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PV Lifetime Project: Measuring PV Module Performance Degradation: 2019 Indoor Flash Testing Results

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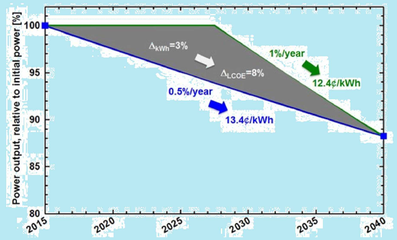
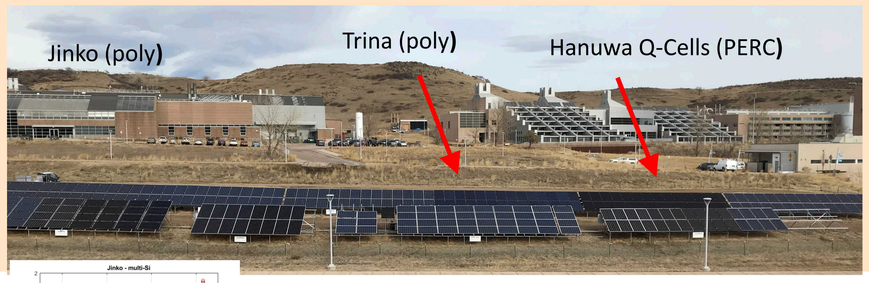
Introduction

Abstract — Photovoltaic (PV) module and system performance degradation is being measured by periodic flash testing of fielded PV modules at three sites. As of early 2019, new results from modules fielded in New Mexico and Colorado are available. These data indicate that module degradation varies significantly between module types and can also vary between modules of the same model. In addition, degradation rates for some module types appear to vary over time. Great care is made to control for stability and repeatability in the measurements over time, but there is still a +/-0.5% uncertainty in flash test stability.

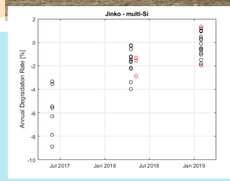


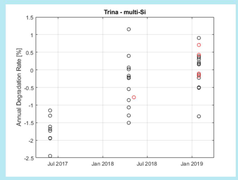
Due to the typically slow pace of PV module degradation in operation, often less than 1% per year [1], as well as variations in the operating and test conditions, any resulting differences in degradation rate are difficult both to measure and compare.



Modules Under Test

Site	Manufacturer	Model	Technology	# of modules	Installation Date
NM	Trina Solar	TSM-PD05.08 260W	poly-Si	56	Jun-16
NM	Jinko Solar	JKM260P-60 260 W	poly-Si	56	Jun-16
NM	SolarWorld	SW 245W Mono	mono-Si	21	2013
NM	Canadian Solar	CS6K-270P 270W	poly-Si	48	Oct-17
NM	Canadian Solar	CS6K-275M 275W	mono-Si	48	Oct-17
NM	Hanuwa Q-Cells	Q.Plus BFR-G4.1 280W	poly-Si PERC	48	Oct-17
NM	Hanuwa Q-Cells	Q.Peak BLK G4.1 290W	mono-Si PERC	48	Oct-17
NM	Panasonic	N325SA16 325W	HIT Mono	48	May-18
NM	LG	LG320N1K-A5 320W	N-type Si	48	May-18
CO	Trina Solar	TSM-PD05.08 255W	poly-Si	28	Sep-16
CO	Trina Solar	TSM-PD05.08 260W	poly-Si	28	Sep-16
CO	Jinko Solar	JKM260P-60 260W & 265W	poly-Si	56	Sep-16
CO	Hanuwa Q-Cells	Q.Plus BFR-G4.1 280W	poly-Si PERC	28	Oct-17
CO	Hanuwa Q-Cells	Q.Peak BLK G4.1 290W	mono-Si PERC	28	Oct-17
CO	Canadian Solar	CS6K-300MS 300W	mono-Si PERC	28	Jun-18
CO	Panasonic	N325SA16 325W	HIT Mono	30	Jun-18
CO	LG	LG320N1K-A5 320W	N-type Si	28	Jun-18
			Total	675 modules	



