Comparison of Thin Film modules and crystalline modules

EE 770 [Course Project]

Under the guidance of
Prof. Narendra Shiradkar

Shashidhar G - 193079010
Sethu Nandan O G - 193079011

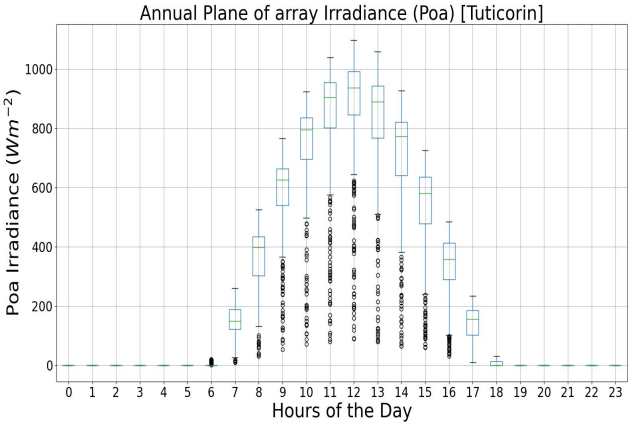
Introduction

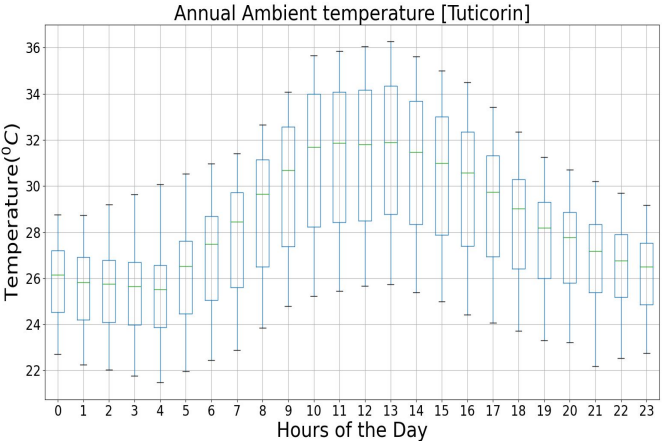
- The aim of the study is to draw the comparison between Thin film modules and Crystalline modules.
- The performance of the above modules is compared for different sizes of the plant at different locations in India.
- The locations under consideration are Tuticorin(coastal), Jaisalmer (Desert) and Leh (Cold climate) throughout a year
- The panels used are of 80 Watts peak power rating and shown below

Module	Type	V_{mp} (V)	I_{mp} (A)	V_{oc} (V)	I_{sc} (A)	Max. System Voltage	Temp. Coeff of Power
BP solar BP980	Thin Film	32.3	2.48	45.2	3.0	1000	-0.36 % / ℃
BP solar BP380J	Multi Crystalline	17.6	4.5	22.1	4.8	1000	-0.5 % / ℃

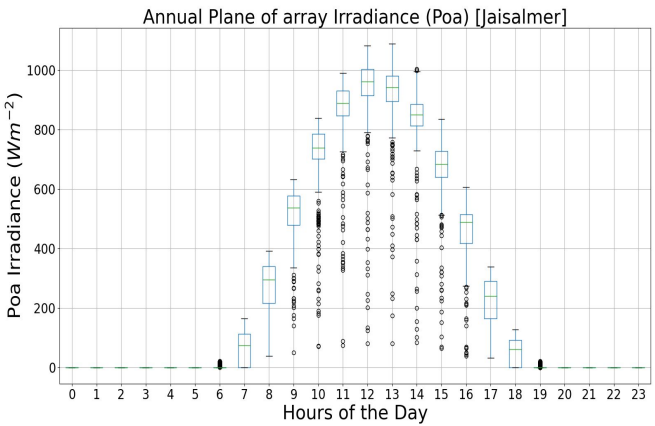
Climatic conditions of different locations

