Clear Tedlar® Backsheets
A game-changer for bifacial panels

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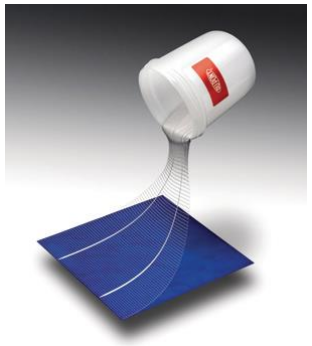
DuPont Photovoltaic Solutions

DUPONT™

DuPont Photovoltaic Materials Portfolio



DUPONT™ Tedlar® Based Backsheets | 30+ YEARS

Field-proven performance

DUPONT™ Solamet® Metallization Pastes | 30+ YEARS

Reliable innovation partner

DUPONT™ Fortasun™ Solar Silicones | 30+ YEARS

Field-proven performance

Over 50% of panels installed in the field since 1975 contain DuPont materials

DUPONT™

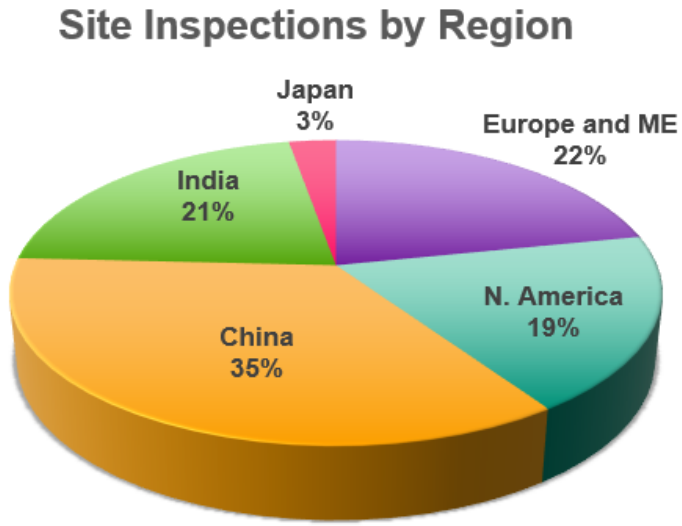
DuPont Global Field Reliability Program

- Quantitative analysis: components, materials, age, failure mode
- Post-inspection analytical characterization
- Collaborative: field partners, developers, government labs, universities
- Improving Accelerated Testing Protocols

