OUTDOOR PERFORMANCE EVALUATION OF FIVE PHOTOVOLTAIC MODULES AT SIRTA

Author: Naveen Fatima – Laboratoire de Météorologie Dynamique (naveen.fatima@polytechnique.edu)
Contributors: Jordi Badosa (LMD), Anne Migan (GEEPS), Vincent Bourdin (LIMSI)

OBJECTIVES

The objective of this research is to evaluate the performance of five photovoltaic module technologies installed at SIRTA: tandem structure with amorphous and microcrystalline silicon layers (a-SI/µ-Si), monocrystalline silicon (c-Si), heterojunction with intrinsic thin layer (HIT), thin film chalcogenide semiconductor (CIS) and thin film cadmium telluride semiconductor (CdTe). These technologies will be compared on the basis of:

- Module Efficiency
- Module Performance Ratio
- Effect of temperature, Irradiance and Angle of Incidence on the performance

METHODOLOGY

The specifications of the five PV modules at STC (1000 W/m^2, AM1.5 and 25° C) are shown in Table 1. Using I-V curves, modules temperature and irradiance, we derive efficiency and module performance ratio using these equations:

$$\eta_{monthly} = \frac{P_{max}}{POA \times size} \times 100; \quad MPR = \frac{Array\ yield, Y_A}{Reference\ yield, Y_R} = \frac{\sum \overline{P_{max,h}} / P_{max,STC}}{\sum \overline{POA}_h / POA_{STC}}$$

Monthly efficiencies and MPR of all the modules are calculated for 2018 and effect of different parameters on MPR is studied.

	SHARP Serie NA-F128GK	France Watts FL60-250MBP	Solar Frontier SF150L	Panasonic N240	First Solar FS Series 3
Technology	α-Si/µ-Si	c-Si	CIS	HIT	CdTe
Maximum Power	128 W	250 W	130 W	240 W	82.5 W
Short-circuit current	3.45 A	8.21 A	2.10 A	5.85 A	1.94 A
Open-circuit voltage	59.8 V	30.52 V	106.0 V	52.4 V	60.8 V
Efficiency	9 %	15 %	12.2 %	19 %	11.4 %

Table 1: Specifications of five module technologies installed at SIRTA

Figure 1: SIRTA test bench platform

RESULTS

- The MPR values range from 80 to 102%.
- Higher MPR in winters, lower in summer
- a-Si/µ-Si has the highest MPR throughout the year and shows constant performance.
- c-Si and HIT perform the best in winter but the performance degrades in summer

Technology	Min	Max	Avg	Datasheet
a-Si/u-Si	7.9%	8.7%	8.3%	9%
c-Si	12.2%	15.4%	13.8%	15%
CIS	10.4%	11.8%	11.1%	12%
HIT	16.1%	18.7%	17.5%	19%
CdTe	9.4%	11.3%	10.2%	11%

