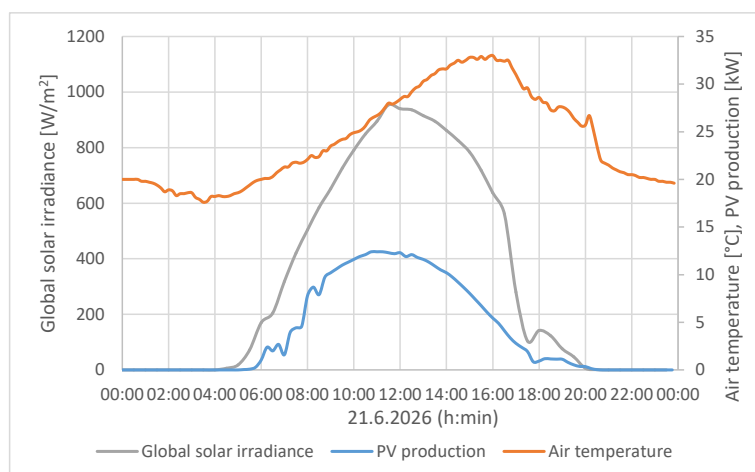


Figure 7: Relationship between the weather conditions and PV power production on 21 June, 2026

Figure 7 presents the weather conditions and PV power production on the final day of the observation period. The global solar irradiance increased gradually during the morning, and reached its maximum around midday before decreasing in the afternoon. The PV system followed this trend closely, and produced its highest output during periods of maximum irradiance. The air temperature continued to rise

throughout the afternoon, when the power production decreased due mainly to lower solar irradiance. This demonstrates that the availability of solar radiation is the primary factor determining photovoltaic power production.

3.2 Comparison of Daily Energy Production

Table 2: Summary of the daily PV power production and cloudiness [3]

	Daily Energy Production (kWh)	Cloudiness at 7 AM	Cloudiness at 2 PM
15 June	38.3	Cloudy	Cloudy
16 June	81.8	Cloudy	Partly cloudy
17 June	74.3	Partly cloudy	Mostly cloudy
18 June	92.4	Cloudy	Mostly cloudy
19 June	107	Clear	Clear
20 June	90.1	Clear	Clear
21 June	101	Clear	Clear

Table 2 summarises the daily PV energy production together with the observed cloudiness at 7 AM and 2 PM during the seven-day observation period. The highest daily energy production was recorded on 19 June (107 kWh), when the weather remained clear throughout the day. Similarly, high energy production was observed on 21 June (101 kWh) and 20 June (90.1 kWh), both of which also had clear weather conditions. In contrast, the lowest daily production was recorded on 15 June (38.3 kWh), when cloudy conditions in the morning and in the afternoon reduced the available solar radiation. Overall, the data indicate that clearer weather conditions generally resulted in higher daily PV energy production, while increased cloudiness was associated with lower energy output.

3.3 Overall results

During the seven-day observation period the daily energy production ranged from 38.3 kWh to 107 kWh. The highest production was recorded on 19 June under clear weather conditions, while the lowest production occurred on 15 June, when cloud cover reduced the available solar irradiance. These results are consistent with the trends observed in all daily graphs.

4 Discussion

The results show clearly that the global solar irradiance was the most important factor affecting the electricity production of the residential photovoltaic system. On all the analysed days PV production increased shortly after sunrise, reached its highest values around midday and decreased gradually towards the evening. This trend followed the changes in global solar irradiance closely.

Several short-term decreases in electricity production occurred during periods when the solar irradiance declined rapidly. These changes were most likely caused by temporary cloud cover, which reduced the amount of sunlight reaching the photovoltaic panels. The close agreement between the irradiance and PV production curves indicates a strong relationship between these two variables. The Pearson correlation coefficient was calculated to assess the relationship between solar irradiance and PV electricity production quantitatively. A strong positive correlation was obtained ($r = 0.95$), indicating that the higher global solar irradiance was associated with higher PV electricity production during the analysed period.

The air temperature also changed during the observation period, generally increasing from the morning until the afternoon. The air temperature was also analysed separately. The results suggest that its apparent influence on PV power was weaker than that of solar irradiance during the analysed period. However, the available data do not allow the independent effect of the air temperature to be separated quantitatively from the effect of solar irradiance. It is well known that an increase in PV module temperature reduces its efficiency, and, consequently, its electricity production. This trend can also be observed in Figure 5. In several cases the air temperature continued to increase while the PV electricity production was already decreasing, mainly because the solar irradiance had started to decline.

The comparison of all seven days also revealed that the stable weather conditions resulted in smoother electricity production, while variable weather conditions caused frequent fluctuations in the PV output. These observations agree with the theoretical principles of photovoltaic electricity generation described in the literature.

A limitation of this study is the short seven-day observation period, which does not capture seasonal variations in the PV system operation. Therefore, the results should be interpreted as a short-term case study, rather than as representative of residential photovoltaic systems under different seasonal conditions.

Overall, the results for the analysed seven-day period indicate that solar irradiance was the main observed weather factor associated with PV power variations in the investigated residential photovoltaic system.

5 Conclusion

This study investigated the influence of weather conditions on electricity production from a residential photovoltaic system during a seven-day observation period.

The results show that global solar irradiance had the strongest influence on electricity production. This is supported by the strong positive correlation between global solar irradiance and PV electricity production ($r = 0.95$) during the analysed seven-day period. The PV system produced the highest amount of electricity during periods with high solar irradiance, while cloud cover caused immediate reductions in electricity generation. The air temperature also changed during the day, but its effect on electricity production was less significant than the effect of solar irradiance. However, the effect of PV module temperature cannot be quantified independently because the PV module temperature was not measured.

The findings of this study, based on the seven-day observation period and the analysed residential PV system, demonstrate that weather conditions should be considered when evaluating photovoltaic system performance. The results should be interpreted as a short-term case study, as the seven-day observation period does not cover seasonal variations in weather conditions and PV performance. Understanding the relationship between weather conditions and electricity production can help improve the analysis and operation of residential solar power systems.

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Povzetek v slovenskem jeziku

Vpliv vremenskih pogojev na proizvodnjo električne energije iz stanovanjske fotonapetostne elektrarne. Fotonapetostni (PV) sistemi predstavljajo pomemben vir obnovljive energije, njihova proizvodnja električne energije pa je močno odvisna od vremenskih razmer. Namen raziskave je bil preučiti vpliv globalnega sončnega obsevanja, temperature zraka in oblačnosti na proizvodnjo električne energije iz hišnega fotonapetostnega sistema v sedemdnemnem obdobju opazovanja. Podatki o proizvodnji električne energije, pridobljeni s platforme SolarEdge Monitoring Platform, so bili primerjani z meteorološkimi podatki Agencije Republike Slovenije za okolje (ARSO), rezultati pa analizirani s pomočjo tabel in grafov, izdelanih v programu Microsoft Excel. Analiza je pokazala, da ima globalno sončno obsevanje največji vpliv na proizvodnjo električne energije fotonapetostnega sistema, medtem ko oblačnost zmanjšuje proizvodnjo, temperatura zraka pa ima manjši vpliv. Ugotovitve raziskave prispevajo k boljšemu razumevanju vpliva vremenskih razmer na proizvodnjo električne energije iz hišnih fotonapetostnih sistemov ter poudarjajo pomen globalnega sončnega obsevanja za njihovo učinkovito delovanje.