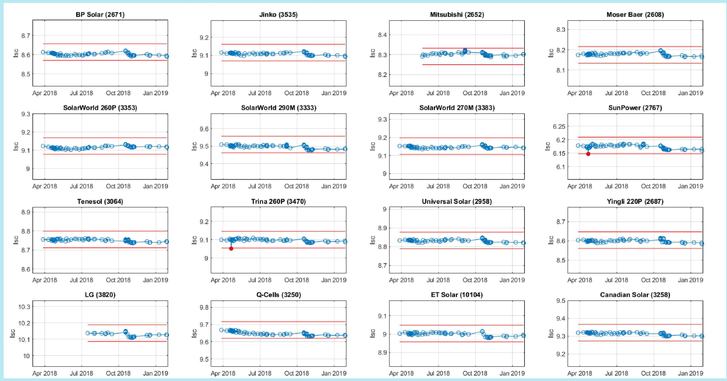


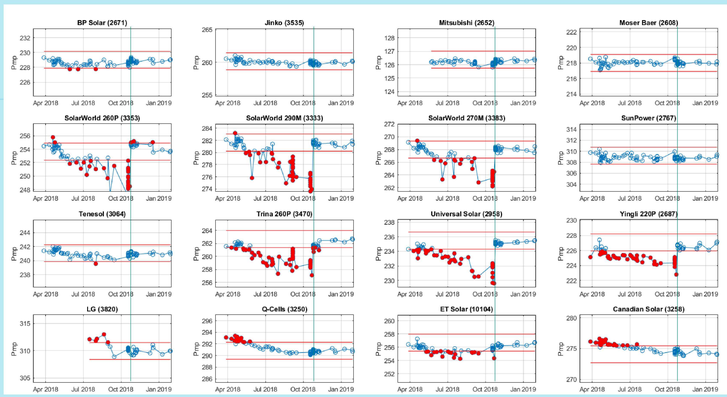
Flash Test Results

Flash test results are shown in the figures below. Trina and Jinko modules have been in the field almost three years and show decreasing rates of degradation over time. Panasonic, Canadian Solar, and LG Electronics modules appear to be improving over time in the first year and then stabilizing or degrading slightly later. One result is clear, degradation rates appear to be changing over time. Within the next year we will get more results from Colorado and can see if we similar patterns on their systems.

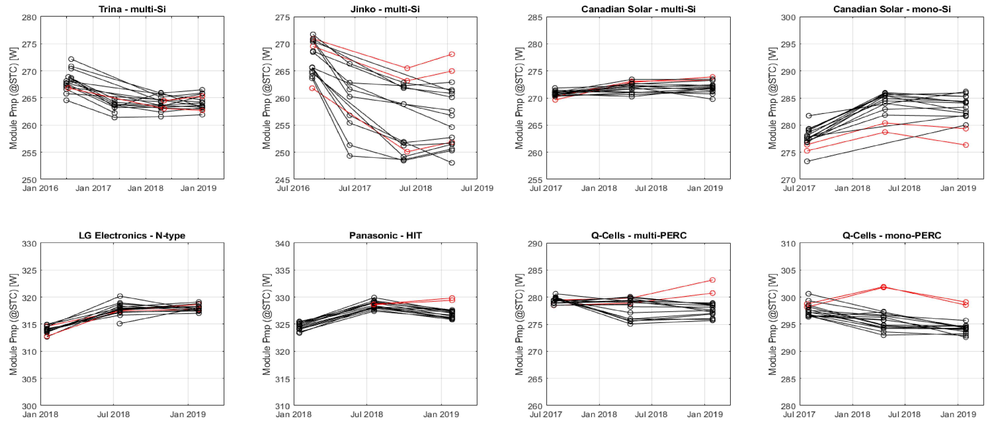
Flasher Stability

The stability of the flash simulators at each lab was monitored by regularly measuring control modules that are stored indoors. We noted that some of these modules showed progressive degradation and variability of Pmp (and RVoc). We attributed this to increasing series resistance from connector fatigue. We replaced all connectors with gold-plated multi-contact connectors and this problem disappeared (vertical lines in Pmp plot). We found that we can maintain approximately +/- 0.5% stability in power (red lines).

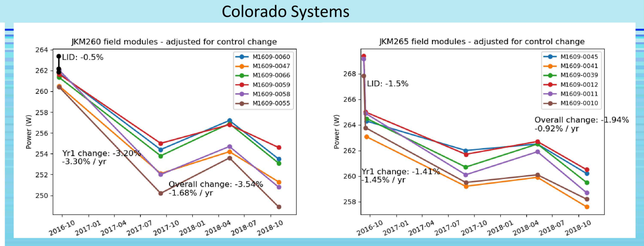


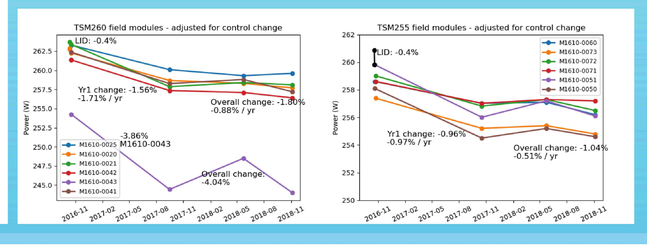


New Mexico Systems



Colorado Systems





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