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

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ABSTRACT

This study analyzed the soiling induced efficiency degradation of five different solar modules, aiming to characterize and quantify the impact of soiling on the performance of these systems. This was accomplished through the analysis of the degradation of the module efficiencies over dry periods, during which rain is insufficient to effectively clean the panels. It was concluded that solar panel cleaning can be neglected in the region of Paris, as soiling losses are rendered insignificant due to the natural cleaning provided by the high frequency of rainfall events.

µc-Si/a-Si tandem
P_{mpp} = 128 W
η= 9,5%
Thin film technology

CIS
P_{mpp} = 150 W
η= 12,2%
Thin film technology

CdTe
P_{mpp} = 82,5 W
η= 11,4%
Thin film technology

C-Si
P_{mpp} = 250 W
η= 15%
1st generation

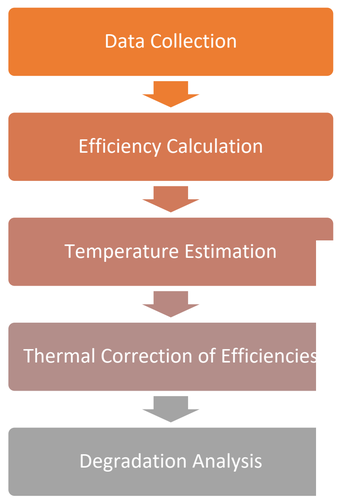
HIT
P_{max} = 240 W
η= 19%
Best PV efficiency

Introduction & Methodology

The accumulation of particles on the surface of solar panels is one of the main factors affecting solar panel efficiency. This phenomenon, commonly referred to as soiling, can amount to a sizeable portion of the system losses.

This study aimed to calculate the soiling induced efficiency degradation rates, by analyzing the module efficiencies during periods without significant rainfall.

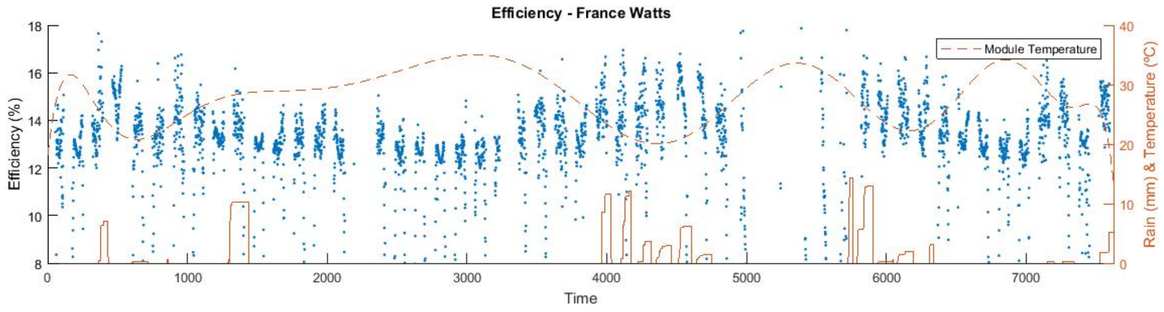
Over the course of this study, the efficiency values of each panel were calculated, filtered, treated and analyzed.