9 MM
modules

551
installations

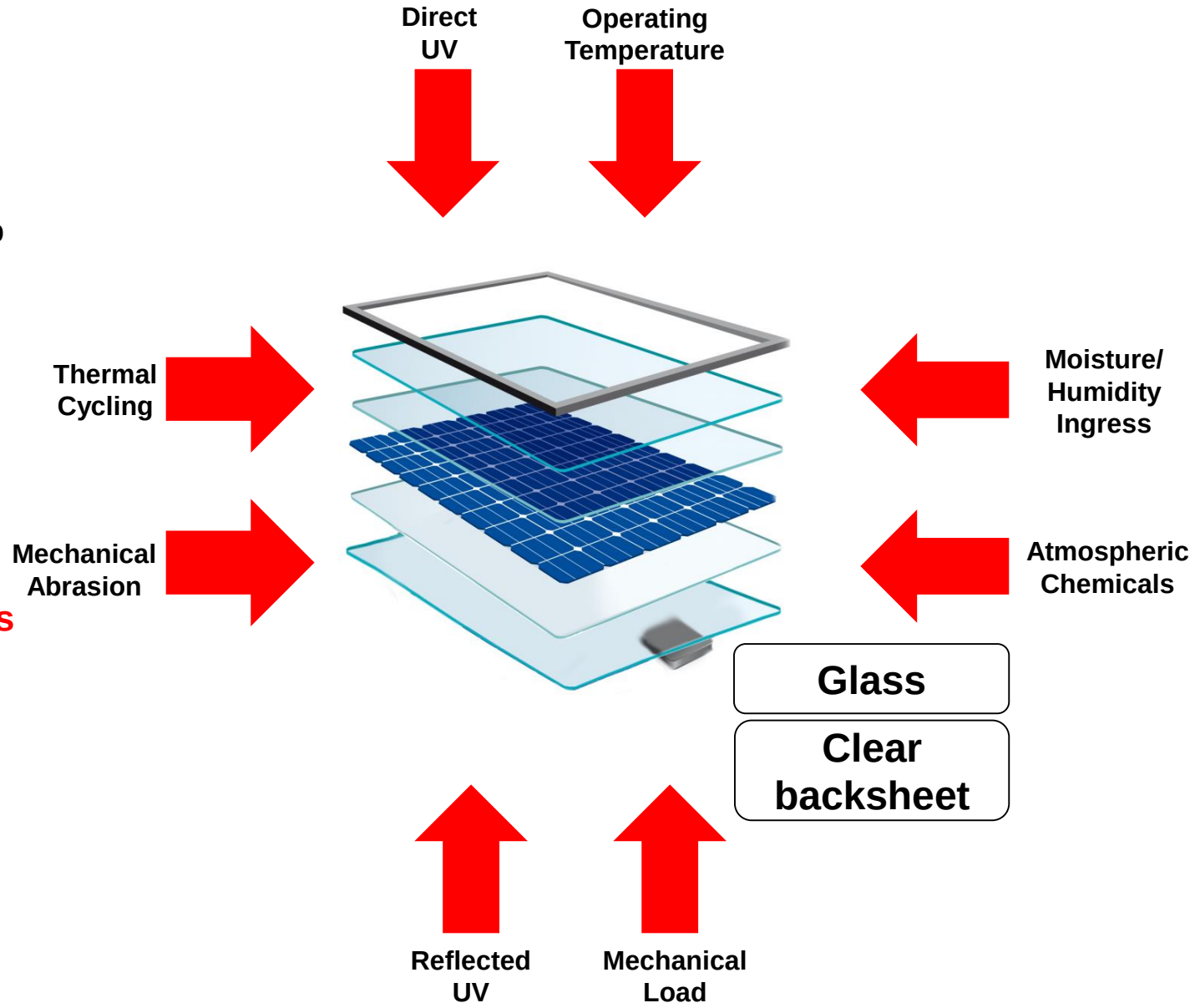
3 GW
modules



Bifacial Panel Reliability

Lifetime expected to exceed 25 years

- Power output can be increased by 10-20%
- Reliability is critical to achieve the lowest LCOE
- High irradiation & albedo environments increase pressure on the panels
- Panel fatigue can lead to degradation over time
  - Loss of electrical protection / safety issues
  - Loss of conversion efficiency / power output degradation
- Glass is a robust material, however…



Dual Glass in the Field: Delamination

Serious corrosion and delamination

Hainan, China,
15-year operation

Delamination and yellowing

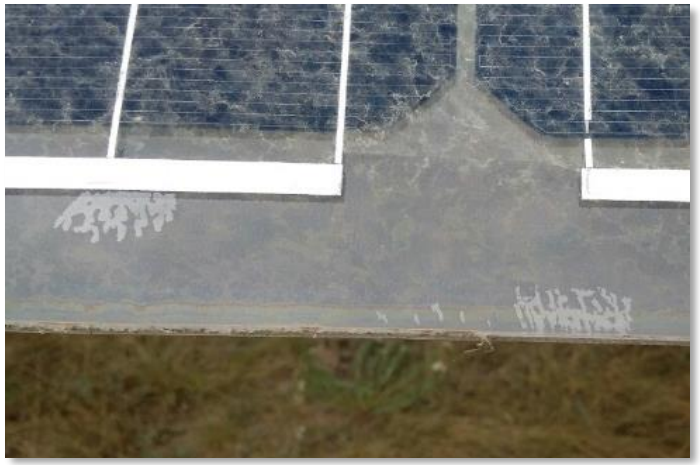
Arizona, US,
10-year operation

Hot spots, rear side delamination

Qinghai, China,
2-year operation

Edge delamination

Datong, China,
Half year operation



Dual Glass in the Field: Deformation & Cracking

West China, 1 year operation

- Installation type: clamping
- 10%~20% of glass shattered
- ~20% glass/glass module bent and deformed

South China, 1 year operation

- Installation type: back rail
- G/G module bending up to 1cm
- 10%-20% glass/glass modules affected

