Case Study of Using a Modified "DC/POA" Method in Determining PV System's Degradation Rate and the Impact of Data Filters

Wilson Zhang, Teck Cheng Tan, Nick Rose, REC Solar, Singapore

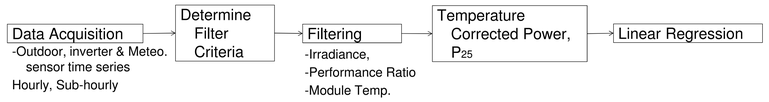
Abstract

Outdoor degradation rates of a PV system can be assessed remotely using DC power and plane of array (POA) irradiance measurements. In this work, a modified so-called "DC/POA" method is introduced to determine the degradation rates of several PV plants of less than 3 years by analyzing the meteorological and inverter hourly and sub-hourly time-series data collected from the data-logging equipment without conducting site inspections. Various filters are applied prior to the linear regression technique to reduce the outliers in the data which is caused by several known issues such as low-light behaviours, data irregularities and system outages. The degradation rates and confidence interval are presented; its relationships with various filters are also discussed. It is found out that the degradation rates are sensitive to data filters and further refinements are required to isolate module degradation rates from system degradation characteristics of the DC system.

Introduction

A robust method to determine the degradation rate of PV systems on site to serve as tool in monitoring the decline in performance of the PV modules installed in the field. Specific filters were applied to DC/POA method, which is recommend as most precise among other methods [1].

Method



- System degradation over time is measured at the AC output of the inverter
- Modified NREL method [2] filter guidelines :
  - Daylight data only
  - Removal of any record with missing data for any parameter
  - Removal of any record with using Irradiance filter condition
  - Remove any records using determined PR condition of site
  - Include only records with module temperature within 0 to 50ºC range (minimise the thermal lag effects at extreme temperatures)

- Module power is adjusted back to 25°C equivalent via the following:

$$P_{25} = Power_{meas} \times [1 + \gamma(T_{mod} - 25\,°C)]^{-1}$$

- Performance Indicator (PI):

$$PI = \frac{Power_{meas} \times 1000}{G \times Power_{rated} \times [1 + \gamma(T_{mod} - 25\,°C)]}$$

- PI is plotted against time from the commissioning of the monitoring system
- Linear regression of data post filtered dataset to determine Degradation Rate, Rd

Sites

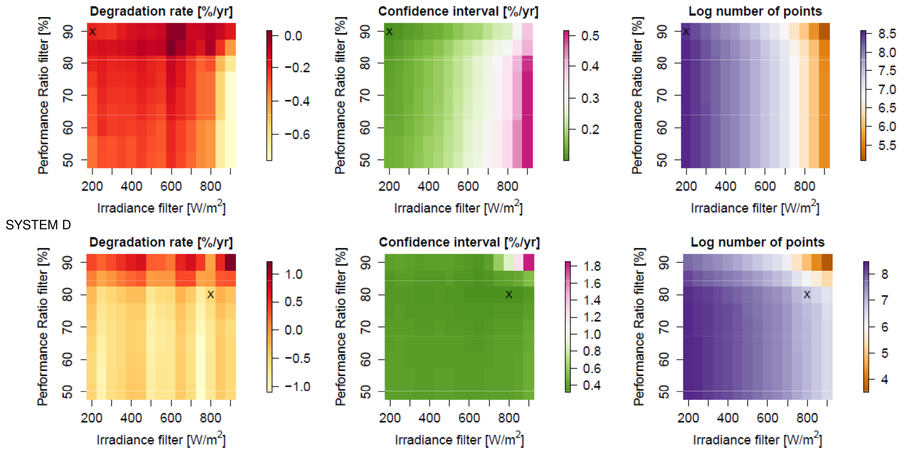
Site	Location	System Size	Commissioning Date	Analysis Period	Module	Inverter	Irradiance Sensor
System A	Germany	725 kWp	Dec-10	37 Months	REC230PE	Refusol 630K	K&Z SMP11
System B	Germany	679 kWp	Dec-10	37 Months	REC210PE	Refusol 630k	K&Z SMP11
System C	Italy	992 kWp	Aug-11	26 Months	REC235PE	SMA 800CP	Silicon Sensor
System D	Italy	998 kWp	May-11	32 Months	REC235PE	SMA 800CP	Silicon Sensor

Uncertainties

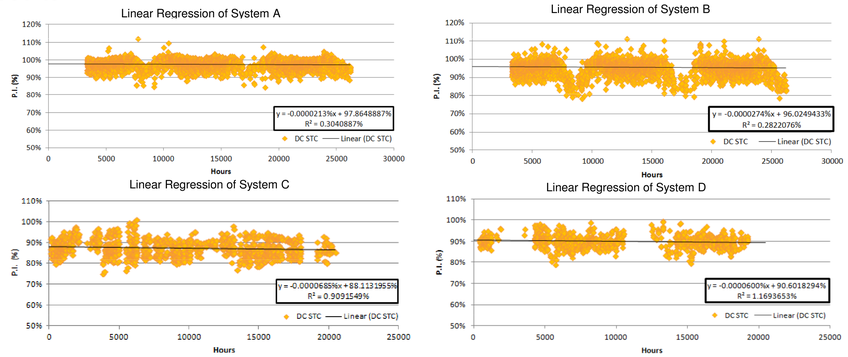
Measurements	Sensor Accuracy
AC, DC Parameters	2%
K&Z SMP11 Pyranometer	1%
Silicon Irradiance Sensor	5%
PT1000 Module Temp. Sensor	1%

Impact of Filters

- Filter: Performance Ratio and Irradiance vs Degradation Rate, Rd, & Confidence interval



Results



Degradation Rates (%/year) of the four sites determined using this model below -0.6%/year; consistent with published data of multi-crystalline PV modules [3].

PV System	PR Filter	Irradiance Filter	Degradation Rate, Rd	Confidence Interval (95%)	Post-Filtered Data Points
System A	PR ≥ 90%	G ≥ 200	-0.19%/year	± 0.12%	4739
System B	PR ≥ 90%	G ≥ 200	-0.17%/year	± 0.10%	4313
System C	PR ≥ 75%	G ≥ 800	-0.60%/year	± 0.35%	1217
System D	PR ≥ 80%	G ≥ 800	-0.53%/year	± 0.31%	953

Discussion

- Modified DC/POA method shown to be robust method
- Filters to apply to exclude abnormities and non-linearity varies from site to site
- The amount of filter also affects the confidence of the reported rate especially for PV plants with low data analysis period
- Degradation rate determined using above method reported degradation rate below published rates
- Mean soiling loss of PV plants reported to be between -2.4 to -8.3 x10^{-4} /day [4] ; Such soiling loss has not been excluded from reported Rd
- Method needs to be improved to take soiling rate into consideration

Reference

[1] Jordan, D.C.; Kurtz, S.R. (2012). "Data Filtering Impact on PV Degradation Rates and Uncertainty." Presented at the *NREL PV Module Reliability Workshop.*

[2] Daryl Myers, "Evaluation of the performance of the PVUSA rating methodology applied to DUAL junction PV technology", *American Solar Energy Society Annual Conference*, Buffalo, New York, 11-16 May 2009.

[3] Jordan, D. C. and Kurtz, S. R. (2013), "Photovoltaic Degradation Rates—an Analytical Review", *Prog. Photovolt: Res. Appl.*, 21: 12–29

[4] Mejia, F. A. and Kleissl, J. (2013), "Soiling Losses for Solar Photovoltaic Systems in California", *Solar Energy*, 95: 357-363