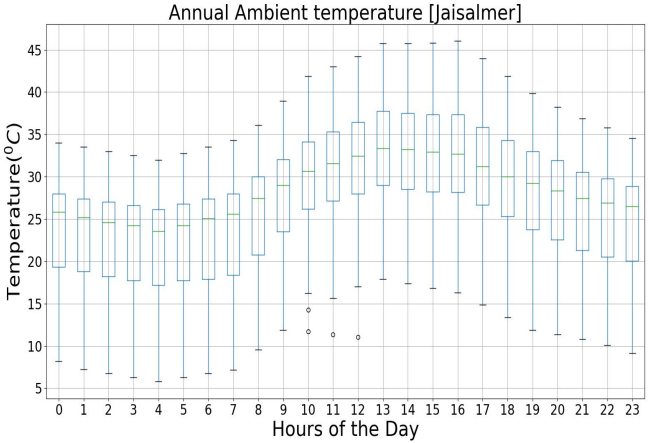
Tuticorin



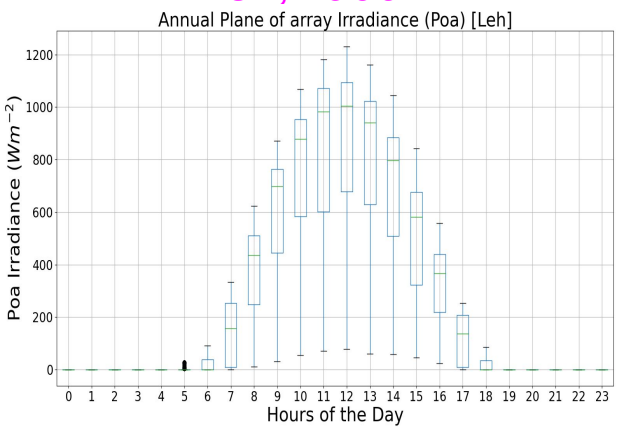


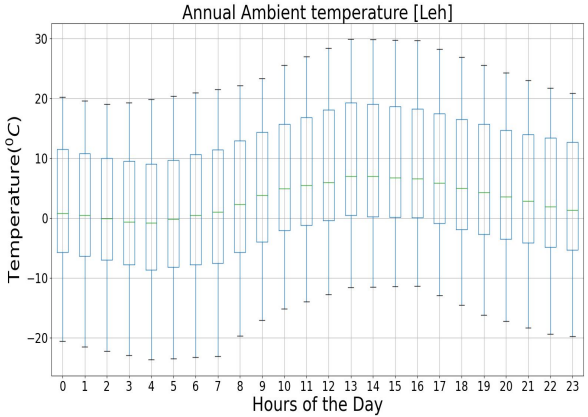
Jaisalmer





Leh, Ladakh





Procedure for calculating power

The steps involved in deriving power using the data from the TMY file are enlisted below

- The solar position is calculated with reference to the specific location for the times of the year.
- Using, the values of Tilt angle , Azimuth angle of the panel , solar position and irradiance data from the TMY file, the Plane of Array irradiance is derived.
- The effective irradiance that is converted to electrical power is calculated considering spectral loss, etc.,
- The module temperature is calculated considering the type of mounting and the global POA.
- From, effective irradiance and module temperature, various DC parameters of the module such as Voc, Isc, Peak power etc are calculated.

Case i) PV plant of size = 96 kW

- We would consider installing a PV farm of size = 96 kW and compare their performance at the before mentioned three locations.
- The PV plant is mounted on the ground using open rack mounting arrangement
- The temperature model parameters for open rack are :