Clear Tedlar® Backsheets

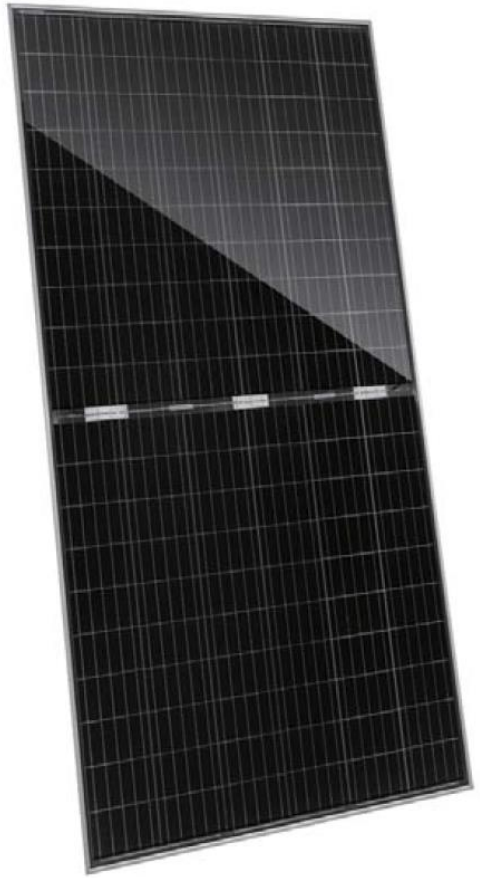
Benefits

- Conventional module technology, field-proven
- Compatible with incumbent production processes
- Breathable film to help eliminate moisture, acetic acid
- Improved heat dissipation, IR transparency, lower NOCT
- Absorbs UV, protects encapsulant & PV cells (LID)
- Na+ free, lower risk of PID on the rear side
- Conventional framed panels, mechanical stiffness and handling
- Lower risk of breakage during transportation and installation
- Ease of rear side cleaning
- Lighterweight

Clear Tedlar® PVF film

Clear Tedlar®: Lighterweight Panels

Market Trend: Larger cells (M2, M4, M6,..), larger panel size, lower BoS cost



Current

400W module — 450W module — 500W module

Structure / Size		2 sqm	2.3 sqm	2.4 sqm
Clear Tedlar®	3.2mm	21.8	25.0	26.1
Dual Glass	2.0mm	+4.2	+4.8	+5.0
Dual Glass(*)	2.5mm	+7.0	+8.1	+8.4

(*) Frameless

Surface normalized panel weight & penalty in kg

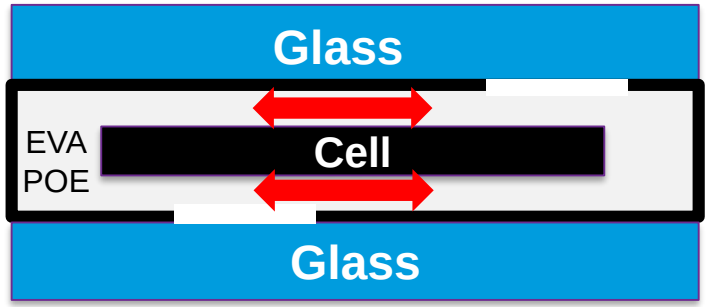
The relative weight advantage increases with the size of the panel

Panel Reliability Improvement

Reducing risks of PV module & cell degradation

Impermeable

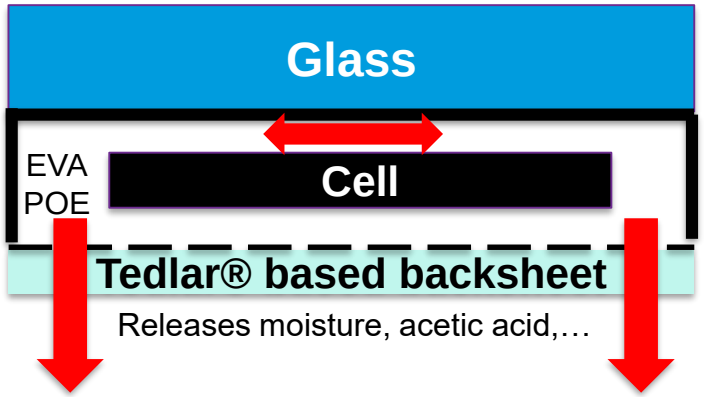
Glass/Glass



- Moisture trapped in dual glass modules causes bubbling and delamination
- Polyolefin (POE) encapsulant with additives will release gases from photo & thermal degradation – increasing risk of delamination
- Acid released from EVA photo-degradation is trapped in module, leading to busbar corrosion and power loss

