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Presentation UDOM & SUZA - Tanzania

MAINTENANCE OF PHOTOVOLTAIC INSTALLATIONS USING INFRARED THERMOGRAPHY TECHNIQUES

Dr. Germán Álvarez Tey
University of Cádiz
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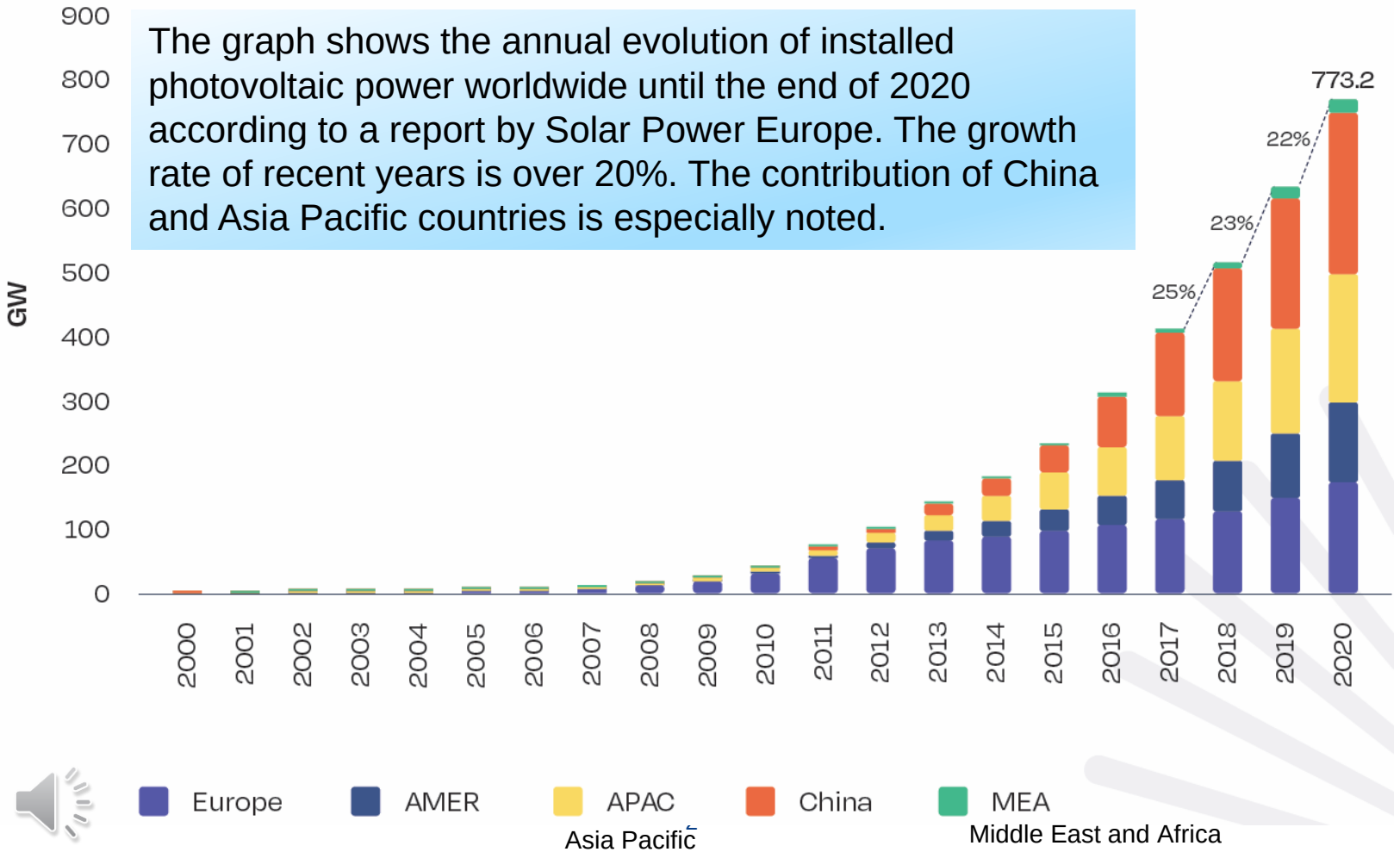
INTRODUCTION

Photovoltaic Market Evolution – Worldwide (Solar Power Europe, 2021)

The graph shows the annual evolution of installed photovoltaic power worldwide until the end of 2020 according to a report by Solar Power Europe. The growth rate of recent years is over 20%. The contribution of China and Asia Pacific countries is especially noted.