Module	a	b
Thin Film	-3.47	-0.0594
Crystalline	-3.56	-0.075

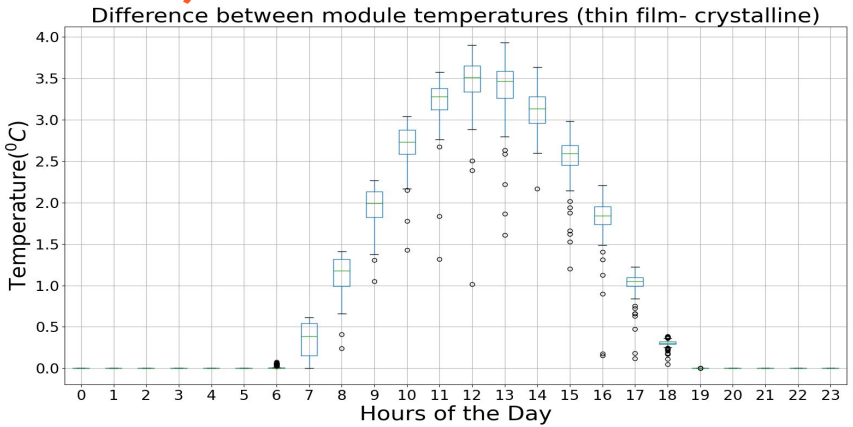
$$Tm = E \times e^{(a + b \times Ws)} + Ta$$

- The Max. panel voltage limit is taken care while connecting the 1200 panels
- For Thin Film panel, Modules per string = 10 and Number of Strings = 120
- For crystalline panel, Modules per string = 20 and Number of Strings =60

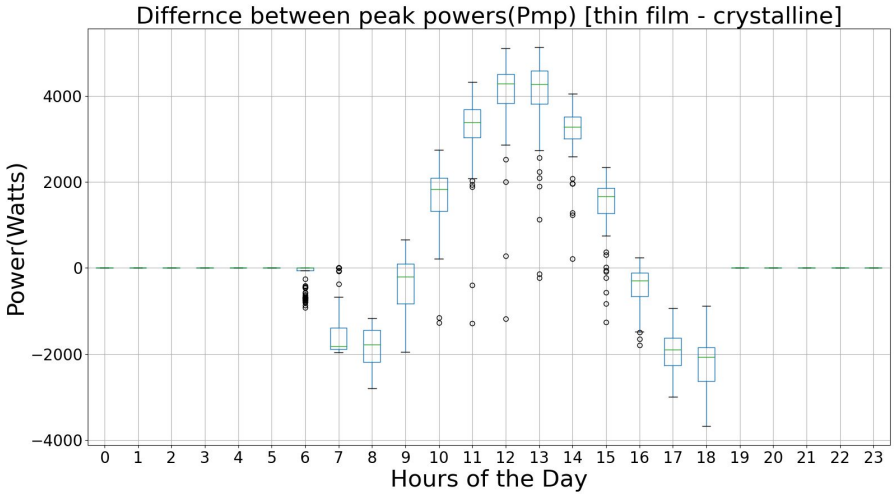
Performance of modules at different times and locations: Open rack

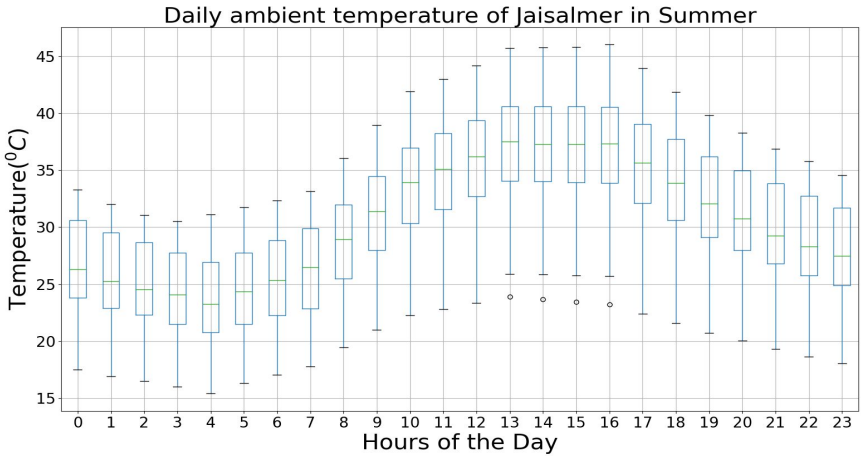
Location	Energy production in kWh					
	Module	Summer (March - may)	Winter (Dec - Feb)	Spring (June - Sep)	Monsoon (Oct - Nov)	Total
Tuticorin	Thin Film	50950 (553)	47380 (526)	61584 (504)	26176 (429)	186092
	Crystalline	50483 (548)	47869 (531)	61564 (504)	26441 (433)	186358
Jaisalmer	Thin Film	54076 (587)	48583 (539)	62395 (511)	33860 (555)	198915
	Crystalline	53234 (578)	49381 (548)	62225 (510)	33813 (554)	198654
Leh	Thin Film	48394 (526)	43228 (480)	66302 (543)	39010 (639)	196936
	Crystalline	49555 (538)	45064 (500)	66158 (542)	39383 (645)	200161