Breathable

Glass-Clear Tedlar® Backsheet

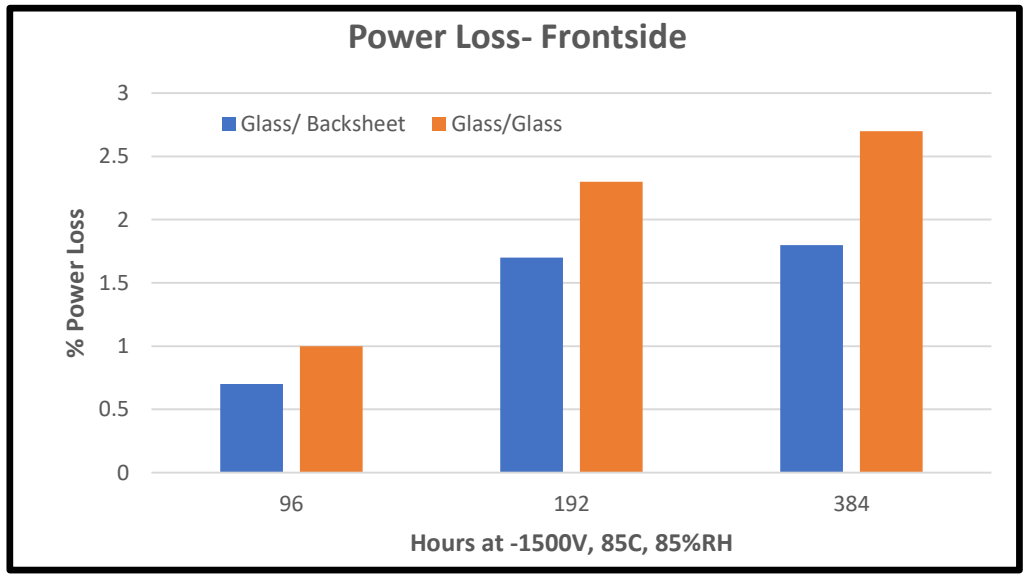


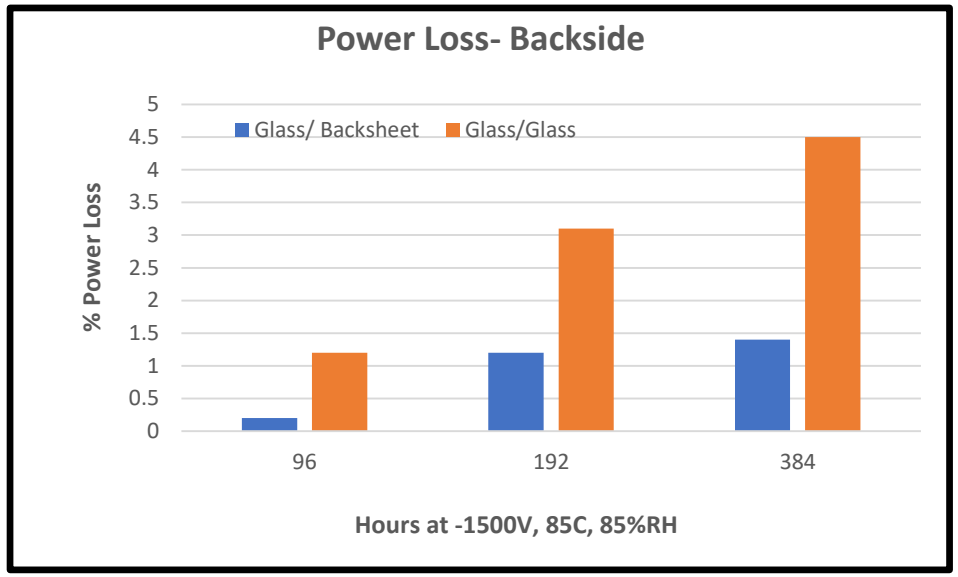
- Clear Tedlar® backsheet is breathable, moisture can be released from module rear side and avoids bubbling and delamination
- With EVA, acetic acid transmission rate of 30mg/m^2/day[1], sufficient to reduce acid concentration in module to prevent corrosion and power loss

