Photovoltaics and Solar Thermal Energy Systems

The Potential of Grid-Connected Photovoltaics in Brazil

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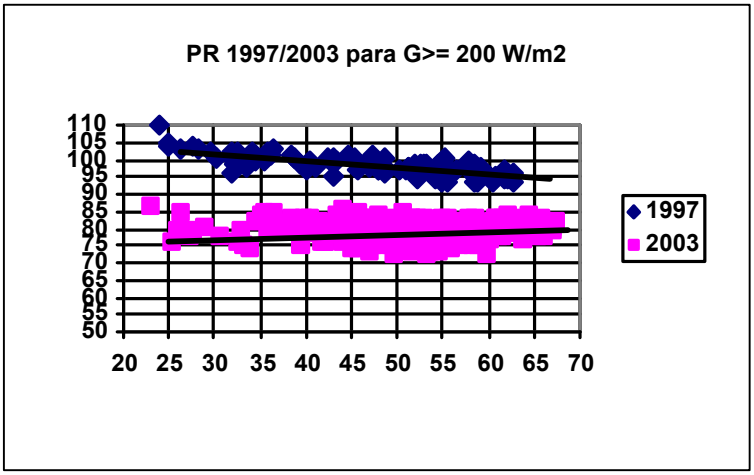
Abstract

In September 1997 the first grid-connected, building-integrated, thin-film PV system in Brazil was installed at LABSOLAR, on the main campus at Universidade Federal de Santa Catarina. The PV installation consists of a 2kWp thin-film amorphous silicon (a-Si) array, plus DC/AC inverter, irradiance (horizontal and plane-of-array), and temperature (ambient and back-of-module) measurement instrumentation, and a dedicated data logging system. The generator is comprised of 54 opaque and 14 semitransparent, double-junction (pin-pin), glass-glass 60 x 100cm^2 a-Si modules from RWE-Schott, with a total power output rated at 2078Wp at STC, and a total surface area of ~40m^2. The total power is distributed in four ~500Wp sub-systems, and fed to four independent single-phase, line-commutated sinewave inverters (from Würth Elektronik GmbH, model WE 500 NWR, each rated at 650W). The PV array uses unframed modules designed for BIPV applications, that were installed onto a simple steel structure retrofitted as an overhang to the existing building, facing true north with latitude tilt (27°). Electrical parameters as well as irradiance and temperature data are continuously measured and stored at four-minute intervals. Figure 1 shows the BIPV system; further details on PV system design and configuration have been presented elsewhere [1,2].

The project's main objectives are twofold: (i) demonstration and dissemination of the concept of PV in buildings in Brazil; and (ii) a long-term experiment on the seasonal effect affecting the performance of thin film a-Si, with emphasis on determining its suitability for operation under the higher temperatures common in building-integrated PV systems in warm and sunny climates. Seasonal performance shifts due to both Staebler-Wronski degradation/annealing

[3] mechanisms enhanced by higher operating temperatures in summer, and to seasonal shifts in the spectral content of sunlight, as well as a small temperature coefficient of power, render a-Si a relatively better PV converter in summer than in wintertime, in contrast to the performance profile of crystalline silicon PV converters, which are more efficient in winter due to lower operating temperatures.

Performance results on the fully monitored BIPV installation operating continuously for over six years have indicated peculiarities in system sizing (PV array vs. inverter rated power) and have demonstrated that a-Si is a good performer at sunny sites and warm climates. Performance ratios (PR, defined as the ratio of the energy output and the rated efficiency, times the total solar radiation incident on the PV module's surface) obtained during this period averaged 91.4% (DC) and 81.5% (AC), and annual AC energy yield was 1231kWh/kWp for a 1507kWh/m^2 annual plane-of-array irradiation level at the site. While in the first year (1997 data) the a-Si modules showed a small but negative temperature coefficient of power ($T_{coeffPmax}$ = -0.22%/^{o}C), after stabilisation of the light-induced degradation inherent to the a-Si material (the Staebler-Wronski effect [3]) our most recent results show that $T_{coeffPmax}$ drops to negligible (and positive, $T_{coeffPmax}$ = +0.08%/^{o}C) values (2003 data); *i.e.*, in the stabilised level, the net performance of a-Si becomes somewhat independent of temperature.



Figures 1: View of the 2kWp grid-connected, building-integrated PV system operating at LABSOLAR in Florianopolis-SC (Brazil) since 1997, and evolution of the performance ratio with temperature and time.

More recently, LABSOLAR started to study the issue of PV grid penetration with two utility companies, namely CELESC (Centrais Elétricas de Santa Catarina – www.celesc.com.br), and CEMIG (Companhia Energética de Minas Gerais – www.cemig.com.br). A number of grid-connected PV systems have been installed in the framework of these projects, to assess the performance of PV at different urban sites. These studies look at the match between PV generation and urban feeder power demands. Preliminary results show that there is a large number of feeders with daytime load peaks in urban areas that could benefit from the distributed generation nature of PV generation. Identifying areas where PV could bring extra value to the utility is one of the purposes of these projects, and figure 3 shows a version of the Brazilian PV Atlas, a PV generation forecasting tool that is being refined in the scope of this project.

References:

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