Comparison of TPT and Thermally Conductive Backsheets in PV Modules

Ashwini Pavgi[1], Jaewon Oh[1,*], George Kelly[2], Govindasamy Tamizhmani[1]

[1]Arizona State University Photovoltaic Reliability Laboratory (ASU-PRL), Mesa, Arizona, USA [2]Sunset Technology, Mount Airy, MD 21771, USA

Introduction

- Module temperature plays the second largest role, next to irradiance, in dictating the performance of photovoltaic (PV) modules
- The thermal conducting property of PV module backsheet can have a large impact on the module operating temperatures
- The focus is to compare cell and backsheet temperatures of modules with Tedlar-Polyester-Tedlar (TPT) and four thermally conductive backsheets (TCB) installed at different sites having varied climatic conditions
- In this study, thermal conductivity of backsheets and NOCT of modules with these backsheets (T_{BS}) were also measured to compare TCBs and TPT.

Experimental Setup

Site	AZ-1 site	AZ-2 site	NC site
Weather condition	Hot and dry (low wind speed)	Hot and dry (high wind speed)	Temperate

➢ **Glass/EVA/Cell/EVA/Backsheet Modules** (20.5" x 22" nine-cell modules)
- TPT: Tedlar-PET-Tedlar
- TCB_A: PVDF-PET-EVA
- TCB_B: PA-Aluminum-PET-PA (polyamide)
- TCB_C: encapsulant -PET-ECTFE (fluoropolymer)
- TCB_D: PA- Core layer- E layer (modified polyolefin)

➢ Identical module installation

➢ **Data analysis (seasonal trends)**
- Fall 2018: September 21st- December 20th
- Winter 2019: December 21st- March 20th

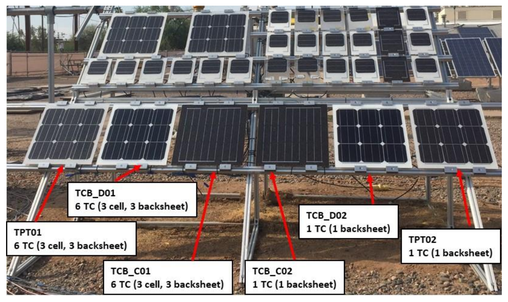

Fig. 1(a) 8 nine-cell modules installed at AZ-1 site

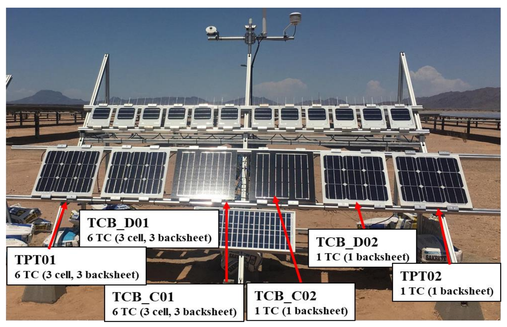

Fig. 1(b) 6 nine-cell modules installed at AZ-2 site

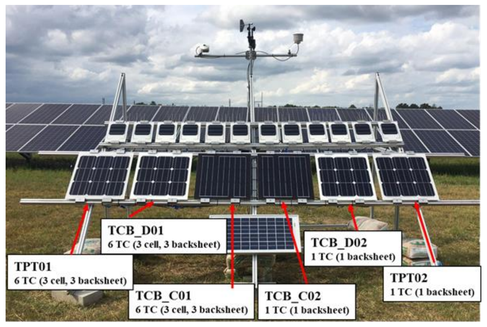

Fig. 1(c) 6 nine-cell modules installed at NC site

Results and Discussion

1. Thermal conductivity of backsheets

- All TCBs clearly have higher axial thermal conductivity values as compared to TPT as measured by a thermal-conductivity meter

Back sheet manufacturer	Axial Thermal Conductivity (W/m·K)	Radial Thermal Conductivity (W/m·K)
TPT	0.153	0.486
TCB_A	0.259	0.371
TCB_B	0.382	13.53
TCB_C	0.256	0.387
TCB_D	0.238	0.343

Table 1: Thermal conductivity values measured at 24 °C

2. Nominal Operating Cell Temperatures (NOCT)

- NOCT represents cell temperature under 800 W/m^2 irradiance, 20 °C ambient temperature, and 1 m/s wind speed.
- Individual NOCT determined by taking average of NOCT measured on three clear sunny days
- The NOCT of TCB_A is about 2 °C lower than TPT

