Laboratory Testing at STC: Necessary but Not Sufficient (
Real World System Testing Picks Up Where Lab Testing Falls Short

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Abstract

- Historically performance evaluations have been performed at standard test conditions (STC). A number of pitfalls may skew accelerated lab test results when evaluating performance at STC. Skewed results may over-estimate or under-estimate real world performance often leading manufacturers astray. A comprehensive look at module performance in real world conditions is required to compliment the lab test results. For example, metastabilities in thin film technologies are inherent in the measurements and can result in incorrect conclusions. Parametric values like temperature coefficients and low light performance may not be stable and can degrade more rapidly than measurements at STC will show. These parameters play a big part in the economics of solar installations due to loss in overall energy yield. Accelerated lab testing is necessary in providing some assurances in stability and durability but field performance is the critical and complimentary piece of testing required to accurately predict performance of installations. In this study we present a detailed analysis comparing and contrasting results between accelerated lab testing and outdoor performance testing. This study highlights the shortfalls of STC only performance assessments.

Indoor Light Soak

- MFG1 and MFG2 were subjected to 1000hrs of indoor 1 sun continuous light soak. Modules were pulled from soak and tested at STC every 100hrs.


MFG1 & MFG2 vs. Time
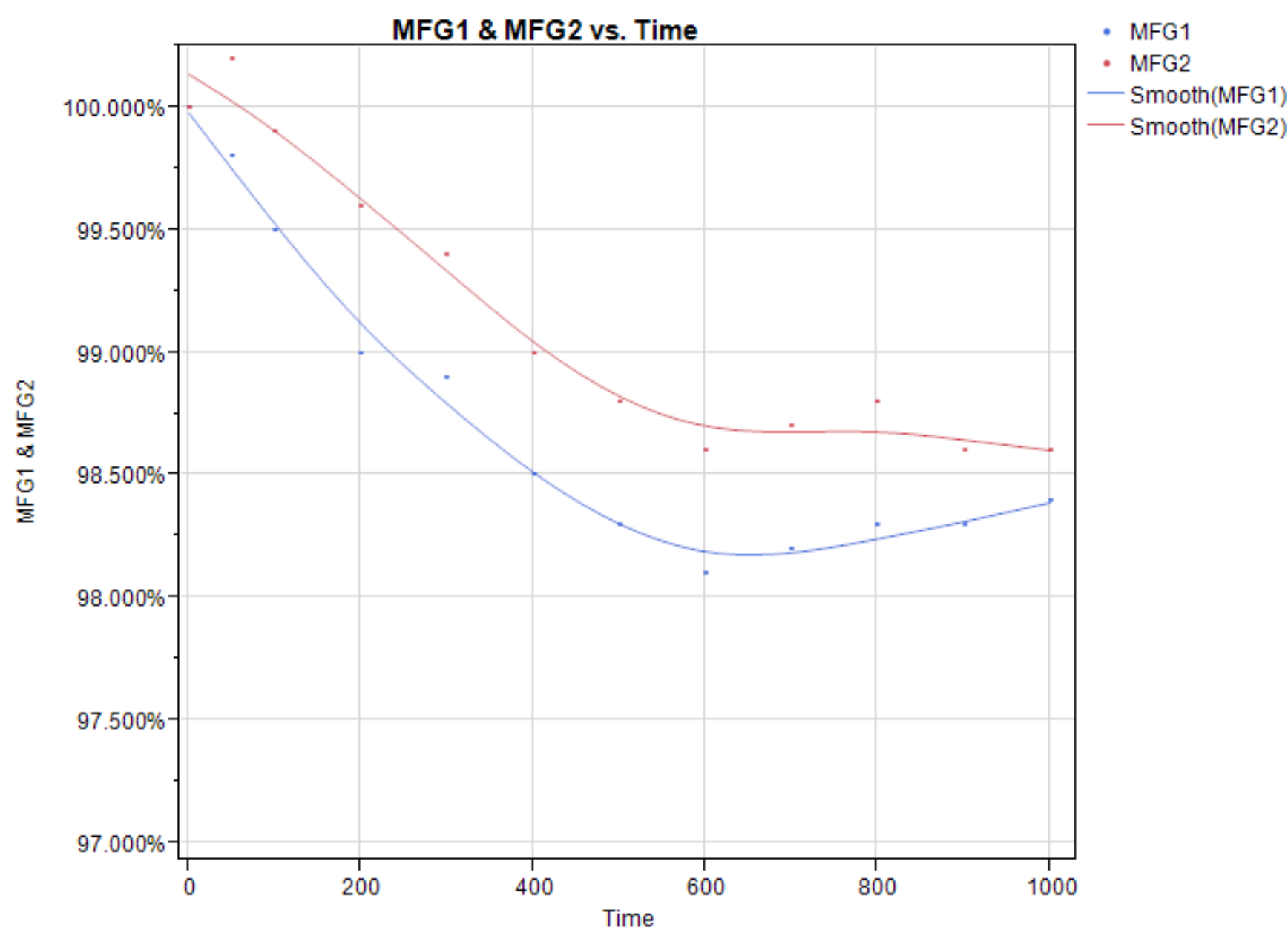
Observations

- MFG1 and MFG2 show very little degradation after 1000hrs of light soak
- MFG1 has begun to recover to match MF2
- IV curves appear nearly identical under STC

MFG1 vs MFG2
Post 1000hr Lightsoak
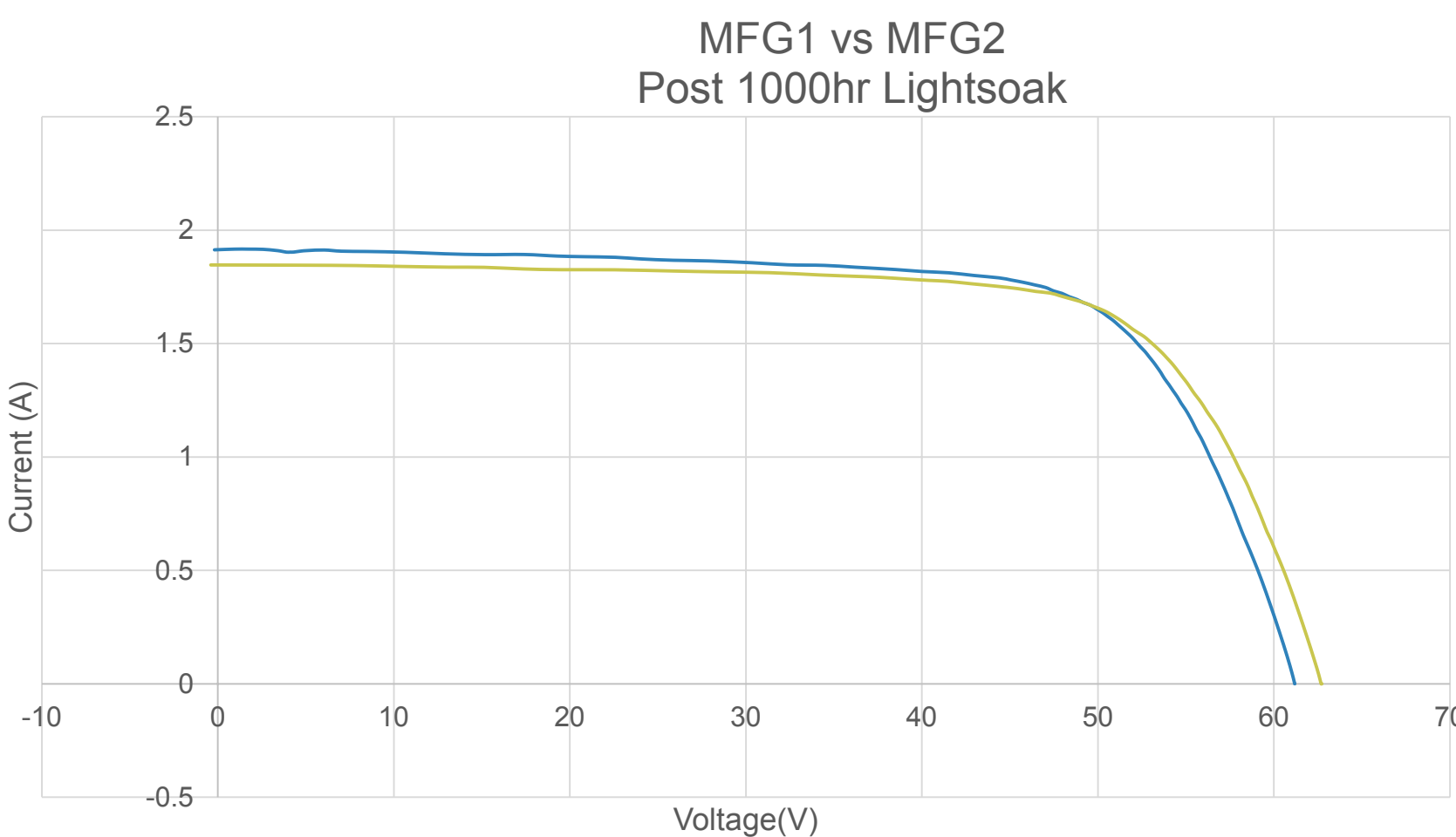
- MFG1 and MFG2 were installed outdoors in identical 5kW systems
- Additionally, 4 modules of each were installed on individual channel MPP trackers and IV curves were swept every 5 minutes.
- Energy yield appeared very similar, noticeable differences occurring on lowlight days