METHODOLOGY FOR IR INSPECTION IN FV INSTALLATIONS

Technical specification IEC TS 62446-3:

- Infrared thermography is applied to the maintenance of photovoltaic installations due to its effectiveness and speed, although certain factors must be taken into account for a suitable procedure.

- This specification establishes the requirements for testing, documentation and maintenance of PV plants and modules outdoor.

METHODOLOGY FOR IR INSPECTION IN FV INSTALLATIONS

Description of equipment and instrumentation used

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Basic data of PV plant to be inspected

- **Rated power:** 100 kW
- **Location:** South SPAIN **; Coordinates:** latitude: 36.85˚N, longitude: -5.59˚O
- **Orientation South / Inclination: 32˚**
- **PV module technology:** Si-p type, later some Si-m types

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Application of the Procedure - Prior Checks

- **IR inspection type 1st scan:** Aerial with Workswell WIRIS 2nd 336 IR camera housed in drone.
- **IR inspection type 2nd sweep:** On the ground with Flir ThermaCam S60 camera.

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Application of the Procedure- Atmospheric conditions

The summary data of the weather conditions during the inspection is as follows:

* **Cloud cover** : 0 okta (clear sky); **Wind speed** < 1 m/s; **Flat irradiance modules** > 890 W/m^2
* **Atmospheric temperature**: between 24 and 26 ˚C; **Relative humidity**: 28/30 %RH

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results: Thermographic video obtained in the PV plant is reproduced

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - Classification of standard occurrences:

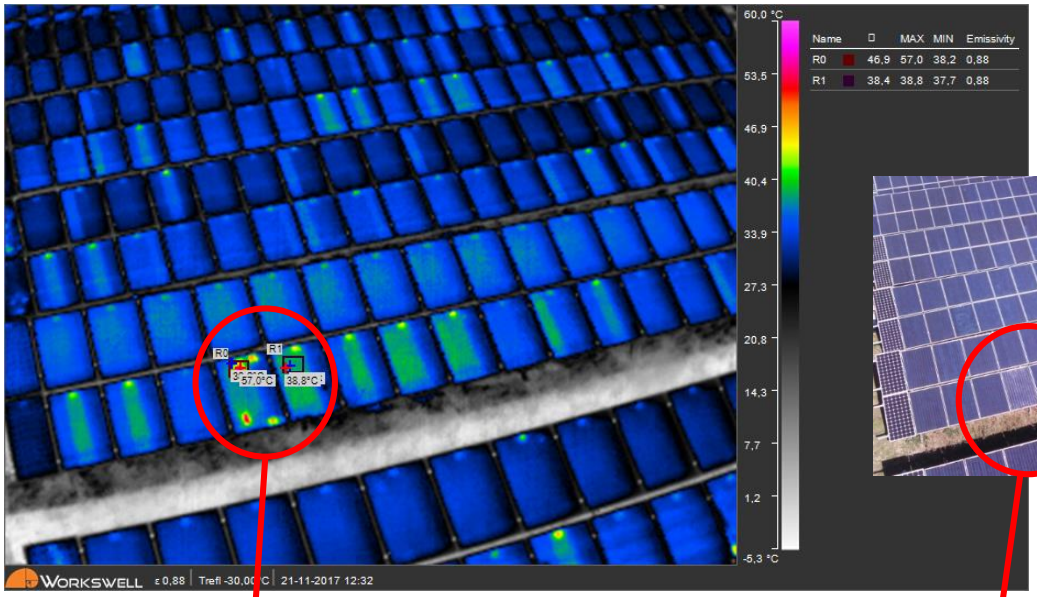
The incidents detected are grouped into the following categories:

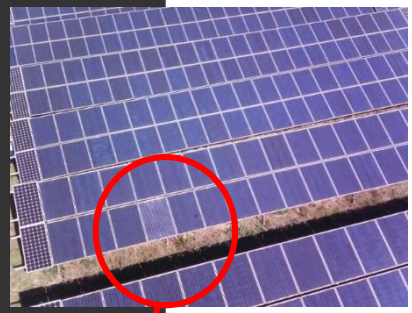
* PV module glass breakage type incidents
* Incidents type partial shading
* PV module technology type incidents
* Open-circuit PV module type incidents
* Other incidents

