CdTe system analysis after 11 years exposure to a hot-humid climate in Huitchila-Mexico

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Background

In Huitchila region in the state of Morelos, are installed PV pumping systems with Thin film technology. The predominant climate the state of Morelos is hot and humid as defined by INEGI[1]. The temperature range is about of 22-35 °C. .

Figure 1. Geographical coordinates of Amate system

The array is composed by 6 CdTe modules of First Solar manufacturer , the system was installed in 2005.

Figure 2. El "Amate" PV system array (2S x 3P). Array title angles: 22°

Electrical Specifications (STC)				
Vmp (V)	Imp (A)	Pmp (W)	Voc (V)	Isc (A)
61	0.9	55	88	1.13
Temperature Coefficient: α= 0.004 %/°C, β= -0.29 %/°C and γ=-0.25%/°C [2]				

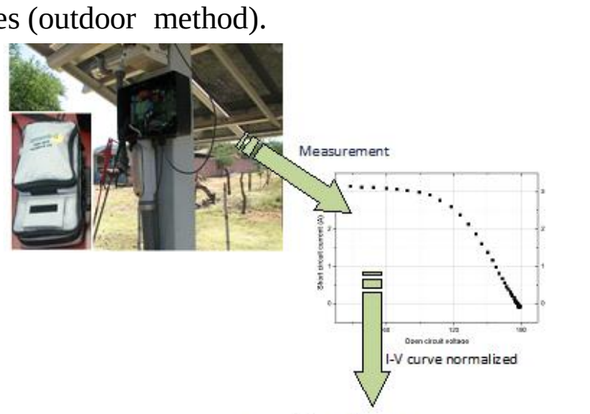
Table 1. Electric Parameter Module Fist Solas Fs55 [2]

Objectives

-Evaluate the CdTe modules electrical performance installed in hot and humid climate after several years of operation..

Test Methodology

Field test procedures for evaluating the electric performance of the CdTe modules were conducted: visual inspection, thermal infrared (IR) imaging and current-voltage (I-V) curves (outdoor method).



$$I_2 = I_1 + I_{sc}\left(\frac{G_2}{G_1} - 1\right) + \propto (T_2 - T_1)$$
$$V_2 = V_1 - R_S(I_2 - I_1) - kI_2(T_2 - T_1) + \beta(T_2 - T_1)$$

Figure 3. Electrical performance outdoor method

Results

Visual inspection:

CdTe modules are in good condition, after 11 years, there are no defects as delamination, corrosion or other degradation problems. It was found lightly soiled near frame.

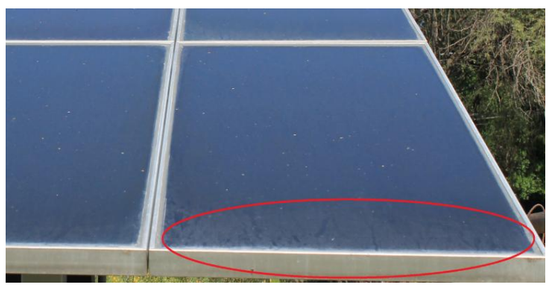
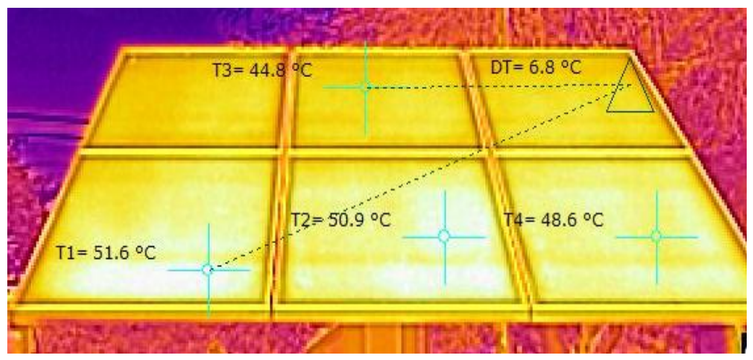


Figure 4. CdTe module dirty near frame

IR image:

The temperature of the module is relatively uniform. The average temperature of the array is 47°C with a difference of 7°C between the higher temperature and the lower temperature.