Table 2: Comparison of calculated efficiencies with datasheet values

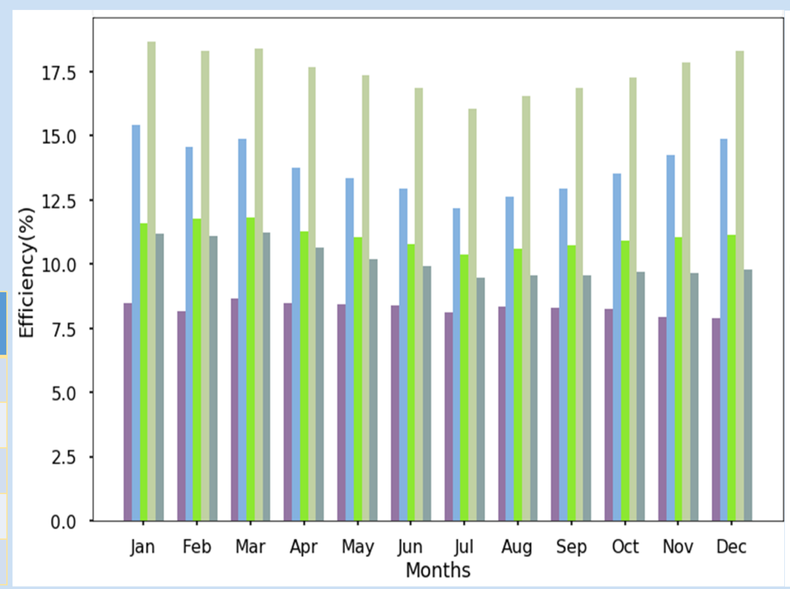

Figure 2: Monthly Efficiencies of the five modules

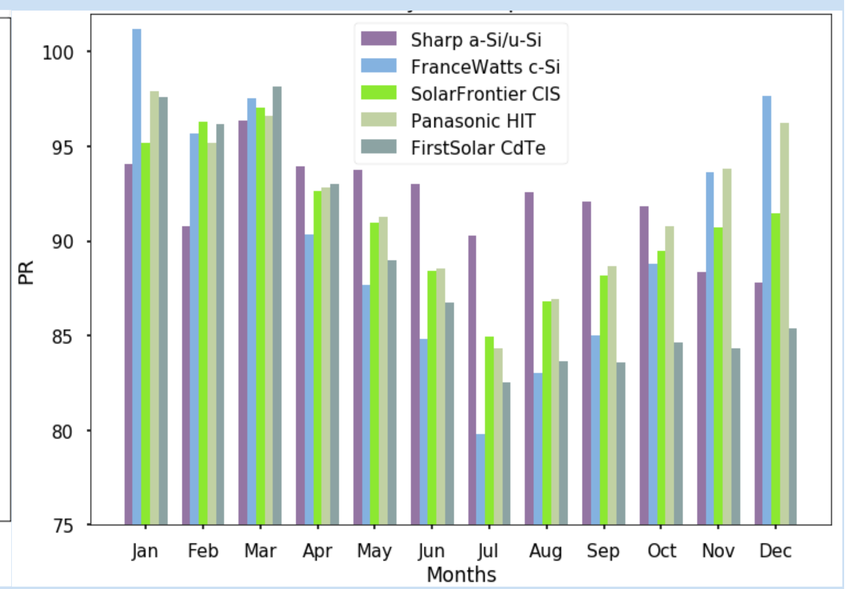

Figure 3: Monthly Module Performance Ratios of the five modules

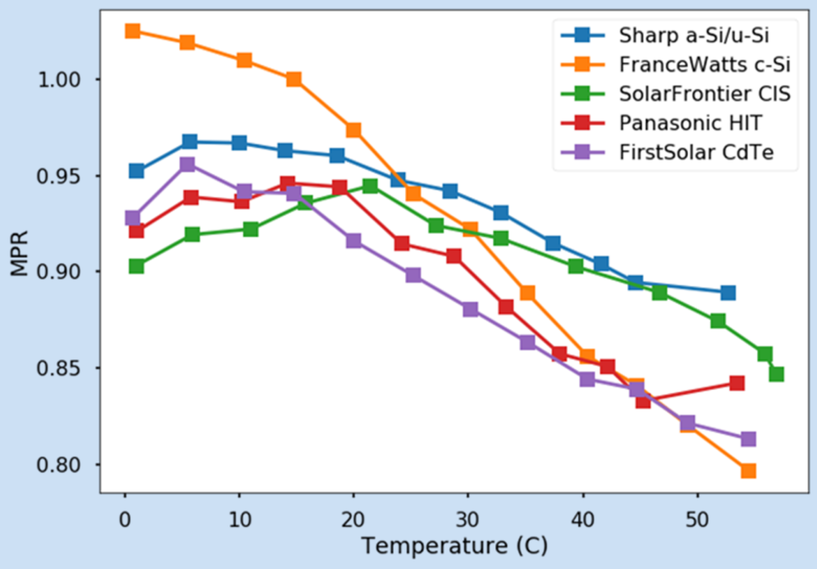

Figure 4: MPR v/s Module Temperature

c-Si performs best at lower temperatures but performance degrades sharply at high temperatures. a-Si/µ-Si shows the least performance degradation followed by CIS. HIT and CdTe also give low MPR values at higher temperatures.

