Subject: Site Evaluation
Prepared For: Anonymous Customer
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Date: August 2012

Summary:
The primary objective of this trip was to determine the underperformance issue of the site. Upon visual inspection of the 4620 modules, it is evident that the site is plagued with buss bar burns. 1003 modules were mapped and tagged with visible buss bar burns. This is equivalent to 22% of the modules but 397 strings are impacted or 95% of the strings on site.
Module breakage occurred due to excessive heating from the buss bar burn on 5 modules. These modules were removed from the strings and the strings were disconnected at the combiner box to reduce any safety hazard. A positive potential was measured from the broken front glass to the rack as high as 200V further supporting the decision to remove these modules from the strings. The locations of these 5 strings which were disconnected are given in the below table.

Combiner Box#	String#	Action Taken
4	11	Disconnected, pulled fuse and placed near GND lug in box 4
3	17	Disconnected, pulled fuse and placed near GND lug in box 3
11	21	Disconnected, pulled fuse and placed near GND lug in box 11
12	16	Disconnected, pulled fuse and placed near GND lug in box 12
10	27	Disconnected, pulled fuse and placed near GND lug in box 10

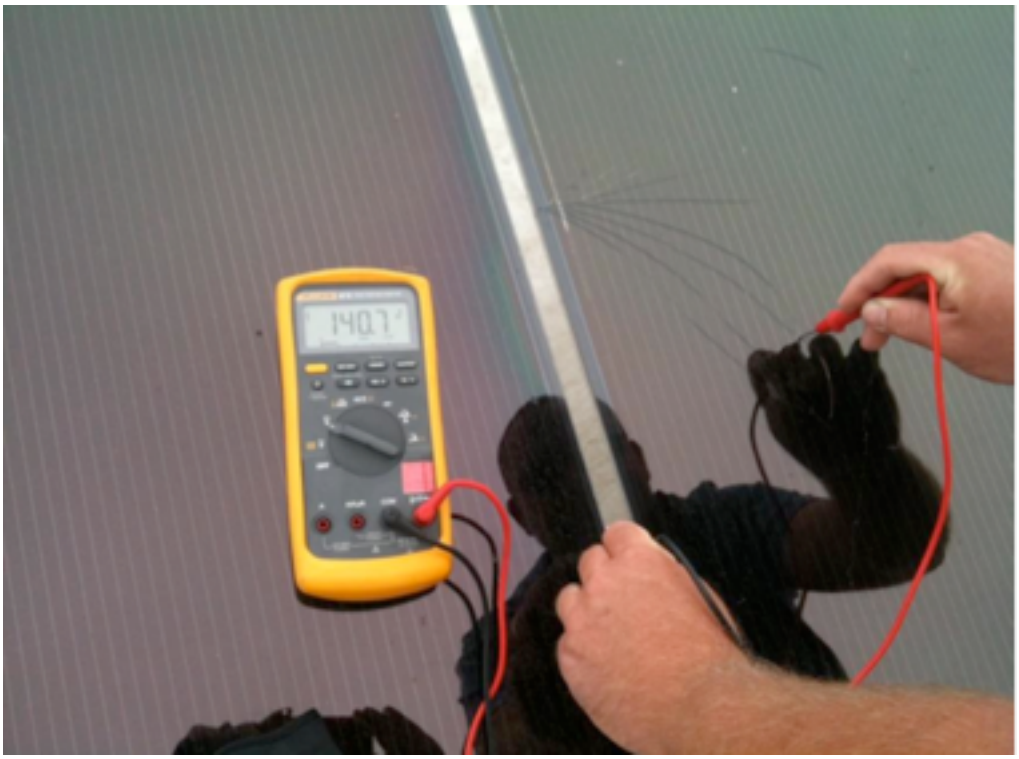

Fig.1: Example of measured potential between cracked front glass and rack.


Fig. 2: All bad modules were identified and marked with blue masking tape in the right hand corner.

In order to determine the risk of failure to the modules not already experiencing buss bar burns, a small experiment was performed. Here, we took 6 “good” modules randomly from strings containing buss failures. These modules were placed into short cct for ~1 minute. 3 of the 6 modules resulted in buss fails, or 50%. This indicates that

as soon as current is restored to the strings (when bad modules are replaced) at least 50% of the remaining modules will go on to fail.