Irradiance 1000W/m^2, Ambiente Temp. 29°C

Figure 5. IR imagen of the PV array

Electrical performance:

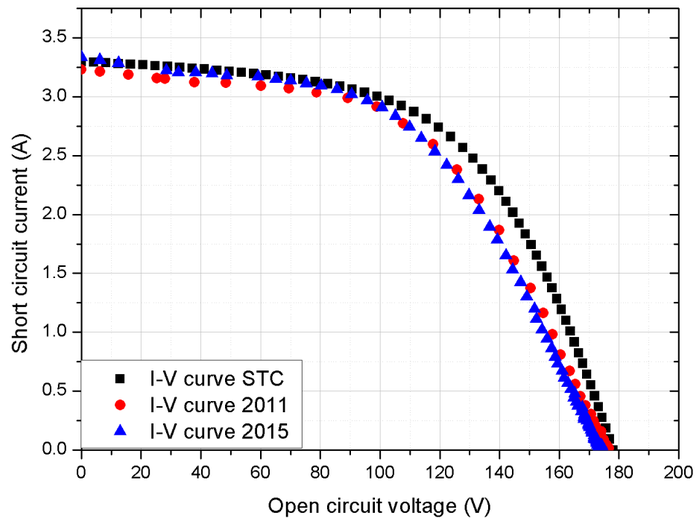


Figure 6. I-V curve normalized @ STC

	Test condition	First Solar Normalized Array Ratings (G = 1000 W/m², Tcell= 25°C)						
		PMP (W)	V_{OC} (V)	I_{SC} (A)	V_{MP} (V)	I_{MP} (A)	FF (%)	Rs (ohm)
Name plate	Rated @ STC	330	176	3.3	122	2.7	0.57	13.42
PV array 2015	Measured @ STC	302.55	175.41	3.21	111.83	2.68	0.53	23.07
	Measured vs rated	27.45	0.59	0.09	10.17	0.02	0.04	9.65
	Total degradation	8.318	0.335	2.727	8.336	0.741	6.72	0.71
	Annual degradation rate (%)	0.76	0.03	0.25	0.76	0.07	0.61	

Table 2. Degradation analysis results of CdTe modules

Conclusions

✓ CdTe modules have a good performance in hot and humid climate, in the visual inspection corrosion problems, delamination or other visual defects weren't found. CdTe modules have soiled in the glass near to frame but this don't affect the electrical performance.

✓ IR image shows a uniform temperature distribution in all PV array, the ΔT is 6.8°C so it is considered that there aren't hot-spot problem.

✓ Degradation analysis was made comparing the IV normalized datas with nameplate data, and results indicate that the power degradation in the PV array is about of 27.45 W and that the annual power degradation is about 0.76% (11 years old module exposed). This value is similar to that reported by manufacturer of 0.70 %/year [5].

✓ The Rs increase about a 72% of initial value . Fill Factor decreases in around of 6.7% with respect to its initial value.

References

[1] INEGI, National Institute of Statistics, Geography and Computing http://cuentame.inegi.org.mx

[2] Datasheet FS55 module, https://ca.grundfos.com

[3] International Electrotechnical Commission, Standard IEC 60891 2005 "Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics "

[4] Packard, C. E., Wohlgemuth, J. H., & Kurtz, S. R. (2012). Development of a visual inspection data collection tool for evaluation of fielded PV module condition (No. NREL/TP-5200-56154). National Renewable Energy Laboratory (NREL), Golden, CO..

[5] Strevel, N., Trippel, L., Kotarba, C., & Khan, I. (2014). Improvements in CdTe module reliability and long-term degradation through advances in construction and device innovation. Photovoltaic international,.

[6] PVSYST V5.05 Databases.

[7] Foster, R. E., Gómez Rocha, L. M., Gupta, V. P., Sánchez-Juárez, A., Cruz, J. O., & Rosas, J. C. (2006). Field testing of CdTe PV modules in Mexico. In Proceedings of the 35th American Solar Energy Society Annual Solar Conference.

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