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Research Article

Thermal image analysis for fault detection of PV systems in Ankara/Turkey

Hale Bakır[1*],

[1*] Department of Electronics and Automation, Sivas Cumhuriyet University, Sivas, Turkey
halebakir@cumhuriyet.edu.tr

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Abstract

Due to the increase in consumption of fossil fuels and the damage they cause to the environment, renewable energy-clean energy orientation has increased. However, renewable energy systems can be affected by environmental conditions and there is a decrease in energy production and efficiency. Types of faults in solar energy systems, such as cracking, soiling, connection faults, cause losses in energy production. In this study, thermal image analysis was carried out with a thermal drone in a solar power plant located in Ankara, Turkey. As a result of the examinations, the faults in the PV panels were immediately detected with the thermal drone. When the problem was solved in the field, 0.68 % improvement was achieved in energy production.

Keywords: solar power plant, energy production, thermal drone, faults

Ankara/Türkiye'deki PV sistemlerinin arıza tespiti için termal görüntü analizi

Öz

Fosil yakıtların tüketiminin artması ve çevreye verdikleri zarar nedeniyle yenilenebilir enerji-temiz enerji yönelimi artmıştır. Ancak yenilenebilir enerji sistemleri çevre koşullarından etkilenebilmekte ve enerji üretimi ve verimliliğinde azalma olmaktadır. Güneş enerjisi sistemlerinde meydana gelen çatlama, kirlenme, bağlantı arızaları gibi arıza türleri enerji üretiminde kayıplara neden olmaktadır. Bu çalışmada, Ankara'da bulunan bir güneş enerjisi santralinde termal drone ile termal görüntü analizi yapılmıştır. Yapılan incelemeler sonucunda termal drone ile PV panellerdeki arızalar anında tespit edilmiştir. Sahada sorun çözüldüğünde enerji üretiminde % 0,68 oranında iyileşme sağlanmıştır.

Anahtar Kelimeler: güneş enerjisi santrali, enerji üretimi, termal drone, arızalar

* Corresponding Author: halebakir@cumhuriyet.edu.tr

1. Introduction

Today, with the increase in living standards, there has been a significant increase in energy use. Renewable energy sources can play an important role in meeting these demands. One of the rapidly developing and promising applications of energy production technology from these sources is solar panel systems (Li & Lam, 2007). Solar panel systems generate power with non-linear current-voltage curves depending on environmental conditions (Taherbaneh, Rezaie, Ghafoorifard, Rahimi, & Menhaj, 2010). Therefore, users' expectations of power and economic benefits need to be realistic. Otherwise, solar electricity becomes an expensive resource (Ancuta & Cepisca, 2011).

On the other hand, there are many studies to increase the efficiency of solar panels as a result of technological innovations (Purvis, 2013). Installed solar panels lose their efficiency as a result of some deterioration. Faults or defects; delamination, connection faults, polymer cracks, front surface contamination, blackening on bottom edge of panel, junction box corrosion, bypass diode fault and hotspot fault, soiling, glass breakage, snail marks, rapid performance degradation and rapid structural deterioration, etc. way can be classified (Djordjevic, Parlevliet, & Jennings, 2014).

A single panel defect can affect the lifetime of all panels connected to the array, resulting in high replacement costs (Ding, 2012)[6]. Panel performance is directly affected by direction, angle, shading, panel type, maintenance, cleaning and back temperature, apart from the above factors.

In this study, the 2.7 MW solar power plant located in Ankara Turkey was examined with a thermal drone. The types of faults found in Turkey and these faults were analyzed and the losses caused by the faults found in real time were calculated. Depending on these losses, an improvement in energy production of 0.68 % was achieved by solving the problem in the field

2. Material and Method

2.1. PV module efficiency

Efficiency decreases with the loss of PV systems due to faults. Production loss due to faults in a solar power plant is calculated with Equation (1), and the percentage of improvement in production loss is found with Eq. (2);

$$P_{loss} = n_{st} P_{pv} n_{fault} \quad (1)$$

Where P_{loss} is the production loss, n_{st} is the number of total panels in a string, P_{pv} is panel power (330 W) and n_{fault} refers to the number of defective solar panels.

$$P_{imp} = \frac{P_{loss}}{P_{out}} 100\ \% \quad (2)$$

Where P_{imp} refers to the energy production improvement, P_{loss} is production loss and P_{out} is output of the panels.

2.2. DJI Mavic enterprise advanced thermal drone

In this study, DJI Mavic advanced model drone was used. The drone picture used in the study is shown in Fig. 1.

This model, which runs quieter and can fly longer than many other models, flies at a speed of 72 km in windless air, and its flight time is 31 minutes. Since obstacle detection is extremely important in drone flights, DJI Mavic advanced drone is used and it has versatile obstacle detection systems. As seen in Fig. 2, the drone camera features are given.

Fig. 1 DJI Mavic enterprise advanced thermal drone

Fig. 2 Properties of thermal drone camera

2.3. Solar Power Plant in Ankara/Turkey

In this study, fault analysis and detection were carried out in a 2.7 MW solar power plant using a thermal drone in the field. The image taken by the drone of the power plant is given in Figure 3. Table 1 gives the drone flight information used while testing the 2.7 MW solar power plant.