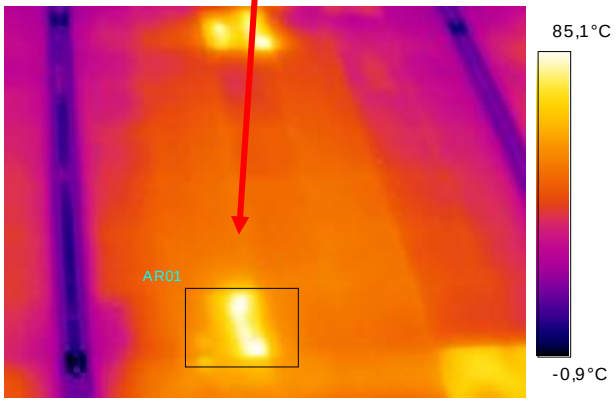
Thermographs and visual images of these types obtained in the inspected plant are shown below:

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - PV module glass breakage type incidents







- **Location D10**
- **Tmax = 86.0 °C**
- **Tmed = 60.1 ºC**
- Point type abnormality.

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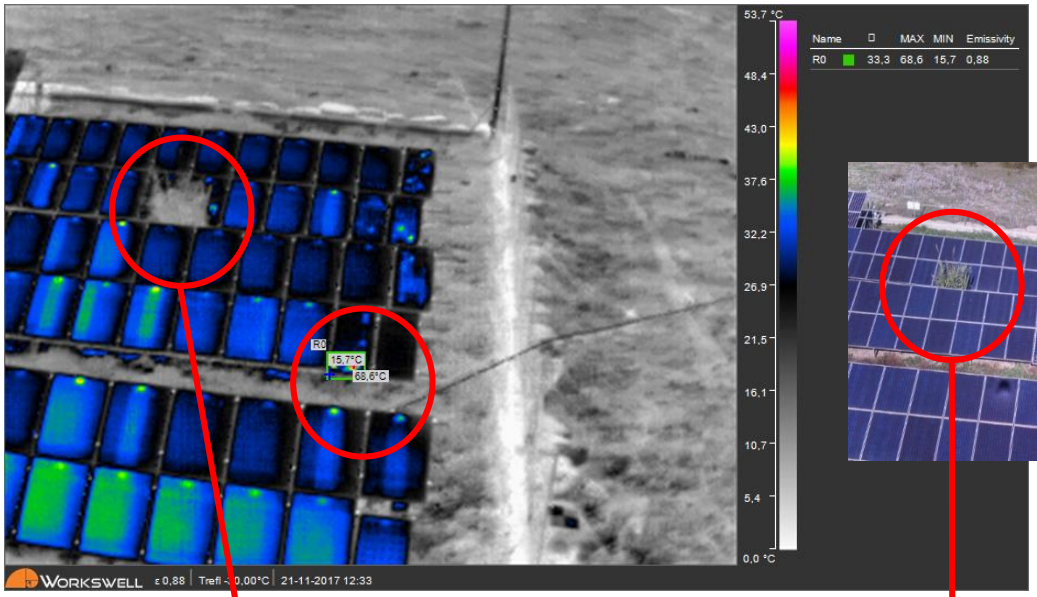
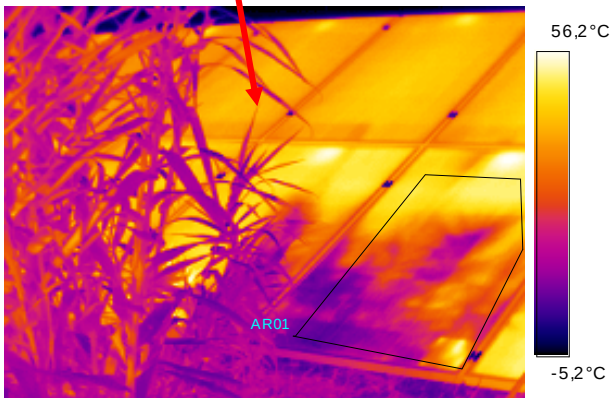
Analysis of results - Partial shading type incidents

