Using IR Thermography for Photovoltaic Array Performance Assessment

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Abstract - In this work infrared thermography is used for the performance assessment of a photovoltaic array integrated on the southern façade of NTUA's Chemical Engineering Building. This grid-connected 50 kWp solar photovoltaic array, installed under an EC Thermie Project (SE-142-97-GR-ES), operates in a standard and hybrid PV-Thermal configuration, meant to save conventional energy. The thermographic system used for the analysis covers the 8-12 μm of wavelength region. The thermal images obtained showed that there are temperature differences on the PV panels, which may be attributed to PV material defects, external abuse, or PV malfunction.

Keywords: PV operating temperature, PV hot spots, PV defects

1 Introduction

The use of infrared thermography in the analysis of a building's envelope is really developing in the recent years. The use of IR data in calculating heat transfer coefficients is reviewed in Astarita et al. [1]. Grinzato et al. analyse the quantitative infrared thermography in buildings [2]. Moreover Moropoulou et al. discuss the use of IR thermography at historic buildings [3]. The use of an infrared camera is a fitting way to evaluate the temperature performance and parameters of an integrated solar energy system, since it is relatively quick procedure and can be accomplished without the need for interrupting system operations. Bazilian et al. use thermographic analysis of a building integrated photovoltaic system [4]. This analysis allows for the interpretation of the surface emissivities and operating temperatures, as well as qualitative graphic analysis of temperature gradients.
In this work infrared thermography is used for the investigation of a building integrated photovoltaic system at the School of Chemical Engineering of the National Technical University of Athens.

2 Experimental Site / methodology

2.1 Site

The thermographic analysis was performed on the southern façade and roof of the NTUA's Chemical Engineering building complex (Figures 1, 2). The project was realised under a Thermie Program (SE-142-97-GR-ES) which involved integrating a grid-connected 50 kWp solar photovoltaic array on the southern facade and roof of the NTUA's Chemical Engineering building complex, in a standard and hybrid PV-Thermal configuration, meant to save conventional energy (thus limiting pollution normally associated with the latter) and to improve the thermal comfort in the adjacent large laboratory space [5].
Such integration demonstrates the potential of solar retrofitting, using appropriate photovoltaic systems and basic heat transfer techniques. The technology applied in the hybrid arrays exploits the synergy between the need for cooling the PV cells - if their electrical efficiency is to remain at high levels - and the existence of a heating load in the adjacent working space. The vertical facade arrays are located outside the southern walls of the large corridors and the Computer Centre, as well as on the southern side of the Unit Operations Lab. The tilted roof-top arrays, on the other hand, are situated above the laboratory, on the southern side of its protruding central dome. The conversion of DC into AC current is effected in the inverters' room, on the laboratory's mezzanine, and is finally led to the power distribution cabinet in the basement.

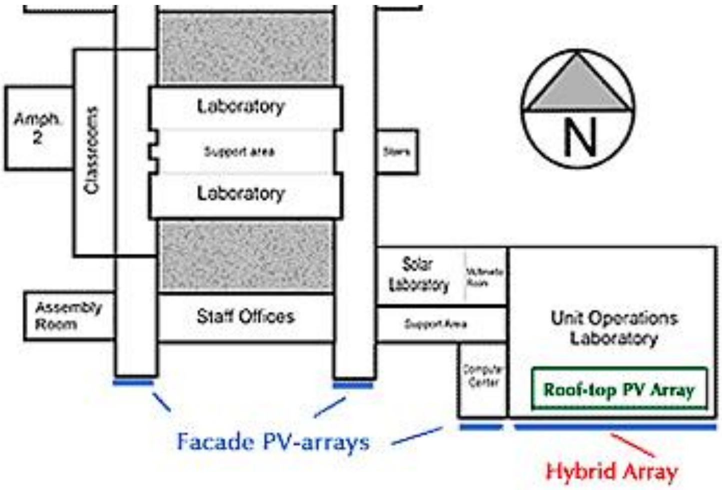

Figure 1 : Ground plan of Chemical Engineering Building where PV arrays are placed

Figure 2 : Buildings façade with the first six PV arrays

2.2 Methodology

This work was the result of a collaboration between the Laboratory of Materials Science and Engineering and the Solar Engineering Unit of the School of Chemical Engineering of the National Technical University of Athens.
The in-situ measurements were performed during September-October 2006 between 10:00-17:00. For this purpose, a TVS-2000 MKIILW NIPPON AVIONICS infrared camera was used, which operates in the 8-12 μm range of the spectrum.
The thermographs were continuously recorded using a pal video, but also at selected time intervals. The ambient conditions were also recorded (air temperature, relative humidity, velocity).