Temperature differences in the PV panel are important and what to do in case of these differences is given in Table 1. If the panel temperature is below 1 °C, it is seen that the panel is normal. If the panel temperature has taken a value between 1 °C and 4 °C, it can be seen that the panel needs to be inspected. If the Panel temperature is detected between 4.0 °C and 15 °C, it is given in the table that the panel should be repaired. When the panel temperature rises above 15.0 °C, it can be seen that the panel needs to be taken to the emergency response.

Fig. 3 2.7 MW solar power plant captured by drone

Table 1. Drone flight information for 2.7 MW solar power plant

Flying height	**Radiation**	**Ambient Temperature**	**Panel Temperature**
20-25 Meter	985 W/m2	24 °C	38.86 °C

Table 2. The importance of temperature differences in PV panel

Normal	**Should be examined**	**Should be repaired**	**Emergency response**
<1.0 °C	1.0 to 4.0 °C	4.0 to 15.0 °C	>15.0 °C

2.4. Experimental results and discussion

When the images taken with the drone were analyzed, a hotspot fault was detected on the panel shown in Figure 4. The panel temperature was determined to be a maximum of 43.0 degrees, a minimum of 11.9 degrees and an average of 38.9 degrees. In Figure 4, C1 is indicated by circle marks. One connection fault has been detected in the panel shown in Figure 4. The panel temperature was determined to be a maximum of 49.0 degrees, a minimum of 14.9 degrees and an average of 32.4 degrees.

With the thermal drone in Figure 5, three Bypass diode faults were detected on the panel and the panel temperature was determined as maximum 43.0 degrees, min 37.0 degrees and average 39.8 degrees.

As another fault, one connection fault was detected on the panel with the thermal drone and the panel temperature was found to be maximum 38.95 degrees, min 20.95 degrees and average 35.13 degrees. The connection fault is indicated by the circle marks C1 in Figure 5. Five Bypass diode faults were detected on the panel with the thermal drone in Figure 6(a-b-c).

According to the tests, a total of 11 faults were detected, and the thermal shot fault distributions taken on the panels with the drone are given in Figure 7. 8 bypass diode faults are given with dark blue colored busbar, two connection faults are given as green colored busbar, one hotspot fault is given as blue colored bus. No other type of fault has been detected. A total of 11 panel fault were detected and the number of panels affected by these faults was determined to be 28.

The calculation of the production loss caused by the faults in a 2.7 MW solar power plant is calculated with Eq. (1), while the percentage of improvement in the production loss is found with Eq. (2) based on the losses.

As a result, an improvement of 0.68 % was achieved in energy production.

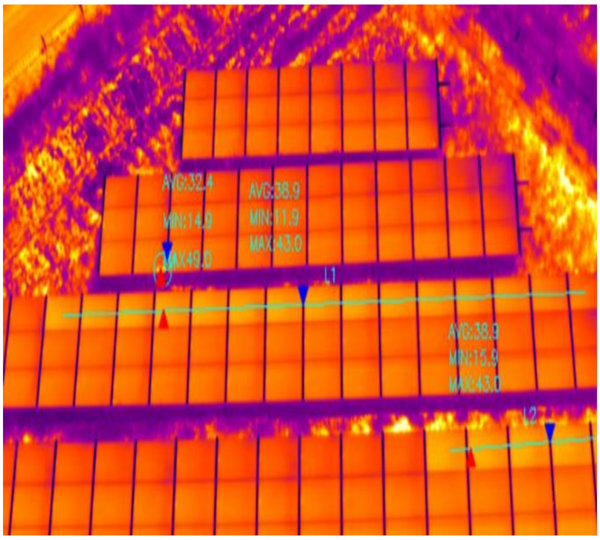


Fig. 4. One Hotspot fault and one connection fault of 2.7 MW solar power plant captured by thermal drone