Performance variation of modules under high temperature(Jaisalmer - summer)

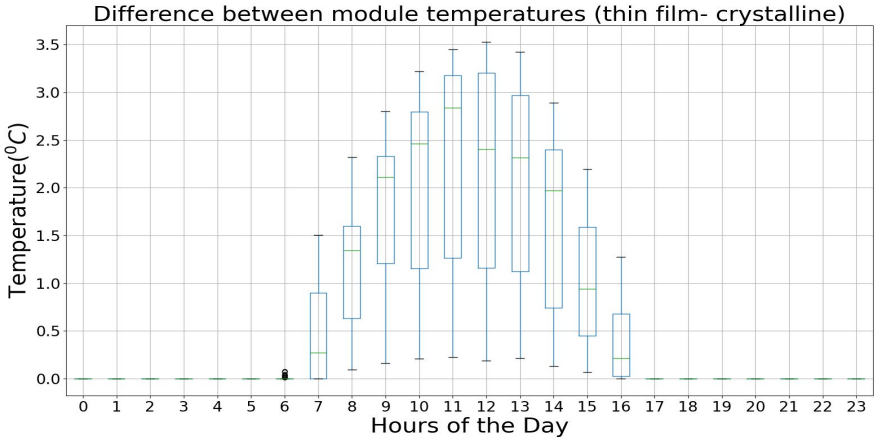


Thin film	Crystalline	At peak power of day
61	58	Temp. median (℃)
83	78	Peak power median (kW)