[1]GC/MS analysis, 85^{o}C, 10% acetic acid

Lower Risk of PID

- Bifacial p-PERC cells are designed with a weaker back surface passivation layer
- Na+ sodium ion can migrate from rear glass, affecting field passivation effect and even inducing corrosion
- Clear Tedlar® backsheet does not contain Na+, reducing risks of rear side PID



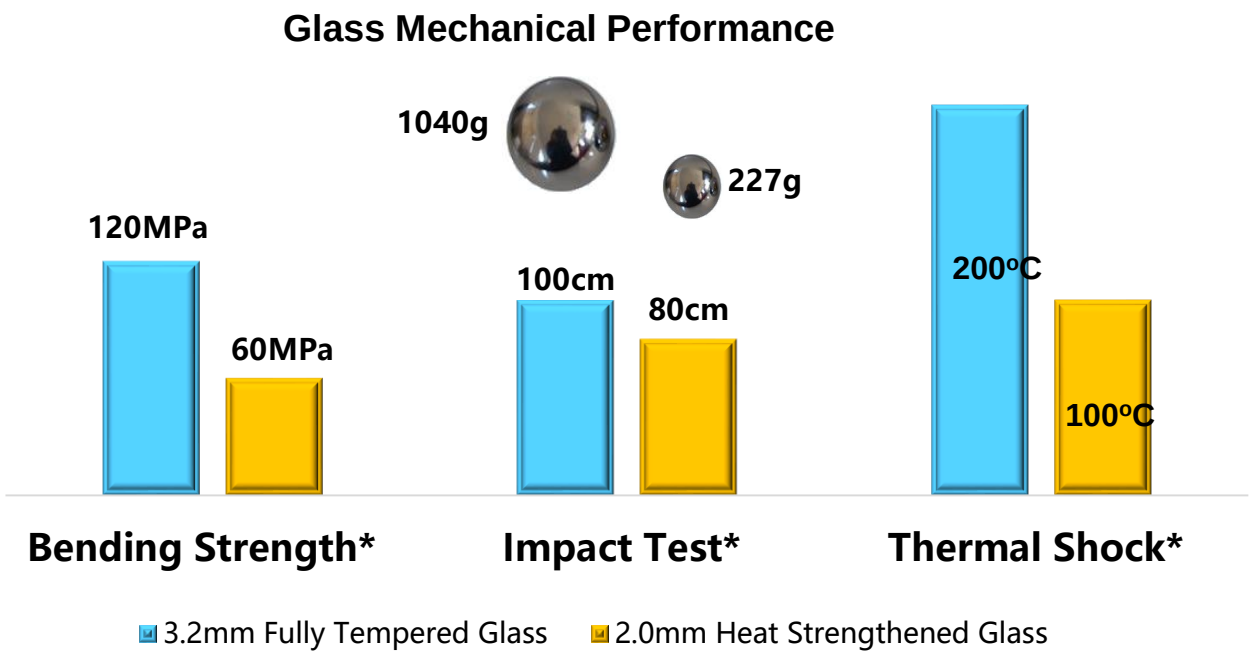


* Comparison of Glass/Backsheet and Glass/Glass 60-cell bifacial modules, with identical POE encapsulant and bifacial p-PERC cells. 1500V, 85ºC, 85%RH

- **Lower PID risk in glass/backsheet** with notable difference on rear side of bifacial modules
- Use of **polyolefin encapsulant does not prevent PID** in glass/glass modules

Lower Risk of Glass Cracking

Thicker tempered glass used in a conventional glass/backsheet panel has a high surface compression compared to the thinner strengthened glass used in glass/glass panels.