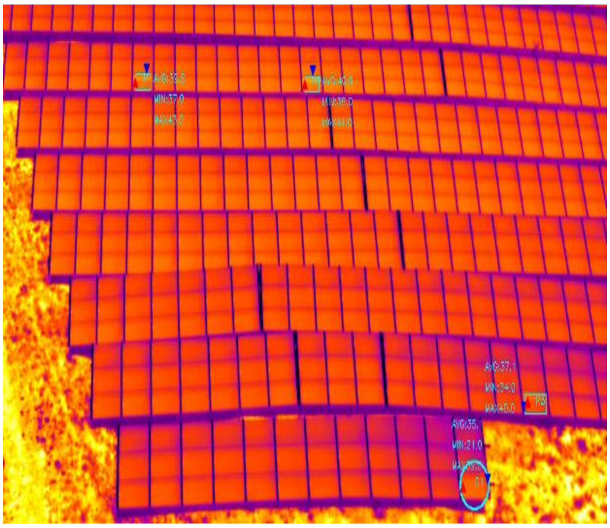
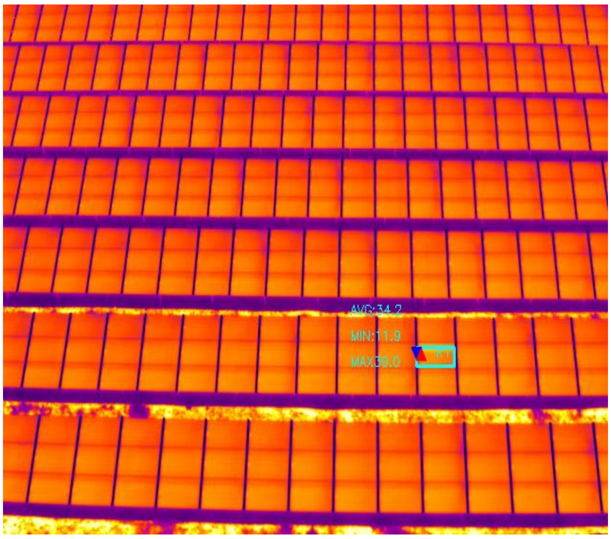
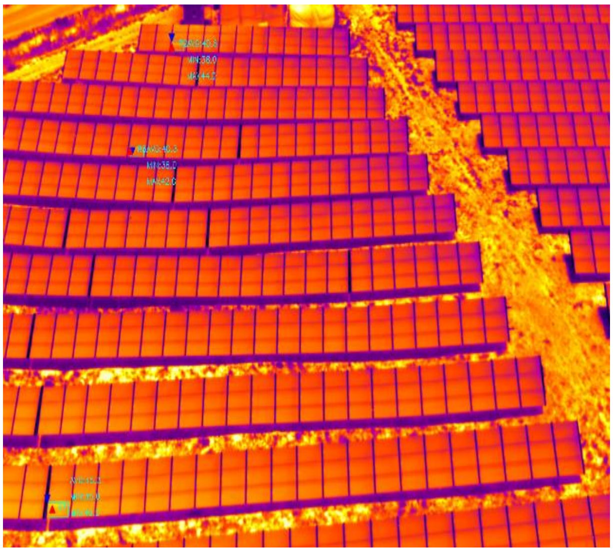


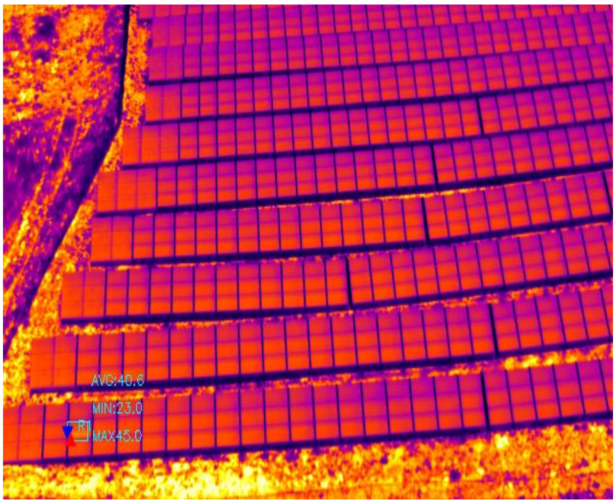
Fig. 5. Three Bypass diode fault and one connection fault of 2.7 MW solar power plant captured by thermal drone



(a)



(b)



(c)

Fig. 6. (a-b-c) Bypass diode fault of 2.7 MW solar power plant captured by thermal drone

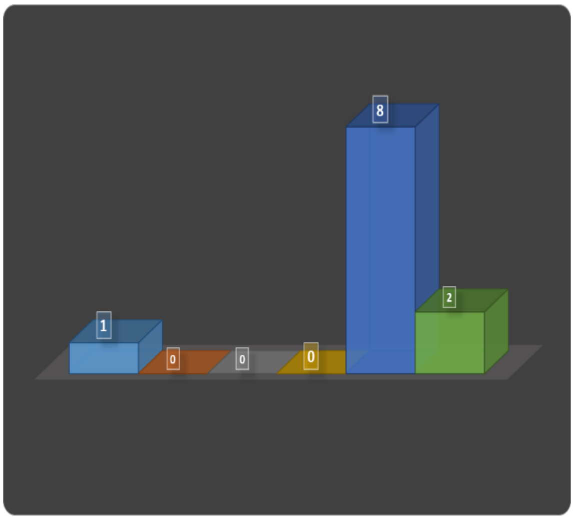


Fig. 7. Thermal shooting fault distributions for 2.7 MW solar power plant

3. Conclusion

The study was implemented in a real environment at a large-scale 2.7 MW PV power station, demonstrating its practical feasibility.

The thermal drone we use detects and pinpoints faulty PV modules in a large-scale PV power station. With the application, the types of faults occurring in solar power plants in Turkey have been observed. Since the connection fault affects the operation of all panels in the array to which it is connected, it is seen that it is important in efficiency and production loss.

A total of 11 panel faults were detected and the number of panels affected by these faults was determined as 28. As a result, an improvement of 0.68 % was achieved in energy production when the fault problems were resolved.

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