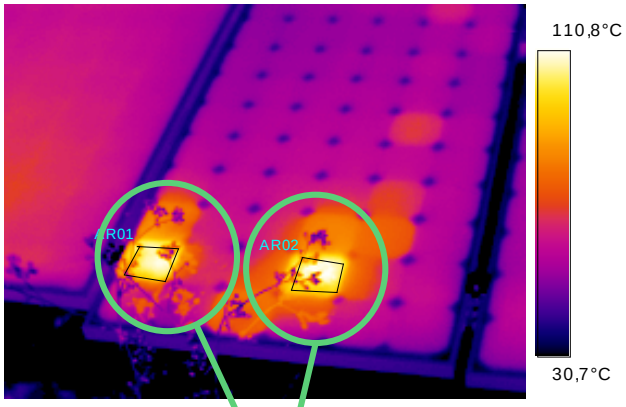


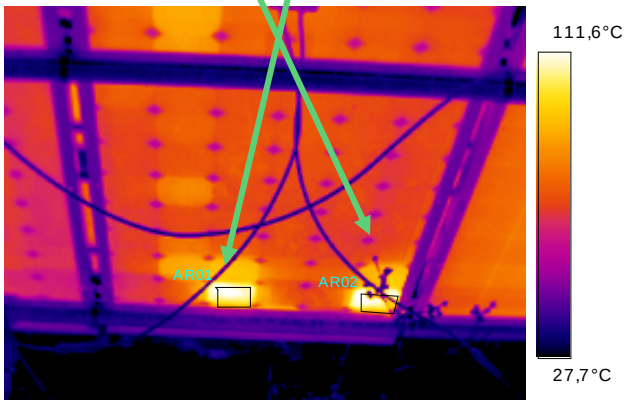


- **Location AQ4 and AR4**
- **Tmax = 49.6 °C**
- The separation of the vegetation causes a moving shadow depending on the position of the sun.

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - Partial shading type incidents

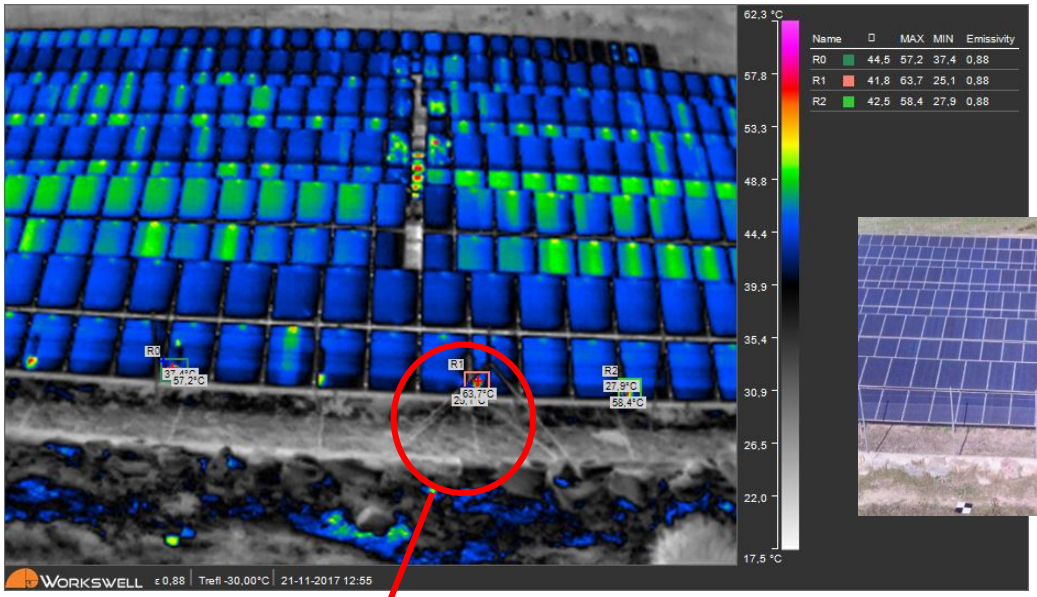


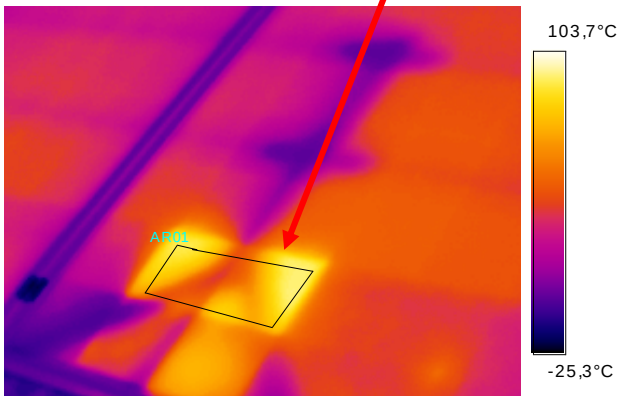


- **Location AV6**
- **Tmax (right) =** 111.8 °C
- **Tmax (left) =** 108.4 °C
- Vegetation without separation and shading effect is fixed on the cells, without influence of solar position.