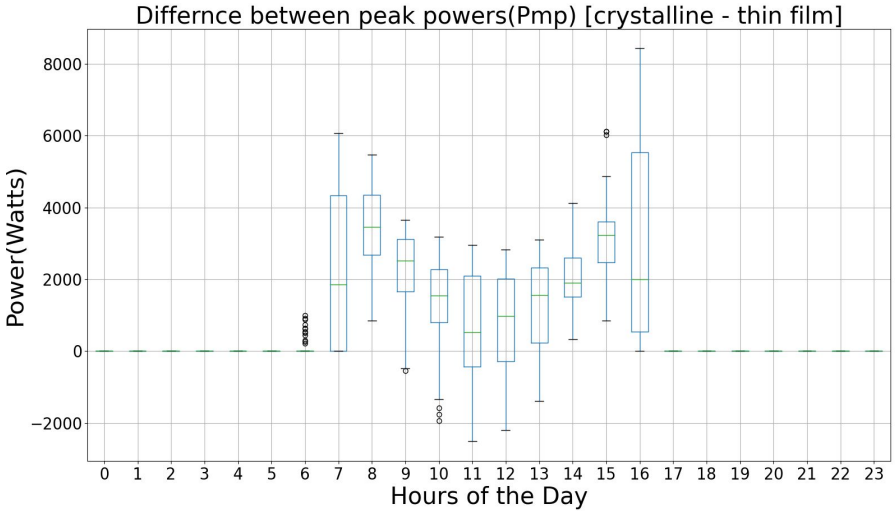


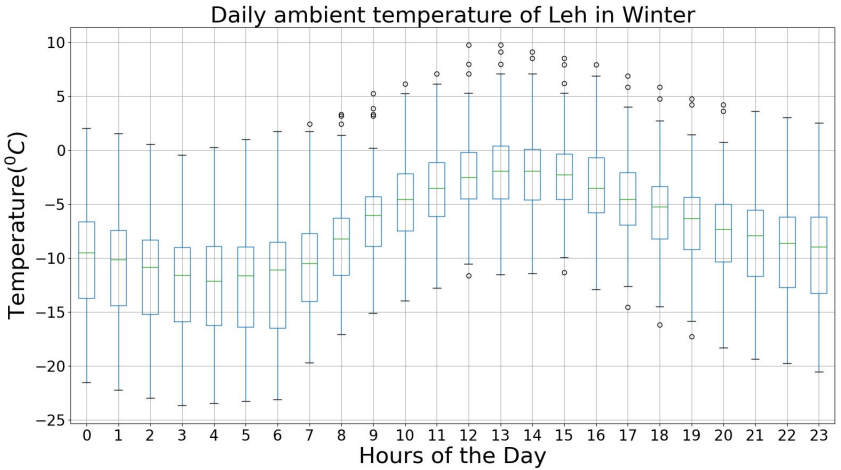


Performance variation of modules under low temperature(Leh - winter)



Thin film	Crystalline	At peak power of day
22	20	Temp. median (℃)
93	96	Peak power median (kW)





Observations: Case i

- For same annual energy production kWh, let us try reducing the installation capacity of a technology that performs better at that location

Leh		
	No. of panels	Energy (kWh)
Thin Film	1200	196936
Crystalline	1180	196928

Jaisalmer		
	No. of panels	Energy (kWh)
Thin Film	1199	198750
Crystalline	1200	198654

- For, same energy production at Leh, we can install 94.4 kW plant instead of 96 kW plant and this is feasible because we can reduce a string. (20 x 59 panels)
- Whereas, at Jaisalmer, even though we get same energy by reducing a panel, but it may not give a significant trade off.
- Power produced at Leh, may sometimes exceed its rated power (STC power).

Case ii) PV plant of size = 10.24 kW

- In this case a PV installation of size = 10.24 kW and compare their performance at the before mentioned three locations.
- The PV plant is mounted on the ground using close roof mounting arrangement
- The temperature model parameters for close roof are :

$$Tm = E \times e^{(a + b \times Ws)} + Ta$$

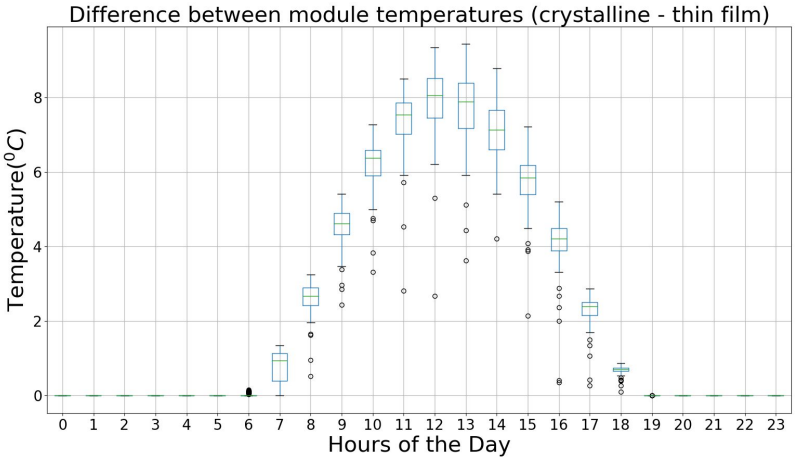
Module	a	b
Thin Film	-2.98	-0.0471
Crystalline	-2.81	-0.0455

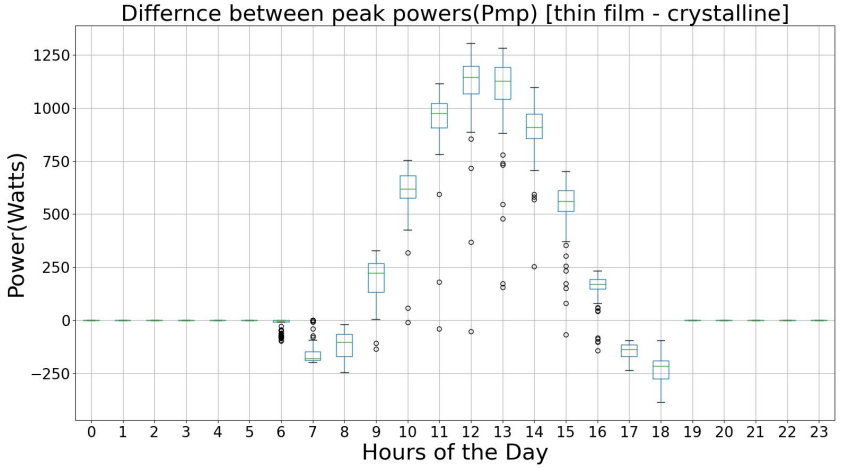
- The Max. panel voltage limit is taken care while connecting the 128 panels
- For Thin Film panel, Modules per string = 8 and Number of Strings = 16
- For crystalline panel, Modules per string = 16 and Number of Strings = 8