3 Results

As expected, the best IR thermographic testing images resulted during sunny windless days with low relative humidity. In the series of images which follows, the left column presents the surface under investigation, while the right column shows the corresponding thermograph.
In the thermograph of Figure 3 hot spots are detected corresponding to areas where the panels have been severely damaged by vandalisms.

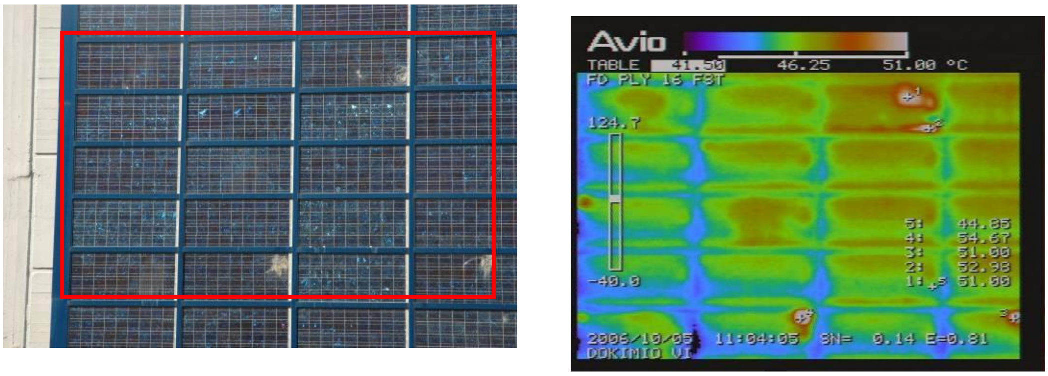

Figure 3 : Hot spot detection. The particular spots are the result of vandalism

In Figure 4 there are hot spots detected, without externally visible damage on the panel surface. Thus, the problem must be attributed to internal causes, corrosion being one possible candidate.

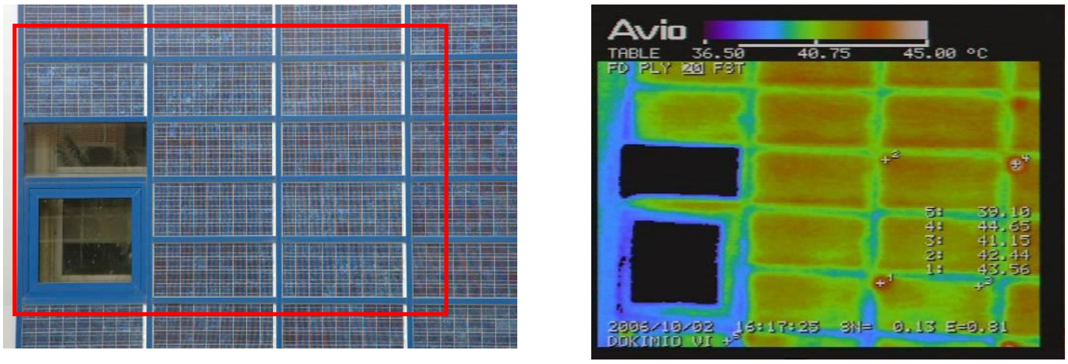

Figure 4 : Hot spot detection

Figure 5 shows that the temperatures of the window frames are substantially lower, as expected.