The module performance was evaluated using strings unaffected by buss fails at this point.
Cell temperatures were measured at 60C-67C, ambient temperature was 37C. 2 modules were cooled to ~30C using iced towels and IV sweeps taken continuously as the modules returned to temperature. Temperature coefficients were calculated as -0.53%/C for Pmax and -0.33%/C for Voc. This high temperature coefficient for Pmax has been attributed to an excursion in the module manufacturers process and since corrected.

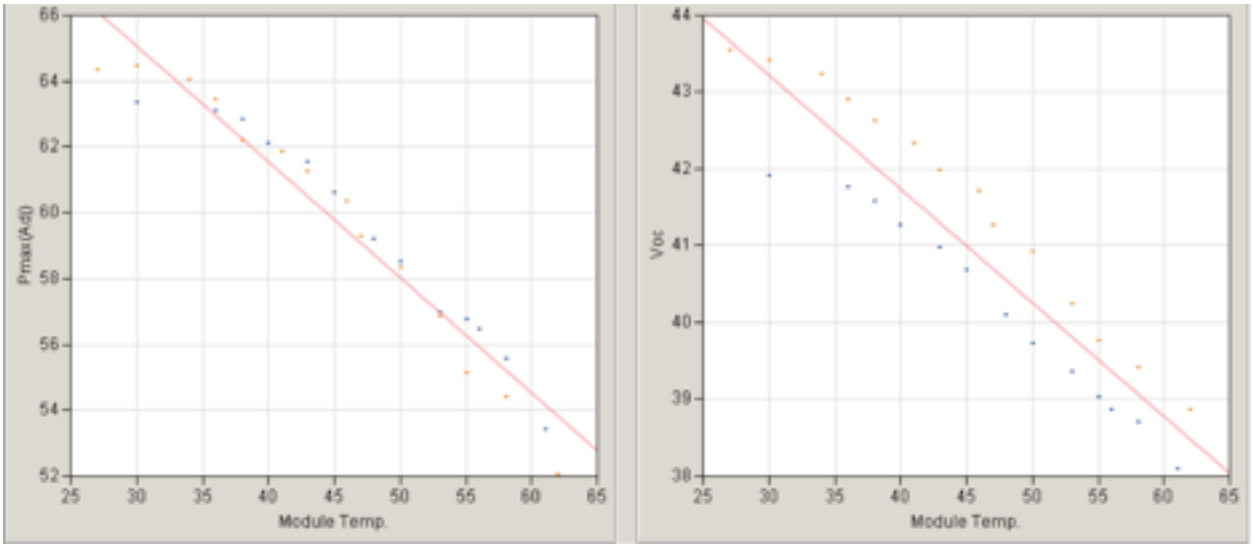

Fig. 3- Pmax and Voc Temperature Coefficient, calculated under constant illumination, cooling modules to 30C and continuously sweeping IV curves until the modules returned to normal operating temperature.

A neutral density filter was used to simulate lowlight conditions. Modules were tested under full light and then with the lowlight filter in place. Lowlight performance is solid. %PM (Performance Metric) is a temperature corrected Performance Ratio using the standard 0.25%/C Pmax temperature coefficient for CdTe technologies. This value should be very near 100% with losses only for soiling, light induced degradation, and light induced transients. The average %PM for this site is 87% and is low primarily due to the higher temperature coefficient.

Taking the temperature effects out, the remaining degradation is ~5%. Soiling can account for ~1% and the remaining 4% is due to Voc degradation. This is in line with module manufacturer's internal reliability testing which would predict ~5-8% losses in the first year and <1%/year after that.

Recommendations:

The buss bar failure rate is in excess of 61% given by: 22% failed modules + expected 50% of remaining modules once current is reintroduced to the strings. These modules are impacting 95% of the strings. Replacement of all the modules at this site as well as the other two identical locations is recommended. All 3 sites should be taken offline until full replacement can be made to eliminate any potential risks.