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Impact and Detection of Pyranometer Failure on PV Performance

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1 Introduction

Long-term PV Performance

1. Financially:
Cash flow !
Uncertainty directly related to risk !

2. Technically:
Lifetime prediction !
Product improvement !

Pyranometers often used to measure Plane-of-array irradiance (POA)

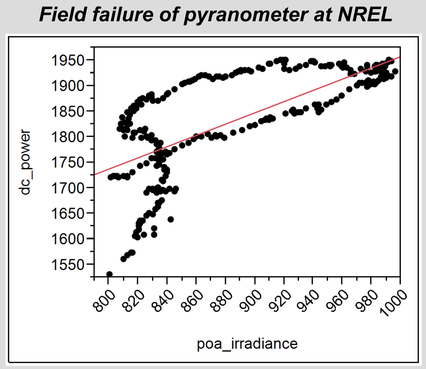
Pyranometers are recommended to be calibrated 1-2 years

Better understand one failure mechanism we observed in the field

Find analytical signal for early-fault detection

2 Catastrophic Failure

Field failure of pyranometer at NREL



Catastrophic field failure: Seal of SiO2 cartridge failed –> moisture penetrated inside

If failure not catastrophic but seal slowly disintegrates
Could be a long time until failure is recognized!

3 Pyranometer with High Humidity '

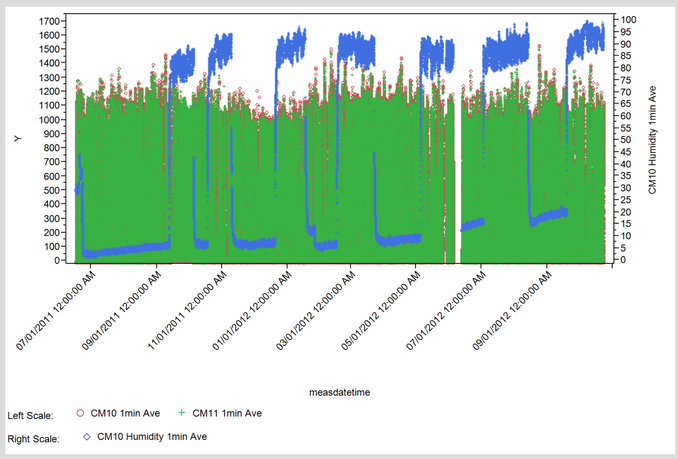
ASTM E104-85 (1996) Standard:
Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions

Cartridge filled with desiccant SiO2 Low humidity

Cartridge filled with saturated NaCl High humidity

Saturated NaCl maintains relative constant humidity in closed-spaced environment

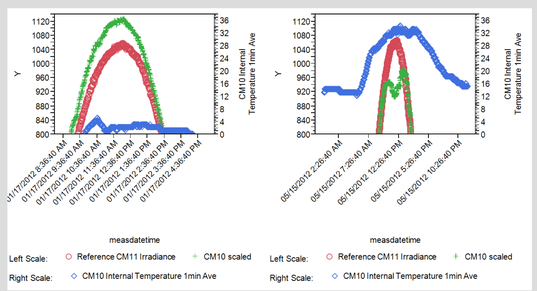
4 CM10 Pyranometer



By swapping salt and desiccant, periods of high & low humidity are alternated so as not to destroy pyranometer

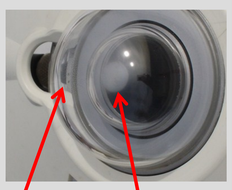
Use both data for PV system degradation rate determination

5 Sunny – High Humidity



Sunny Day - Winter

Sunny Day - Summer



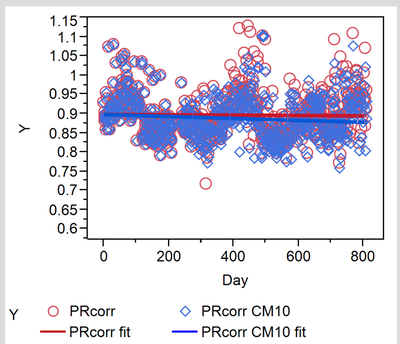
Some droplets on outer dome

Condensation film on inner dome

On sunny days, high humidity leads to condensation that diminishes signal

Effect clearly visible on sunny days & high temperature

6 Performance Impact '



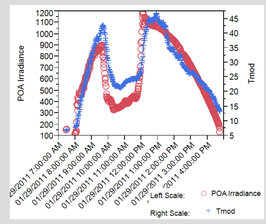
Pyranom.	R_d (%/year)	Uncertainty (%/year)
Regular	-0.18	0.38
High humidity	-1.15	0.36

CM10 pyranometer (high humidity) drifted about 1%/year

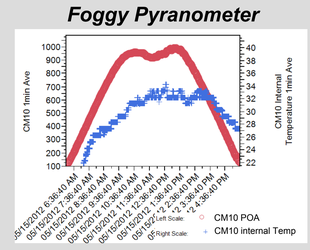
Significant performance impact if problem is not detected

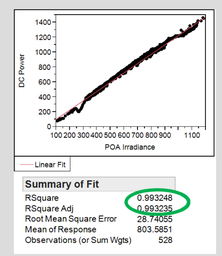
7 Detection Method

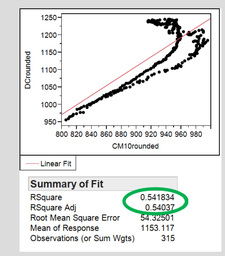
Cloud effect



Foggy Pyranometer

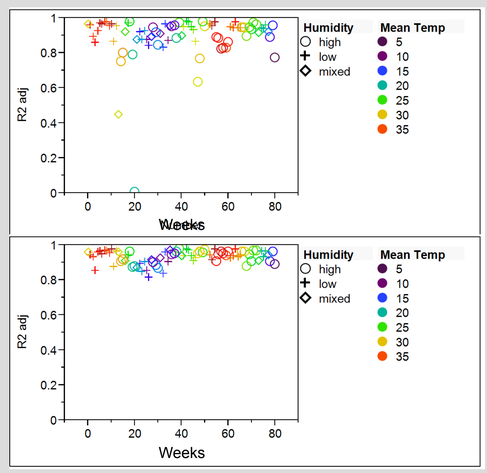






Careful tracking of R^2 of DC Power vs. POA

8 Detection Results



Using CM10 irradiance, High humidity: circles

Using system POA irradiance

Humidity is indicated for comparison sake

R^2 adj = R^2 adusted for different number of data points per interval

R^2 adj drops significantly during pyranometer problem

9 Conclusion

Accurate PV performance often depends on accurate irradiance measurements

Pyranometer with high humidity inside was used to simulate slow failure

More than 1 year of data have been collected

Pyranometer has drifted by about 1%/year

At sufficient high temperature condensation forms on inside of dome that skews data

An analytical method based on the fit of DC Power vs. POA irradiance in weekly intervals was used to detect the faulty pyranometer.

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