Chapter 11
Measurements and Characterization of Photovoltaic Modules for Tolerance Verification

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ABSTRACT

One of the most important aspects of photovoltaic modules is reliability for future uses, that is, a certain module will last certain number of years in use (generally 30 or 35 years). Reliability yields from excellent qualification tests on photovoltaic (PV) modules. Testing for reliability identifies unknown failure mechanisms and whether modules are susceptible to known failure mechanisms. This paper illustrates techniques of outdoor measurements and qualification characterization to know PV module conditions for commercial uses. Matrix methods are used for energy prediction. Failure material tests, using digital imaging and thermography, have also been conducted.

1. RATIONALE

The energy and power yielded by a PVM are quantities depending upon many factors. These factors influences PVM operating mode and are very important for PVM certification, that are:

cumulative solar irradiance: long-term irradiance profiles depend on surface orientation and eventual tracking (King, Boyson, & Kratochivl, 2002). This factor depends on the location and varies between a reduction by about 25% for a vertical surface to over 30% increase for two axis tracking (Abella, Lorenzo, & Chenlo, 2003).

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• **Module power rating at standard test conditions:** Analysis of several PV technologies has shown that for the same power rating all technologies were equivalent in terms of the expected annual energy production within 5% calculation error.

• **Operating temperature:** Analysis of various technologies and sites shows that the annual production can be reduced due to the operating temperature by a factor between 2 and 10%, depending on the module design, wind speed, mounting technique and ambient temperature.

• **Maximum power point voltage dependence on irradiance level:** A-Si and CdTe modules tend to have a value of the maximum power point voltage larger at low irradiance levels than at the standard 1 sun conditions: this fact can result in an additional 10% increase in annual energy production (Ghaisari, Habibi, & Bakhshai, 2007). **Soiling:** soiling may account for up to a 10% of reduction of the annual energy production.

• **Variation in solar spectrum:** It is found that the effects of the hourly variation of the solar spectrum almost cancel out in a yearly basis.

• **Optical losses when the sun is at a high angle of incidence (AOI):** The optical losses are due to the increased reflectance of the cover glass of the PV modules for AOI greater than approximately 60°.

The above factors are not the only ones used in PVM characterization and measurements, but they are mostly utilized for the certification of PVM.

Practical uses of PVM in manifold applications able to produce energy with simultaneous other objectives have opened the way to interesting uses as depicted in Figures 1 and 2. The first figure shows PVMs used to cover a parking area while the second depicts an example of a photovoltaic greenhouse for agriculture applications. Both examples are developed by Roam Srl company working in this research. The use of PVMs for diverse applications requires specific materials for endurance conditions. Even if PVMs are mounted and installed on roof and they are apparently in static conditions, the milieu where they are located can provoke further stress. That is the reason we need to know their response once stressed in laboratory. In general, apart from electrical tests, PVMs must undergo the following tests: temperature cycling, humidity-freeze cycling, cyclic pressure loading, ice ball impact, hot-spot endurance, twisted-mounting surface test, UV irradiation, High-temperature storage, high-temperature and high-humidity storage, mechanical loadings.

PVM certification is a formal process involving accredited testing facilities and laboratories that issue licenses to manufacturers indicating their products have been tested and are in conformance (Osterwald, Hammond, Zerlaut, & D’Aiello, 1994). Currently, certification approach is based on qualification testing. There are a

*Figure 1. Parking roof constructed using PVMs*
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