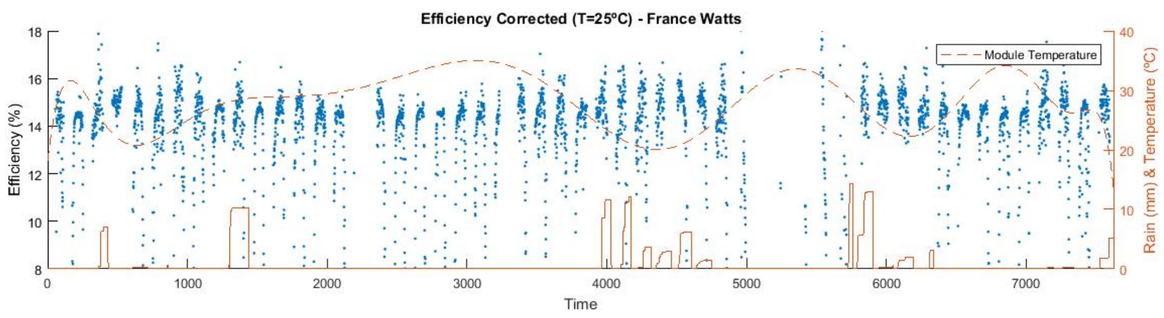


Temperature Correction

In order to remove the influence of the temperature on the photovoltaic efficiency, the module efficiencies were corrected to the standard temperature of 25ºC.

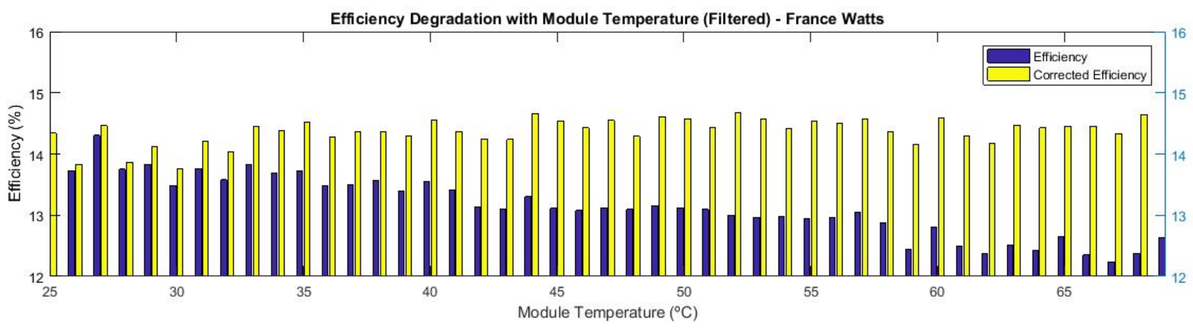
$$Efficiency_{T=25ºC} = \frac{Efficiency}{[1+\beta\times(T_M-25)]}, \qquad \beta: Power\ Thermal\ Coefficient$$





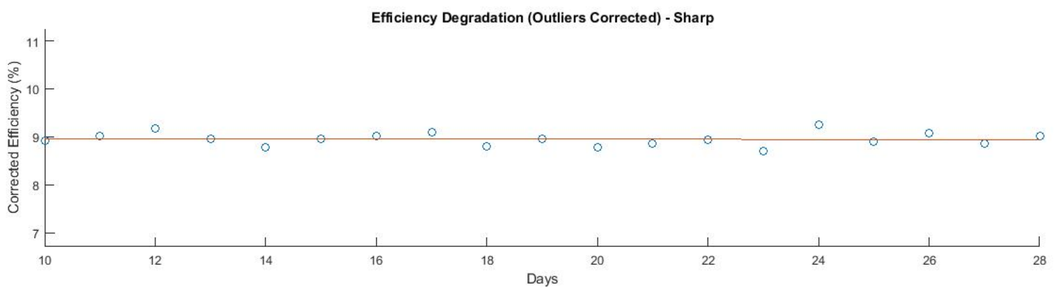
Quality of the Correction Procedure

The quality of the correction process can be assessed through the examination of the linearity of the corrected efficiencies over the temperature range. The process is then deemed successful if the resulting efficiencies are systematically within a reasonable range of each other.



Efficiency Degradation Rates

The quantification of the efficiency losses was obtained through a linear regression of the efficiencies over the dry period. The degradation rate, measured in percentage per day, corresponded to the slope of this curve.

