Field Evlauation of Photovoltaic Modules and Systems at GREEN-IPUC/PUCMinas, Brasil

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Introduction

The GREEN-IPUC *(Grupo de Estudos em Energia-Instituto Politécnico da PUC Minas)* is a technical laboratory that belongs to the Polytechnical Institute of the Pontifical Catholic University of Minas Gerais, located in Belo Horizonte, Minas Gerais, Brasil. Its activities are centered in research, deployment, and qualification assurance of ***solar photovoltaic*** and ***solar thermal*** technologies and distributed generation deployment with renewables.

The Systems and Scope

This study presents the investigation of performance losses of photovoltaic systems in Brasil, and the identification of component failure and durability issues. It covers some 1000 stand-alone PV systems, composed of solar-home systems (sized 150 Wp) and school systems (about 2000 Wp), that are operated by CEMIG D. These PV systems are installed in the state of Minas Gerais, with the oldest being10 years in operation. The *stand-alone systems* are located at the northern and eastern regions of Minas Gerais. These regions are considered subtropical climate zones, with dry winters (low humidity) and rainy summers. Also, there are a set of PV systems implemented under several photovoltaic rural-electrification demonstration programs, such as the US-Brasil program initiated in 1995, PRODEEM in 1997, and Luz Solar in 1999, with the oldest being15 years in operation. These systems had not had a rigorous evaluation for their reliability and operation performance—reporting any module aging or identifying major degradation mechanisms.

Performance Losses

The investigation of the performance of these PV systems started with an evaluation of the history of PV systems failure from the CEMIG database. This was followed by a selection of typical solar-home PV systems based in years of field exposure (CEMIG database) and selection of modules that had been replaced because of performance issues and put into storage. All modules had crystalline Si cells. From the database and storage, a sample set of 20 modules from the oldest systems was chosen, typically the most damaged and exhibiting degradation. Also identified were the systems with maintenance issues and with at least 10 years of field exposure. A sample of these PV systems was inspected in the field during technical visits, and the PV modules with the worst degradation modes were taken from the field and analyzed at the laboratories of GREEN Solar-IPUC in Belo Horizonte. The major PV module degradation modes were identified as gradual encapsulation discoloration and encapsulant delamination—proposed to be caused by the existing high incidence of ultraviolet radiation and high temperature. The inspection of all the system components revealed a high-rate of inverter failure (despite a routine maintenance schedule followed by CEMIG's technicians) due to high temperatures encountered inside the storage cabinets where they are installed and the lack of appropriate ventilation inside the inverter.

Performance Investigation Results

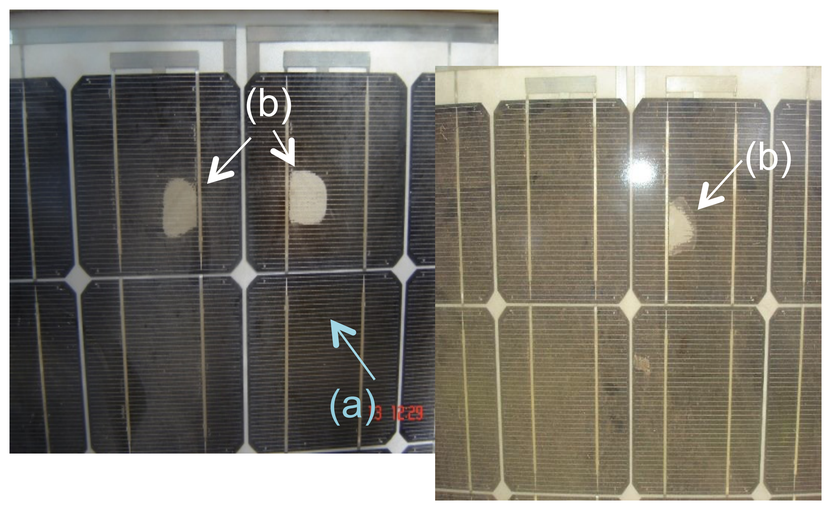

Figure 1. Examples of (a) browning and (b) encapsulant delamination for modules from stand-alone systems. Several areas of browning and delamination are highlighted by the arrows—although many such areas can be seen.

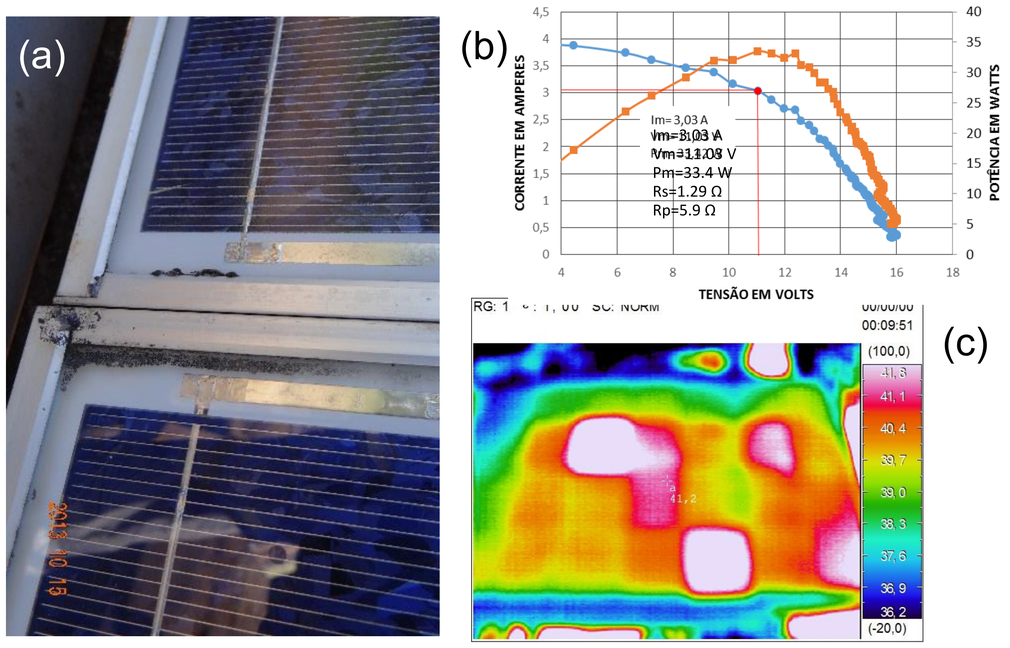

Figure 2. Reliability studies (a) Degraded modules; (b) Current-Voltage characteristic of lower module; and (c) Infrared image of lower module in (a).

Extensive corrosion at the interconnections, junction boxes, and system wiring was also discovered. In addition to major interconnect corrosion, extensive encapsulant discoloration, and prolonged inverter failures, some modules had fairly severe module soiling issues with up to 20% transmission obscuration.

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Acknowledgement: Funding has been provided by FAPEMIG and and PUC Minas; and, CEMIG for the systems and modules. This poster contains no proprietary information.