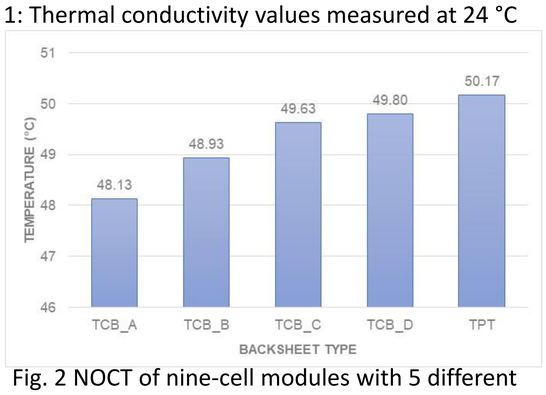

Fig. 2 NOCT of nine-cell modules with 5 different backsheets (1 TPT and 4 TCBs)

3. Backsheet and Cell Temperatures: Seasonal Trends

3.1 Comparison between 2 TCBs and TPT at different sites

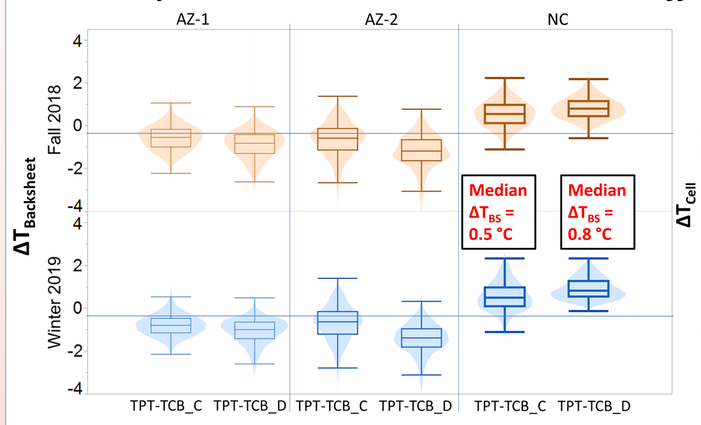

Fig. 3(a) ΔT_{BS} (TPT–TCB_C/TCB_D) seasonal trend at 3 sites

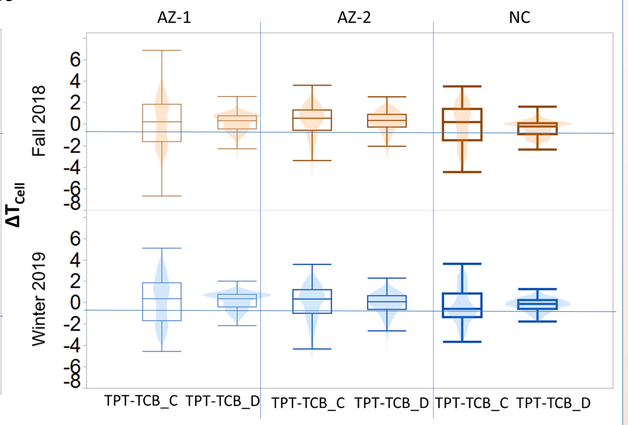

Fig. 3(b) ΔT_{cell} (TPT–TCB_C/TCB_D) seasonal trend at 3 sites

➢ Fall and Winter seasons have same ΔT_{cell} trends with median values about 0.2 °C - 0.5 °C

