Mechanical Engineering Thesis Defense

Field Accelerated Stress Testing (FAST) of Photovoltaic Module in Hot-Dry and Hot-Humid Climates

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Abstract

This study introduces a new field accelerated stress testing (FAST) method for photovoltaic (PV) modules performed outdoors at two different climatic sites of Arizona (hot-dry) and Florida (hot-humid) over two years of exposure. In this study, the module temperatures were increased by using thermal insulations on the back of the modules under natural and identical ambient conditions of ambient temperature, ambient humidity, natural sunlight, wind speed, wind direction, and tilt angle. The degradation effect of 4-cell modules with two different constructions, glass/glass (GG) and glass/backsheet (GB), were studied. Two different encapsulants, ethyl vinyl acetate (EVA) and polyolefin elastomer (POE), were considered for this approach. To conduct the FAST reliability study, a set of four modules (non-insulated: natural field aging), glass/backsheet - POE, glass/backsheet - EVA, glass/glass-POE and glass/glass-EVA,were installed at each of the two sites. Similarly, another set of four modules with the same construction was exposed in the field in accelerated conditions, operating at higher temperatures due to the presence of thermal insulators on the back of these four modules. A total of sixteen modules (eight modules at each site) were tested under short-circuit conditions in two different climates of Arizona (AZ; BWh, hot-dry) and Florida (FL; Cfa, hot-humid or humid-subtropical). The FAST modules attained an acceleration factor of 5 to 7 times, compared to the non-insulated modules, at each site for the degradation modes of encapsulant discoloration and cell finger degradation. All the modules were extensively characterized before installation in the field and after exposure. The methods used for characterizing the devices included I-V (current-voltage curves), EL (electroluminescence), UVF (ultraviolet fluorescence), and Reflectance. iiKey findings of this study are: the glass/glass modules operate at a higher temperature (2-3oC) than the glass/backsheet modules, which is expected to reduce the lifetime of glass/glass modules compared to glass/backsheet modules. The test results indicate that the glass/glass modules tend to degrade at a higher rate than the glass/back sheet modules, primarily due to encapsulant discoloration at both sites. The encapsulant discoloration level was higher in the EVA modules compared to the POE modules. In these 4-cell glass/glass modules, no significant sign of oxygen bleaching irrespective of encapsulant type at both sites. In addition, the insulated (FAST) glass/glass modules tend to experience minor grid finger degradation at the Florida site, not at the Arizona site. However, the non-insulated glass/glass modules, insulated (FAST) backsheet modules, and non-insulated backsheet modules do not seem to suffer from grid finger degradation.

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