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - Partial shading type incidents

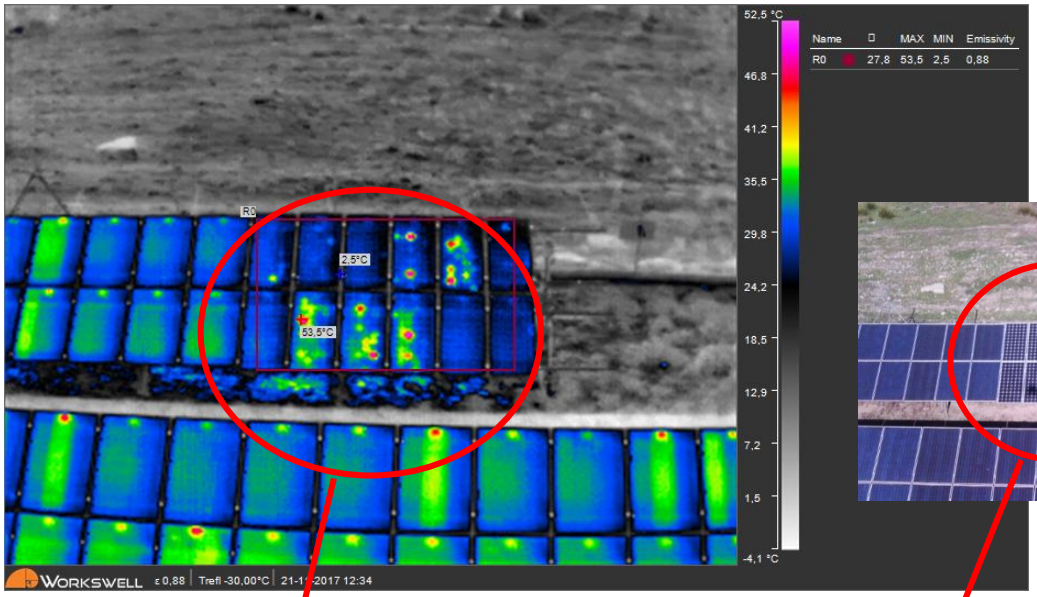


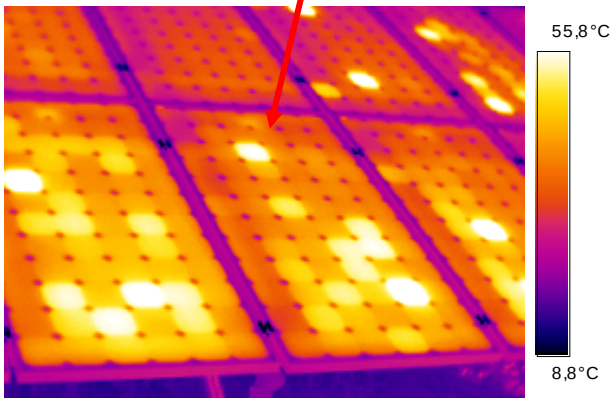


- **Location AC12** (Array 6)
- **Tmax =** 77.5 ˚C.
- **Tmed =** 56.2 ˚C.
- This shadow moves with the movement of the sun so the value changes with time

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - PV module technology type issues





- Si-m PV modules (Array 1) show an irregular pattern Tmax = 53.5 ˚C.
- This pattern is characteristic of a short-circuited module.
- In Si-m type module its Isc = 5.22 A is lower than the Imp = 7.57 A of Si-p type module.