MFG1 vs MFG2 Outdoor %Performance (Normalized to STC)
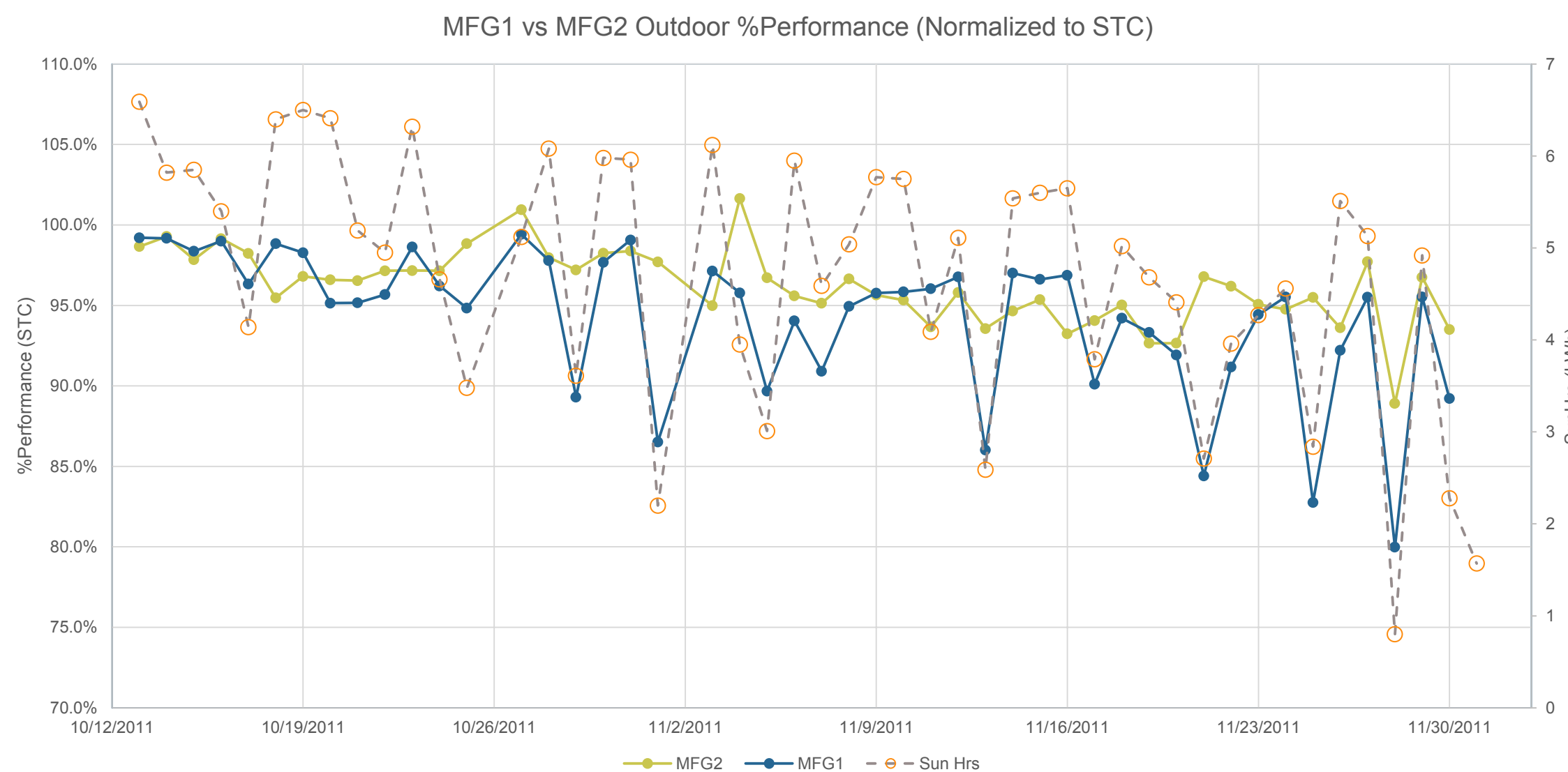
- Using module temperature and Irradiance, each value was corrected to STC and normalized