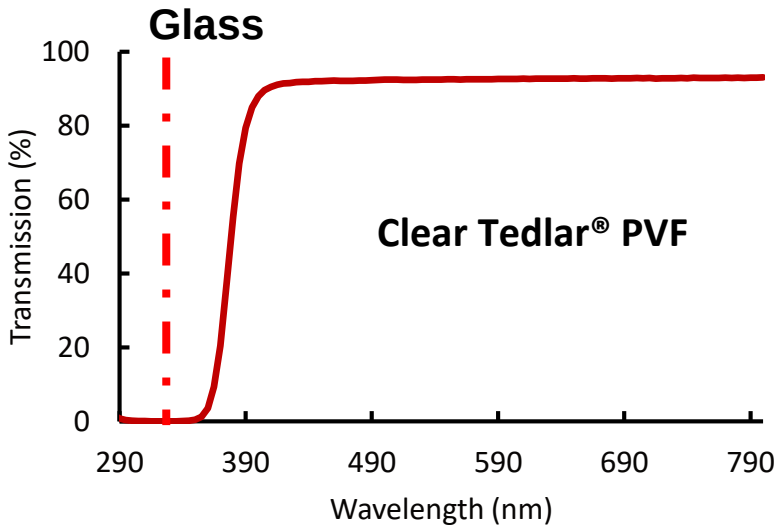


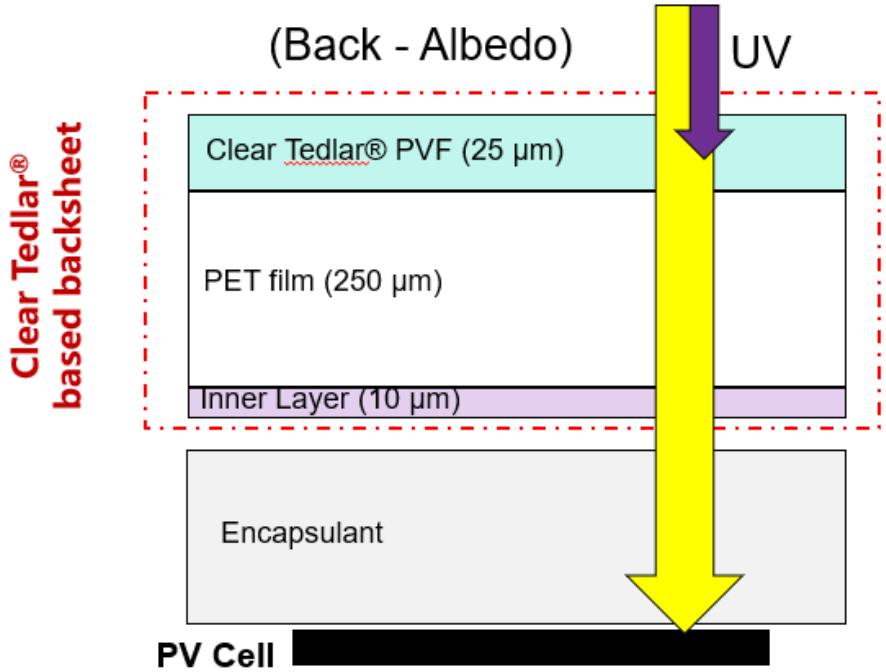
Improved UV Protection

High transparency and protection against UV on rear panel side

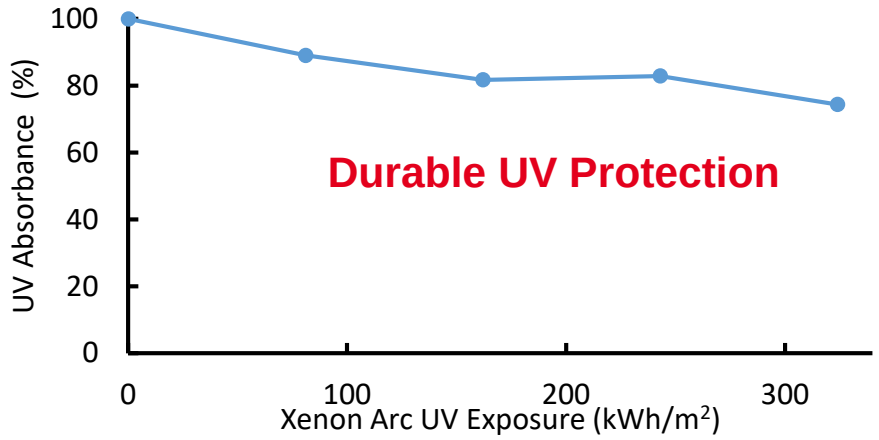
Clear Tedlar® PVF film offers superior protection to:

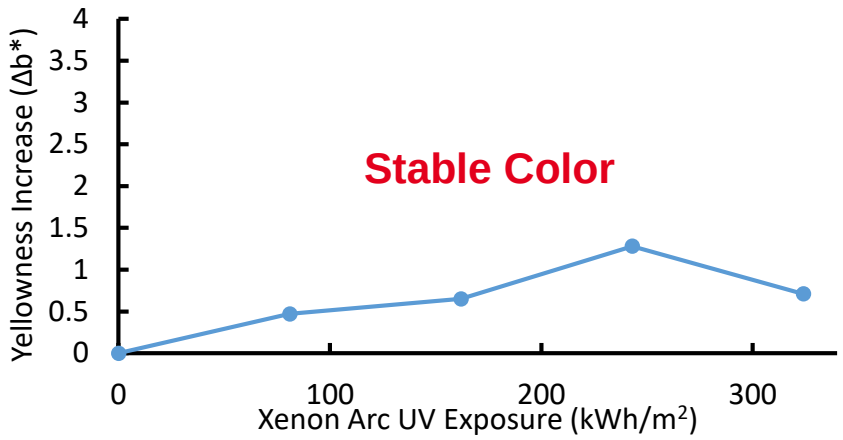
1. The core backsheet layers
2. The encapsulant
3. The PV cell rear side passivation layer
   - reducing risk of LID