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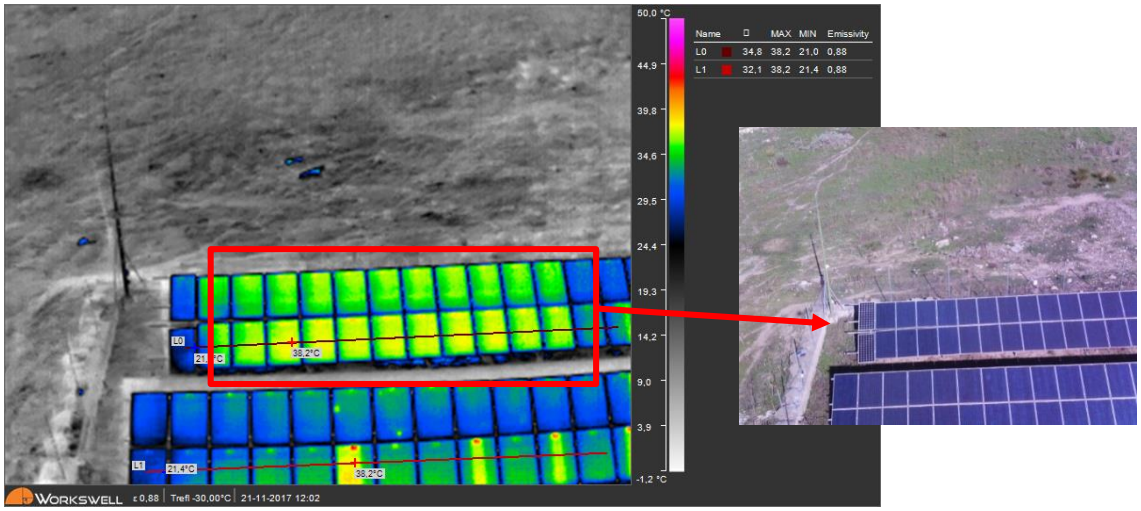
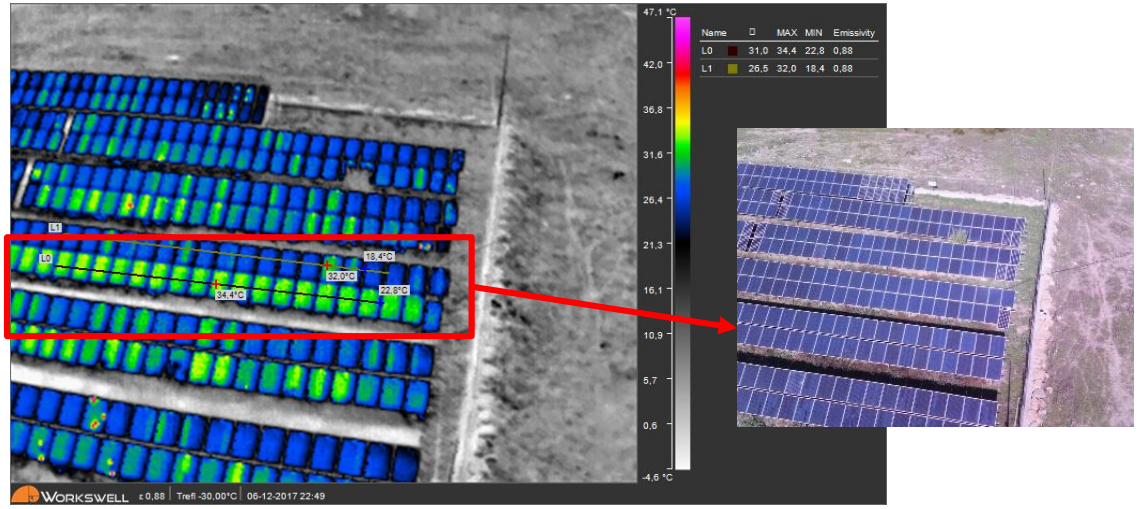
Analysis of results - Open-circuit PV module type occurrences

