Study and Characterization of the Impact of Soiling on the Performance of Photovoltaic Systems

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This study analyzed the soiling induced efficiency degradation of five different solar modules over the course of a year, aiming to characterize and quantify the impact of soiling on the performance of these systems.
For every dry period (defined as a series of consecutive days with no rain), the degradation of PV efficiency was analyzed. A special attention was given to the longest dry period.
The modules, located at the SIRTA observatory, were installed at a fixed tilt angle of twenty-seven degrees directly facing south. All the data was processed using MATLAB.
This study is divided into three parts. The first concerned the calculation of the photovoltaic efficiencies, and their subsequent thermal correction to STC conditions.
The second part consisted on the reprocessing of the efficiency values in order to facilitate the detection of soiling related losses and increase the accuracy of the analysis. This included the removal of outliers and the calculation of the cumulative daily efficiency values.
The third step was the estimation of the efficiency degradation rates through linear regressions, and the assessment of their statistical significance aiming to validate the results. To this end, the confidence and prediction intervals were calculated for each panel, as seen in Figure 1.
For the case of the longest dry period, the panel's average power degradation rate was -0.042 %/Day, a value that it's in accordance to several studies of similar nature [1,2].
Finally, the regression slopes were tested unidirectionally, aiming to determine the probability of registering an efficiency decrease during this period. The results of this analysis are displayed on Figure 2, where a one tailed t test was performed for each module, focusing exclusively on the upper confidence interval, revealing the level of confidence with which one can affirm that soiling losses were present for each panel. Results showed that all panels registered an efficiency degradation within a ninety-percent confidence interval, and within ninety-five for four panels.

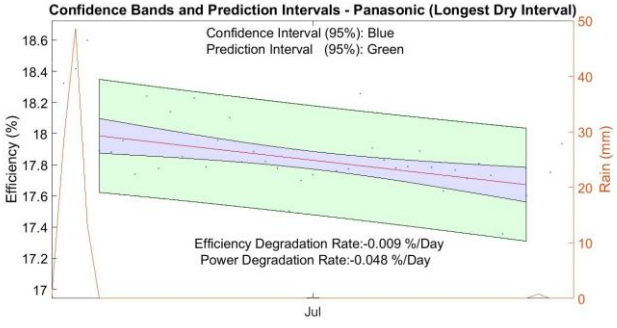

Figure 1: Confidence and Prediction Intervals for the Panasonic solar module

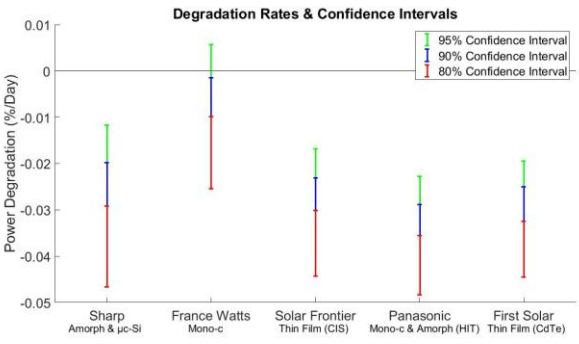

Figure 2: One-Tailed Confidence Intervals for each panel

[1] Kimber, A., Mitchell, L., Nogradi, S., Wenger, H. The effect foiling on large grid-connected photovoltaic systems in California and the Southwest region of the United States. *Conference Record of the 2006 IEEE 4th World Conference on Photovoltaic Energy Conversion*, 2, 2391-2395. 2006.
[2] J. Zorrilla-Casanova and M. Piliougine, "Analysis of dust losses in photovoltaic modules" Proceedings of the World Renewable Energy Congress, Sweden, 2011, pp. 2985–2992.