to sticker giving a %Performance (STC) value.
- The days total sun hours in kWh are plotted on the secondary axis to highlight lowlight vs full sun days.
- MFG1 shows significantly poorer performance when days are cloudy or higher percentage of lowlight hours
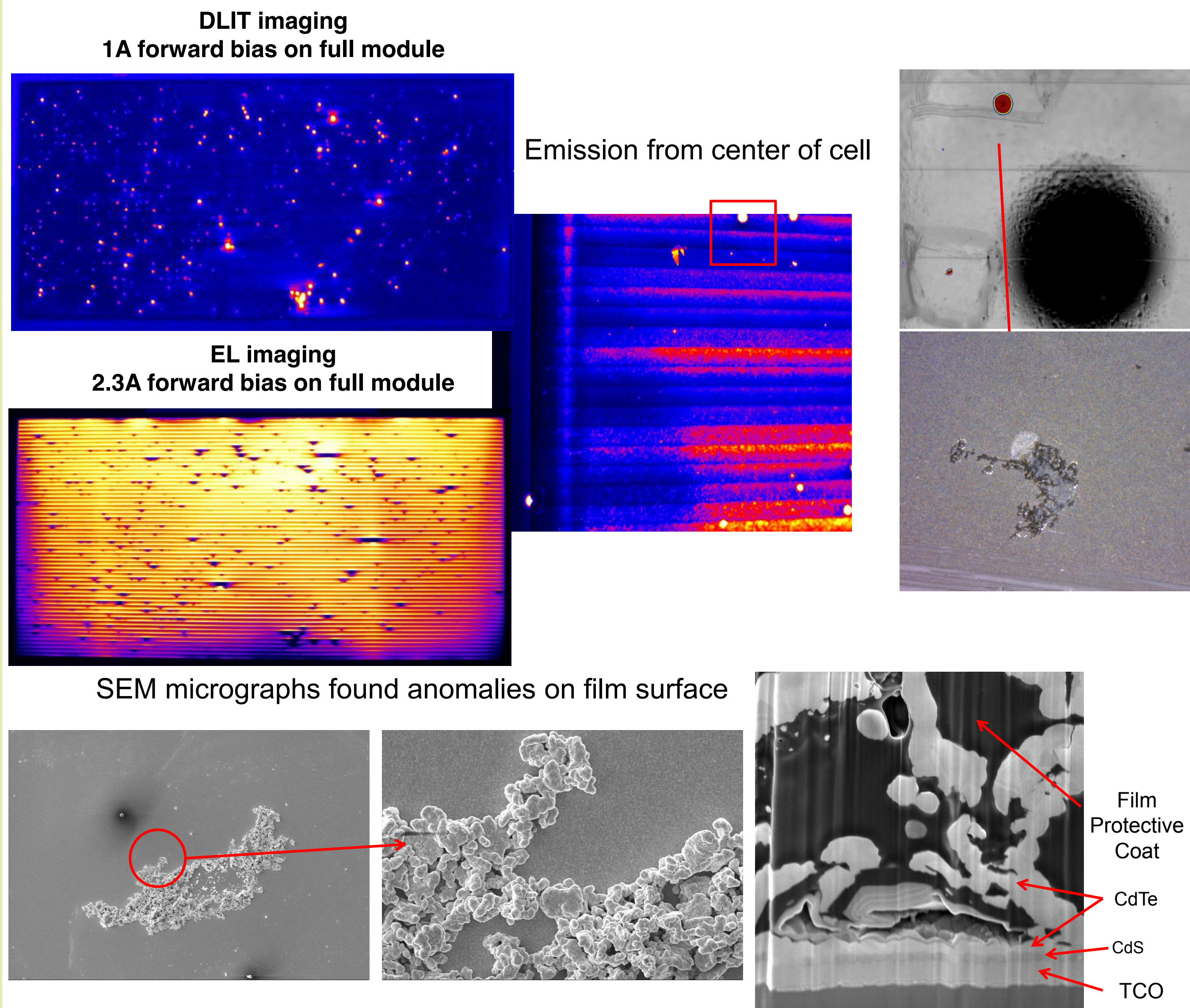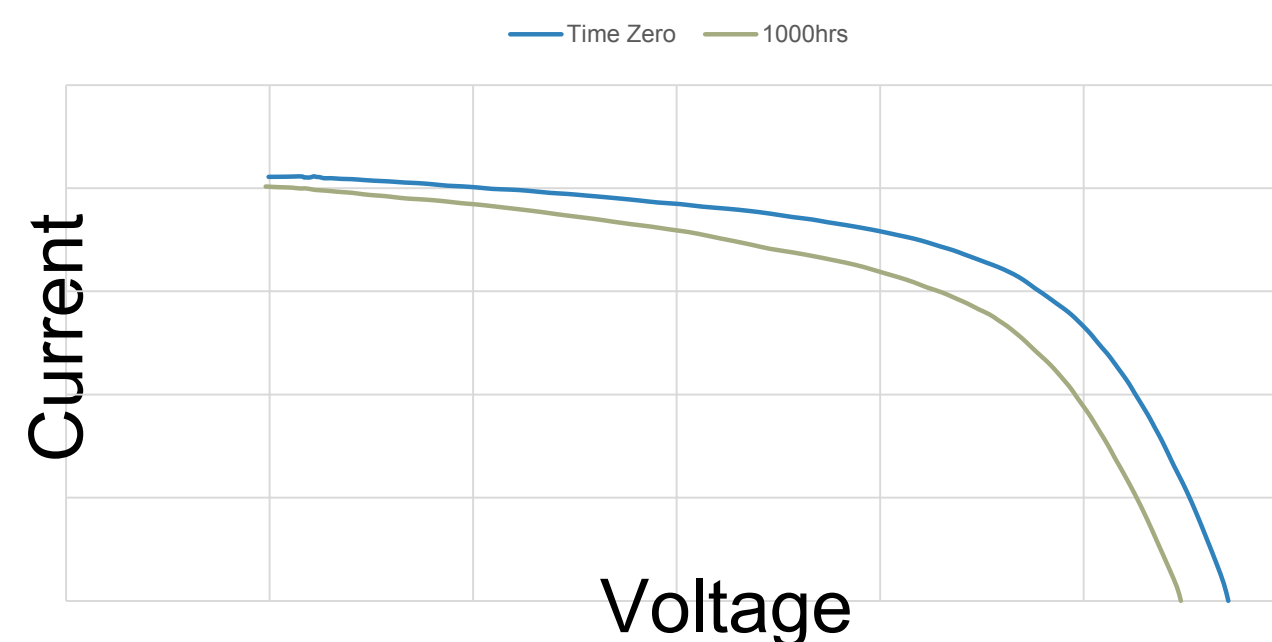
Performance vs Irradiance