3.2 Comparison between 4 TCBs and TPT at AZ-1 site

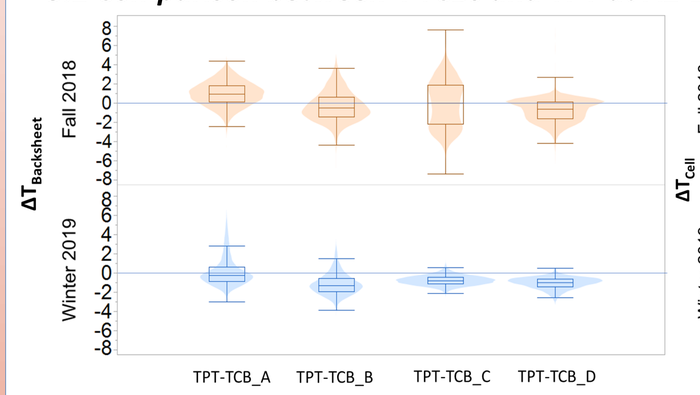

Fig. 4(a) $\Delta T_{backsheet}$ trends between TPT and 4 TCBs at AZ-1 site

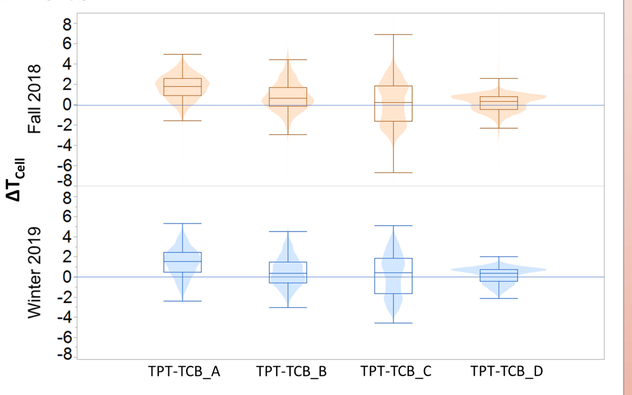

Fig. 4(b) ΔT_{cell} trends between TPT and 4 TCBs at AZ-1 site

➢ ΔT_{BS} values in Fall > ΔT_{BS} values in Winter. But Fall and Winter seasons have same ΔT_{cell} trends.
➢ ΔT_{cell}, the actual cell temperature differences between TPT and all TCBs, are higher than ΔT_{BS} values
➢ Median ΔT_{cell} values between TPT and TCB_A is about 2 °C and highest than with any other TCBs

4. Cell-to-cell differences between TPT and TCBs

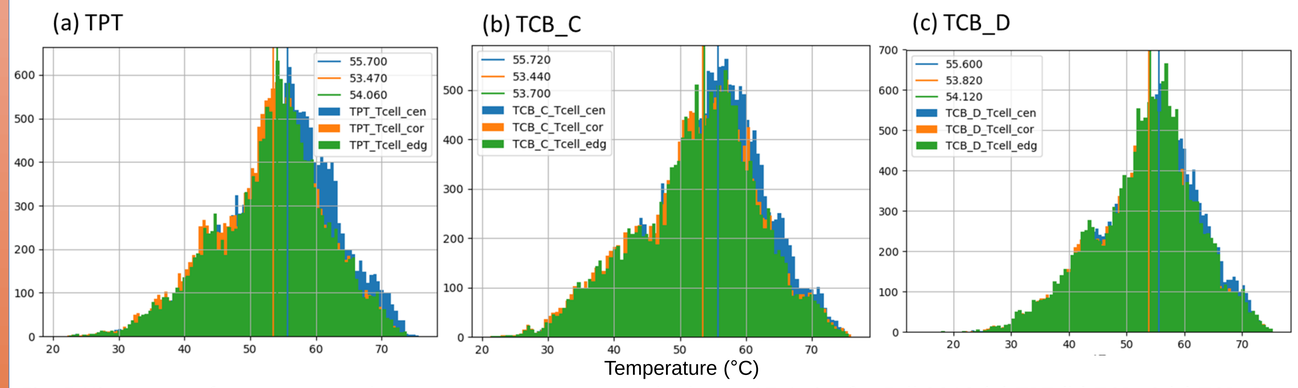

Fig. 5 Histogram of temperatures between center, corner, and edge at AZ-1 site for Fall 2018 (a) TPT (b) TCB_C (c) TCB_D

➢ Center cell operates at about 2 °C higher than edge/corner, temperature differences highest in TPT
➢ TCB-based module maintain more uniform temperature throughout the module compared to TPT

Conclusions

➢ The thermal conductivity measurements clearly showed that TCBs have higher axial TC than TPT
➢ NOCT values of nine-cell modules are lower for TCB than TPT with difference as high as 2 °C in TCB_A
➢ All TCBs (TCB_A, TCB_B, TCB_C and TCB_D) operate at lower cell temperatures than TPT under hot climatic conditions. Since backsheet temperatures are largely and dynamically affected by wind speed, only TCB_A operates at lower temperature as compared to TPT
➢ TCB_C and TCB_D nine-cell modules operate at lower cell temperatures than TPT in temperate climates

* Currently at Department of Sustainable Technology & the Built Environment, Appalachian State University, Boone, NC 28608, USA

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