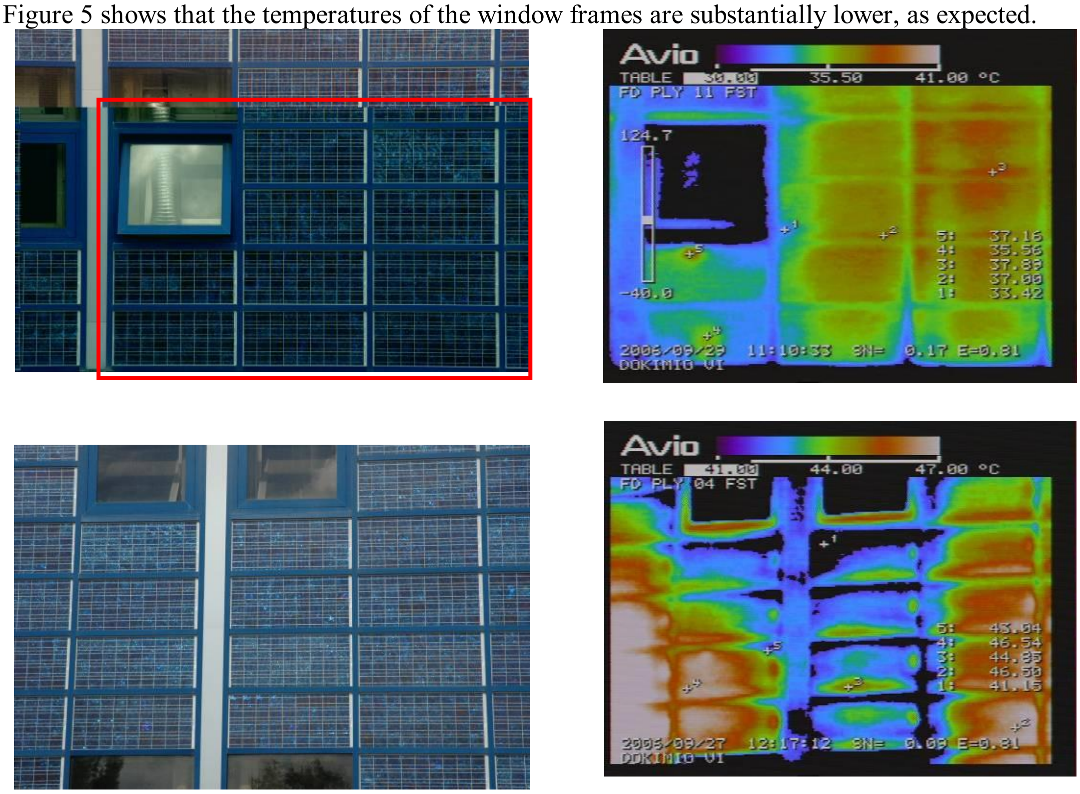

Figure 5 : Areas around windows exhibiting lower temperatures

In Figure 6 it is noticed a horizontal temperature differentiation.

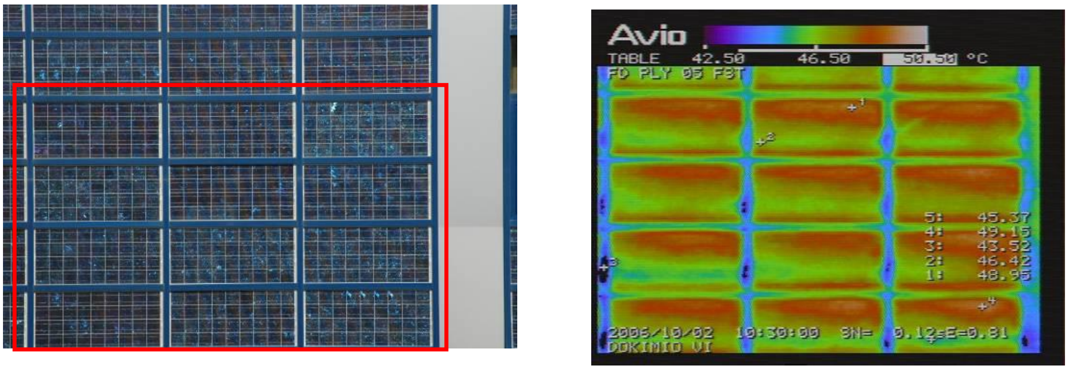

Figure 6 : Horizontal temperature gradients in the modules

4 Conclusions

The thermographic analysis is a useful tool for on-site monitoring of building integrated photovoltaic systems. On the basis of the resulting thermographs, various abnormalities can be investigated concerning either the panel material itself or its function.

References

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