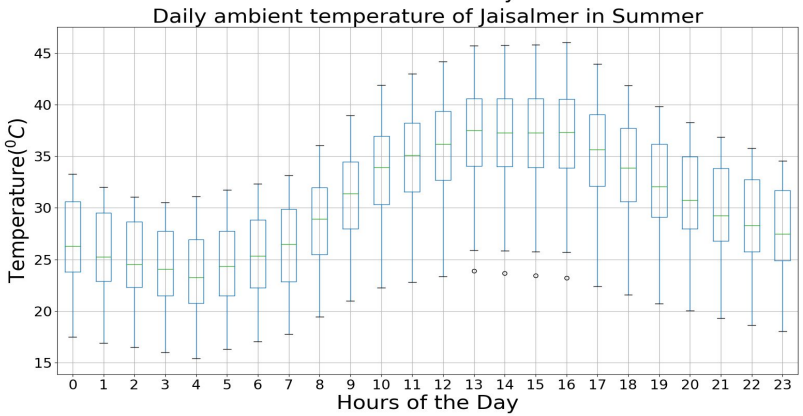
Performance of modules at different times and locations: Closed roof

Location	Energy production in kWh					
	Module	Summer (Mar-May)	Winter (Dec-Feb)	Spring (Jun-Sep)	Monsoon (Oct-Nov)	Total
Tuticorin	Thin Film	5180.17 (56.30)	4846.21 (53.84)	6312.63 (51.73)	2673.81 (43.83)	19012.23
	Crystalline	4811.23 (52.29)	4625.46 (51.39)	5976.46 (48.98)	2552.98 (41.85)	17966.14
Jaisalmer	Thin Film	5478.20 (59.54)	4930.91 (54.78)	6373.60 (52.24)	3427.86 (56.19)	20210.59
	Crystalline	5031.16 (54.68)	4694.70 (52.16)	6001.10 (49.18)	3193.59 (52.35)	18920.56
Leh	Thin Film	4909.86 (53.36)	4383.35 (48.70)	6700.23 (54.91)	3918.73 (64.24.19)	19912.18
	Crystalline	4745.9 (51.58)	4300.29 (47.78)	6273.93 (51.42)	3671.69 (60.19)	18991.84

Performance variation of modules under high temperature(Jaisalmer - summer) for case ii