- Initial performance vs irradiance was very good for both MFG1 and MFG2
- Post 45 days performance vs irradiance has degraded at lowlight in MFG1

Day1

Day45
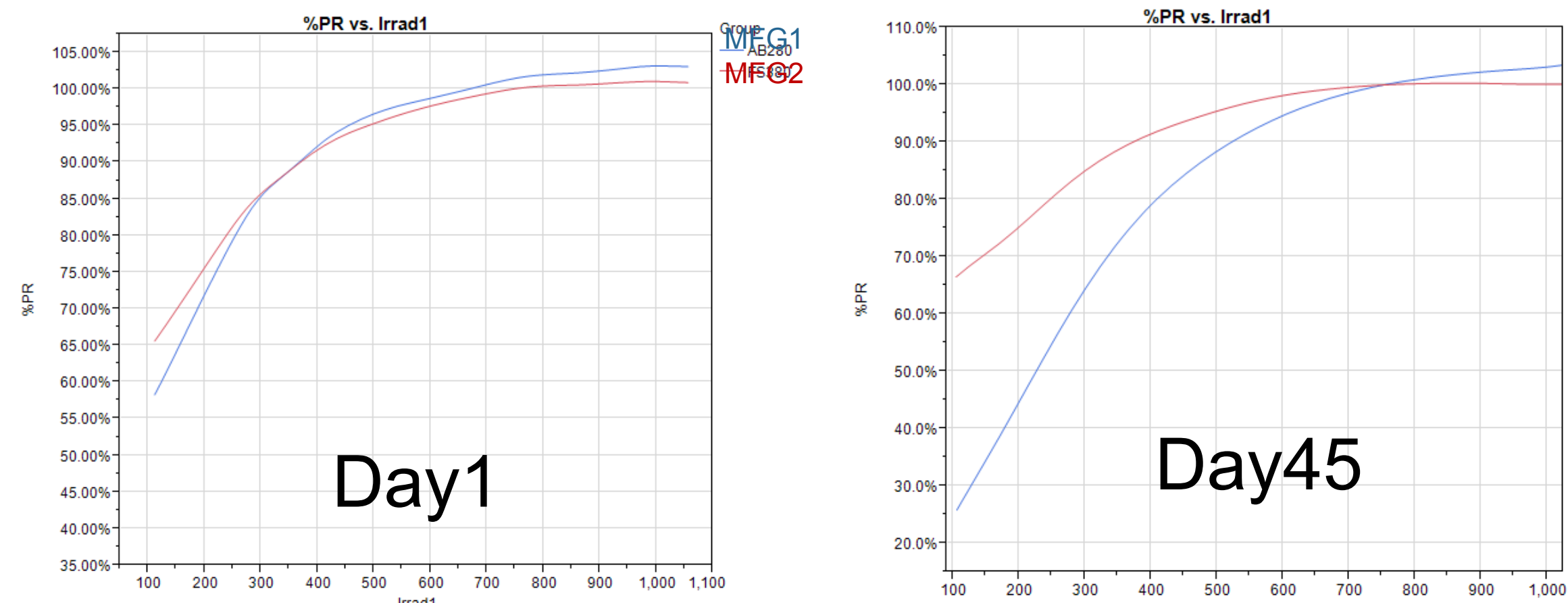
IV Analysis

- A more in depth analysis of the IV curves after 1000hrs of indoor light soak shows a significant difference when tested off of STC
- Using neutral density filters to assess the curves at varying IRR levels reveals MFG1 has degraded performance under lowlight conditions

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DLIT imaging
1A forward bias on full module

Emission from center of cell

EL imaging
2.3A forward bias on full module

SEM micrographs found anomalies on film surface

Film Protective Coat
CdTe
CdS
TCO

- This defect was traced back to the CdTe source form factor which resulted in "spitting" during sublimation.

Conclusions

- Very different conclusions can be drawn about the equivalence of these two thin film manufacturers when looking at laboratory STC testing and actual outdoor performance.
- This particular type of Rsh defect degrades over time and manifests itself in lowlight performance first.

%Energy Yield Loss Due to Degrading Rsh, Poor Lowlight Performance

$$$ LOST!

- The PVSYST PAN files for these 2 manufacturers show identical dark Rsh and exponential relationships because at time zero they do match.
- Adjusting the PAN files to account for the degraded Rsh values reveals a significant loss in energy yield each year.
- Above shows the %energy lost when MFG2 is modeled using a 50% Rsh relationship and MFG3 is modeled using a 25% Rsh relationship.