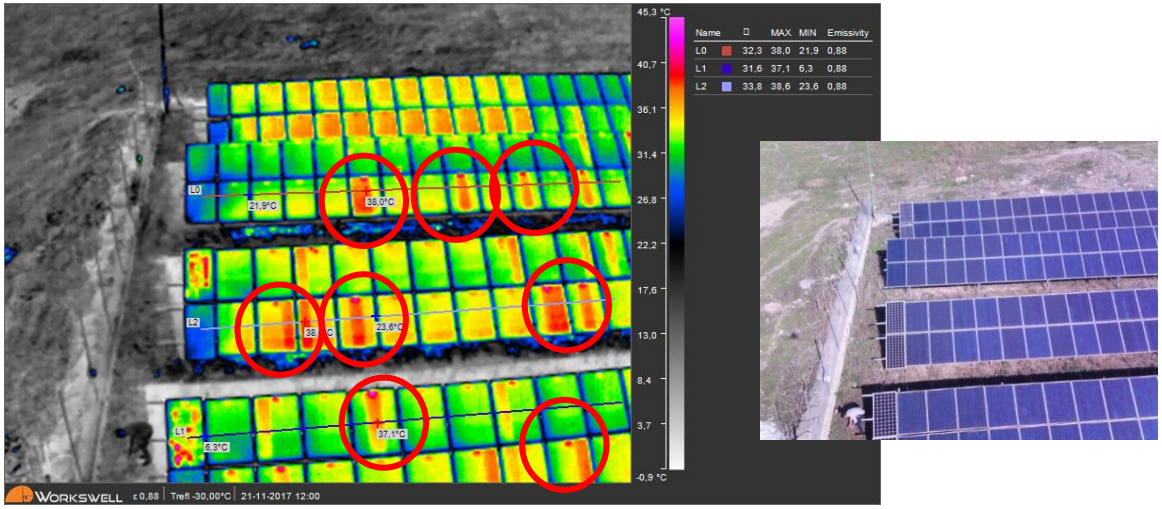


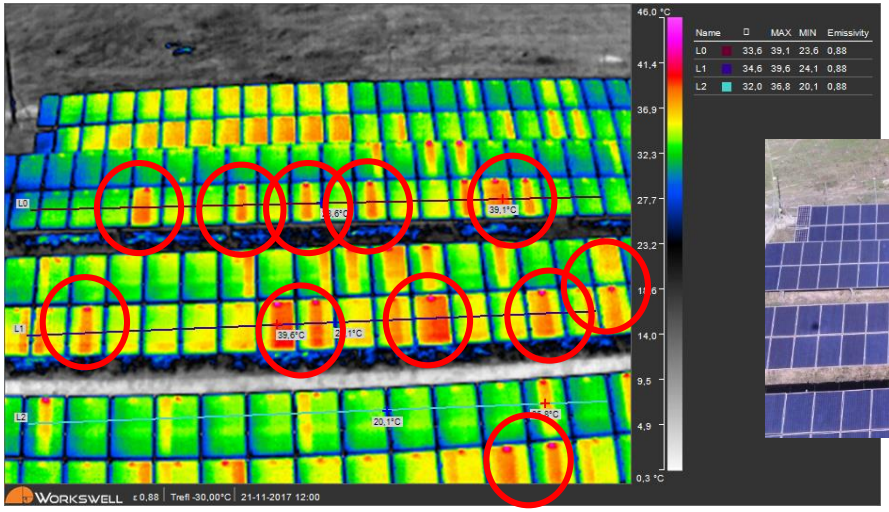


- The string seen in Array 1 is in open circuit.
- The string seen in Array 4 (bottom) is in open circuit.
- They are overtemperature above 5˚C.

APPLICATION OF THE INSPECTION PROCEDURE TO A REAL PV INSTALLATION

Analysis of results - Other incidences





- Several PV modules have open-circuit substrings on Arrays 1, 2, 3 and 4.
- The maximum temperatures are reached in the upper area of PV modules (diode box) with values above 45 ˚C.

CONCLUSIONS

* Infrared thermography is a powerful and versatile tool for the maintenance of photovoltaic installations.
* It is necessary to apply an inspection procedure to systematise and homogenise the results.
* Environmental and configuration factors must be taken into account for a correct interpretation of the results.
* Infrared thermography perform fast and effective maintenance on PV plants to maximise their energy and economic efficiency.

RELATED SCIENTIFIC PUBLICATIONS

Some scientific publications related to this topic are listed bellow

Contents lists available at ScienceDirect

Infrared Physics & Technology

journal homepage: www.elsevier.com/locate/infrared

Regular article

Analysis of the configuration and the location of thermographic equipment for the inspection in photovoltaic systems

G. Álvarez-Tey [a,*], R. Jiménez-Castañeda [a], J. Carpio [b]

RELATED SCIENTIFIC PUBLICATIONS

applied sciences

MDPI

Article

Strategy Based on Two Stages for IR Thermographic Inspections of Photovoltaic Plants

Germán Álvarez-Tey * and Carmen García-López

sensors

MDPI

Article

Evaluation of the Uncertainty of Surface Temperature Measurements in Photovoltaic Modules in Outdoor Operation

Carmen García-López * and Germán Álvarez-Tey

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Thank you for your attention