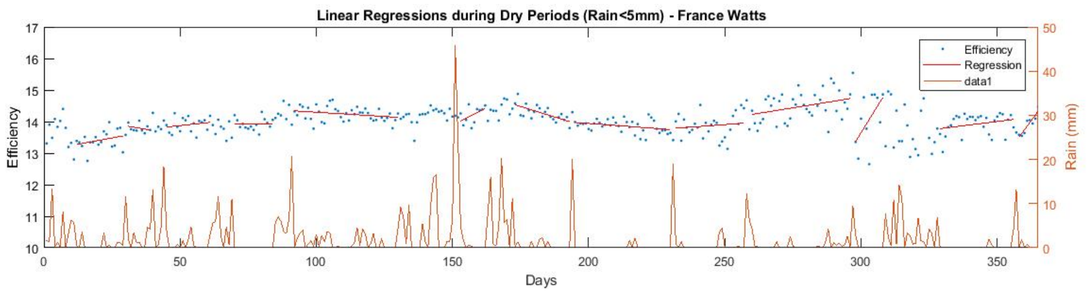


The table below summarizes the results of this single-period analysis.

	Sharp	France	Frontier	Panasonic	First
Max. Efficiency Degradation	-0.02%	NaN	-0.31%	-0.25%	-0.16%
Max. Power Degradation	-0.27%	NaN	-2.33%	-1.41%	-1.34%

Multi-Period Analysis

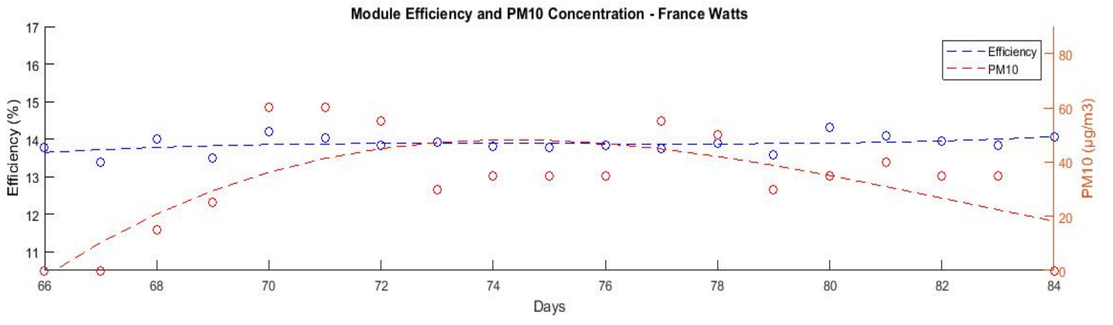
Similarly to the prior analysis, the efficiency degradation rate was calculated for each period whose total daily accumulation did not exceed five millimeters. The example below corresponds to a year-long period.



As the red lines suggest, no consistent efficiency degradation was found.

Soiling & Air Pollution

Finally, it was postulated that an above average soiling deposition could occur during intense pollution episodes, a phenomenon already well documented in the literature. To this aim, the module efficiencies were plotted over several of these events, aiming to detect an efficiency loss.



Upon further analysis, it became clear that the panel's efficiency was not correlated with periods of peak pollution or PM 10 concentration.

Conclusion

Particle accumulation on solar module surfaces can lead to sharp decreases in system performance, affecting the availability of the incoming solar radiation. In the Parisian climate, however, this phenomenon is greatly mitigated by the high frequency of rainfall events, which are the single most effective natural cleaning process [1].

Having analyzed the efficiency over dry periods (<5mm/Day), this study has found no evidence of soiling induced efficiency degradation. The fact that the power degradation rates obtained for the five modules aren't closely matched, suggests that these degradations do not correspond to soiling losses. Moreover, the average linear regression on the multi-period analysis spanned a mere twenty-one days, a period much too short for any meaningful soiling accumulation [2].

References

[1] Hammond R, Srinivasan D, Harris A, Whitfield K, Wohlgemuth J. Effects of soiling on PV module and radiometer performance. In: Proceedings of the twenty-sixth IEEE photovoltaic specialists conference; 1997.p.1121–1124.

[2] Kimber A, Mitchell L, Nogradi S, Wenger H. The effect of Soiling on Large Grid-Connected Photovoltaic Systems in California and the Southwest Region of the United States. IEEE 4th World Conference 2006 .