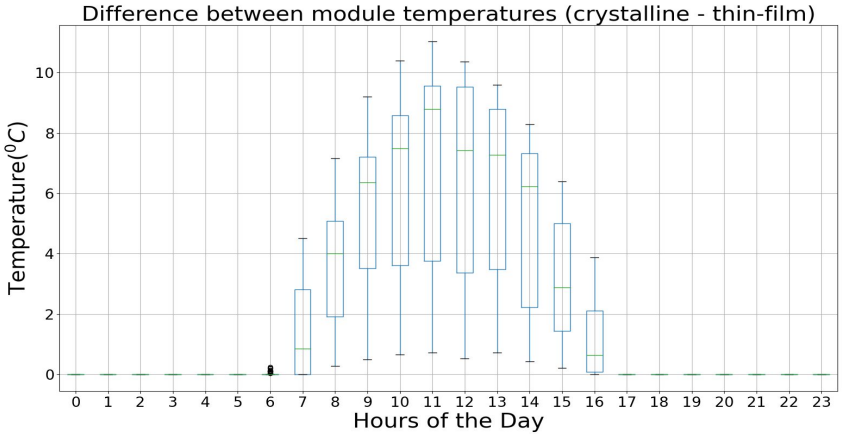


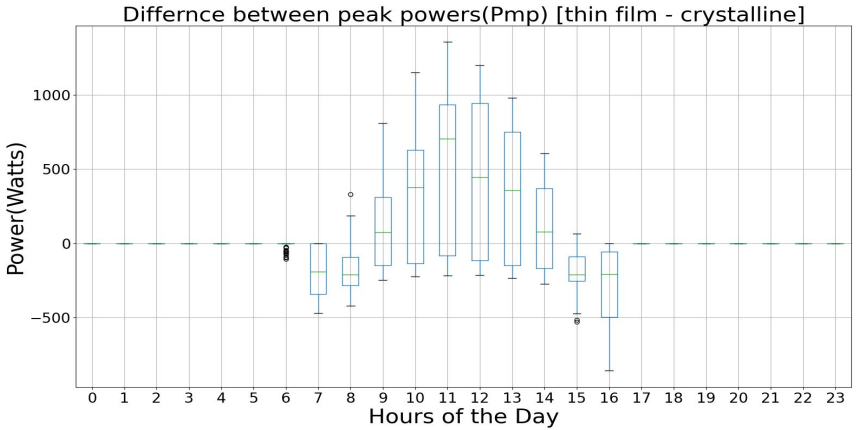


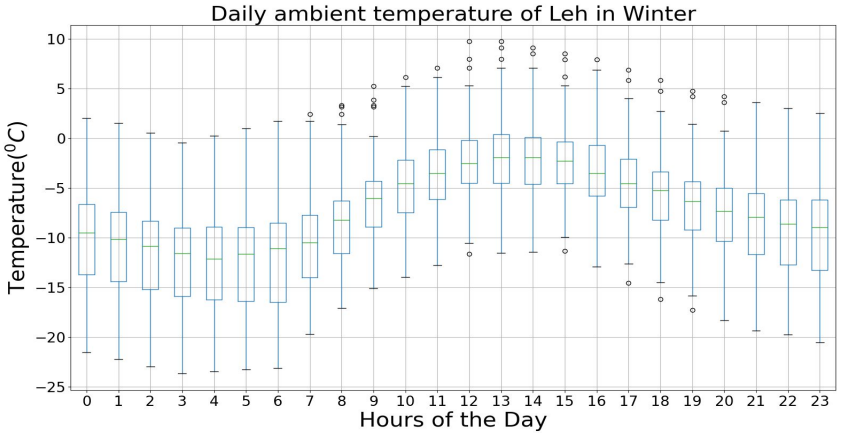


At peak power of day	Thin film	Crystalline
Temp. median (℃)	79	86
Peak power median (kW)	8.2	7.2

Performance variation of modules under low temperature(Leh - winter) for case ii







At peak power of day	Thin film	Crystalline
Temp. median (°C)	41	46
Peak power median (kW)	9.6	8.4

Observations: Case ii

- For same annual energy production kWh, let us try reducing the installation capacity of a technology that performs better at that location

Leh		
	No. of panels	Energy (kWh)
Thin Film	122	18978.80
Crystalline	128	18991.84

Jaisalmer		
	No. of panels	Energy (kWh)
Thin Film	120	18947.42
Crystalline	128	18920.56

- For, same energy production at Leh, we can install 9.76 kW plant instead of 10.24 kW plant and it is feasible to reconfigure the system for less panels.
- Whereas, at Jaisalmer, we can install 9.6 kW plant instead of 10.24 kW plant and this reduces an entire string for same power output.

Conclusion

- In large size installations with open-mount, Crystalline modules out perform Thin film modules in the aggregate power generated over a year for cold climates like Leh.
- However, in hot climate zone, during hotter seasons of the year thin film produces more power than the Crystalline.
- In small size installations with closed roof mount, Thin film modules out perform Crystalline modules in the aggregate power generated over a year.
- Even in cold climate zone, during colder seasons of the year thin film produces more power than the Crystalline which owes to the close roof mount because of which crystalline panel is always at higher temperature.

Thank You