Area: Performance and Reliability of PV Modules.

DEGRADATION ANALYSIS OF MONOCRYSTALLINE-SILICON PHOTOVOLTAIC MODULES EXPOSED OVER 22 YEARS IN A HOT-HUMIDITY ENVIRONMENT

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This paper presents the degradation analysis of monocrystalline silicon modules (SM55, produced by Siemens Solar company in 1992) in Shenzhen of China exposed in the hot-humid climatic conditions, and the installed location is less than 500m from the sea. The system capacity was 110kWp with 2051 modules, which used for power supplier with diesel system. And these modules were collected in 2013, then a series testing including visual inspect, electrical characteristics testing, infrared thermal image (IR) and material analysis were carried out.

From the electrical performance, the average power degradation of Siemens modules is 22.57%, and the annual average degradation rate is 1.07%/a for 22 years, with the minimum is 0.54%/a and the maximum is 2.01%/a (Figure 1). There is no serious visual defects. The power degradation is mainly caused by the decreasing of fill factor (FF), resulting from the solder bond failure and the corrosion of Ag electrode, which can be reflected by the brighter area on bus bar than others and dark region observed from EL and IR images. From material analysis, SEM image of cross-section showed a gap between ribbon and cell, which may be caused by the thermal fatigue of ribbon. The SEM image and EDS mapping image in the dark region showed that the formation of acetate, which is supported by the needle observed on the top of the finger result from the corrosion of grid by acetic acid which as product of hydrolysis within EVA in hot and humidity climate. It can be found that the chemical reaction rate of acetate exhibit strong temperature dependence, allowing for the Arrhenius model, which result in the corrosion of Ag gridline occurred mainly in the center of cells where operating at a higher temperature for long-time in field.

From the degradation mechanism of modules in hot-humidity which proposed in this paper, the quality assessment of PV modules in hot-humid areas should consider not only the effect of temperature, humidity and light but also salt-fog which are the critical factors that affect the reliability of PV modules operated on the sea.

Figure 1: The box plot of degradation rate