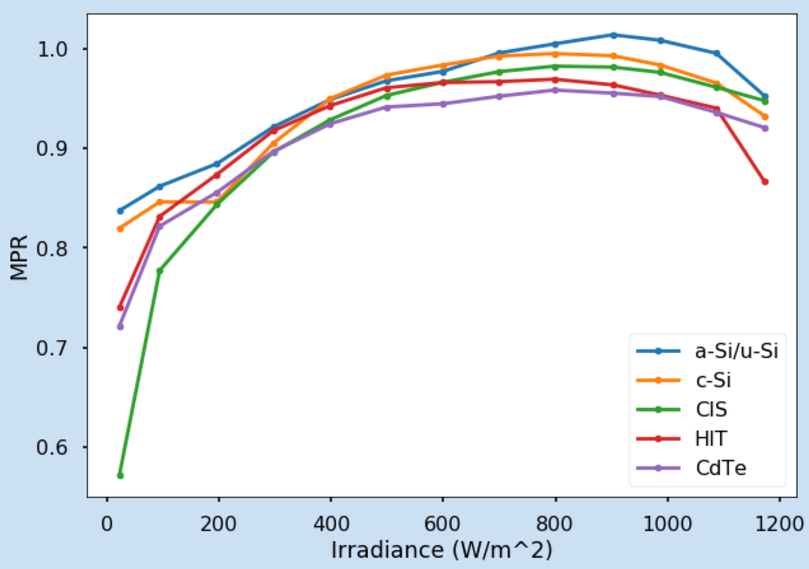

Figure 5: MPR v/s Irradiance

CIS is most affected by low irradiance. a-Si/µ-Si is the least affected by low irradiance and performs best at 1000W/m^2. HIT and CdTe have the lowest MPR at 1000 W/m^2. c-Si gives the best MPR for 400-600 W/m^2.

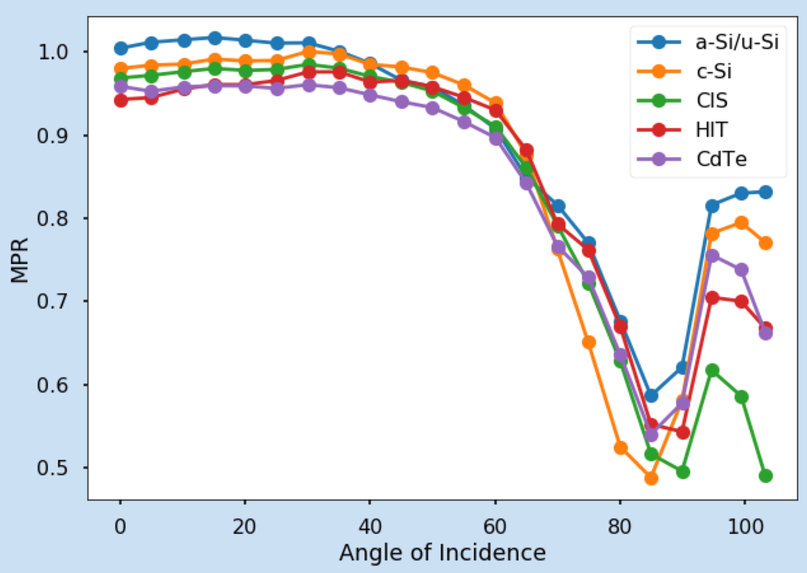

Figure 6: MPR v/s AOI

a-Si/µ-Si performs the best at low AOI. Maximum MPR from 0° to 40° for all the modules. Sharpest decrease for c-Si and CIS for AOI> 60° . a-Si/µ-Si experiences minimum drop in MPR

CONCLUSION

c-Si performs better in winter whereas a-Si/µ-Si performs better in summer . a-Si/µ-Si is most stable in response to higher module temperatures, low irradiance and high AOI. c-Si and HIT, have high efficiencies but performance is strongly affected by the change in conditions. Thin film CdTe and CIS show moderate effect of changing parameters.

REMERCIEMENTS

This work was conducted in the frame of the TREND-X research program of Ecole Polytechnique, supported by Fondation de l'Ecole Polytechnique.