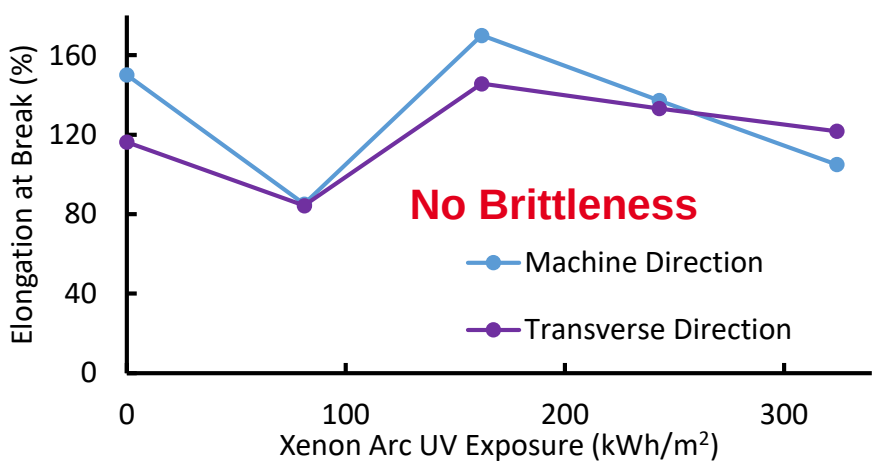


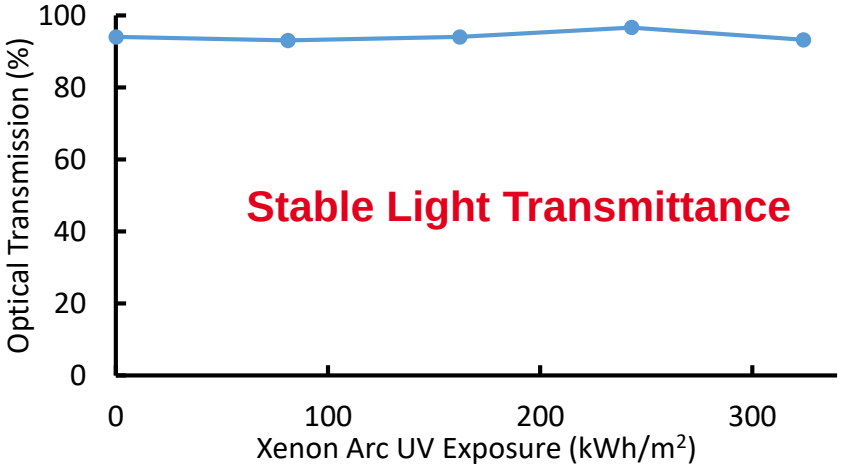


Stable UV Performance



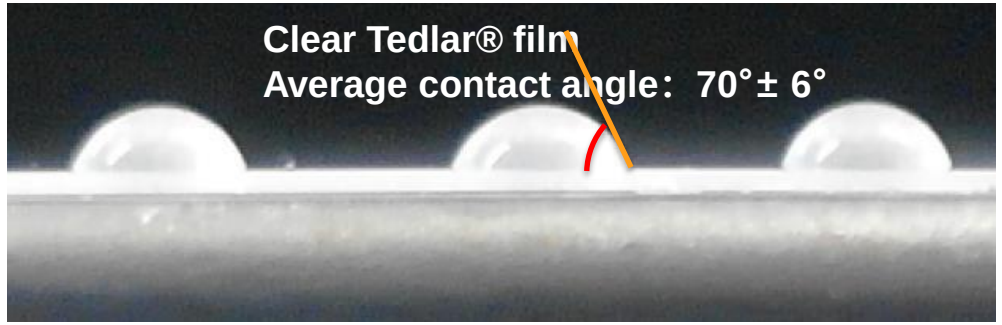


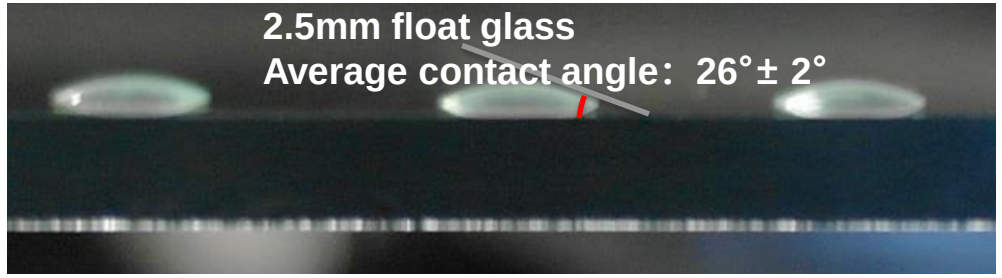


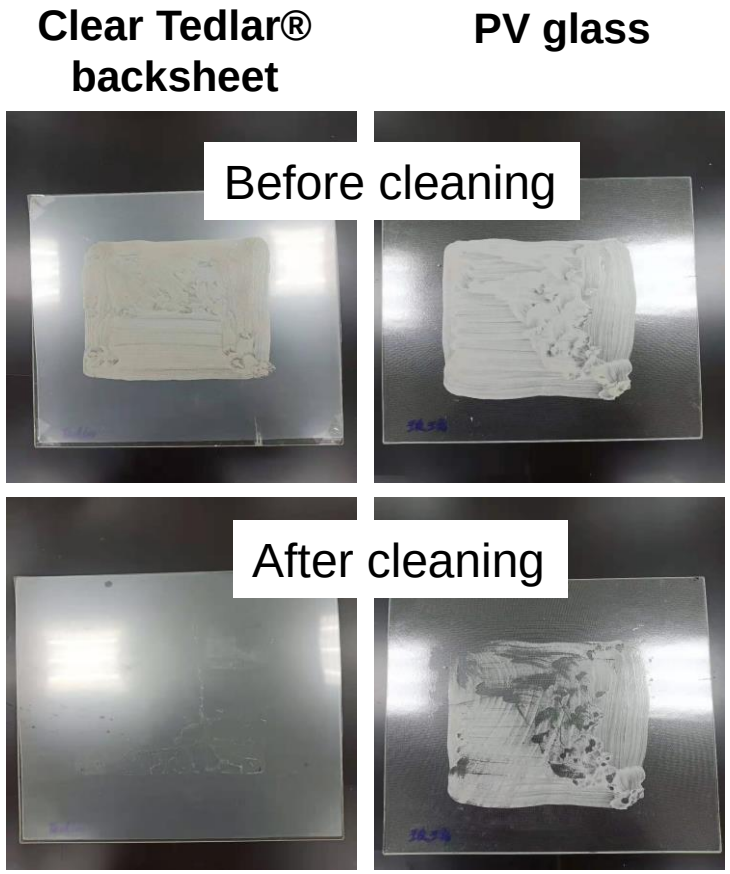


Clear Tedlar® PVF film maintains stable optical and mechanical properties after long-term UV aging

Easy Cleaning



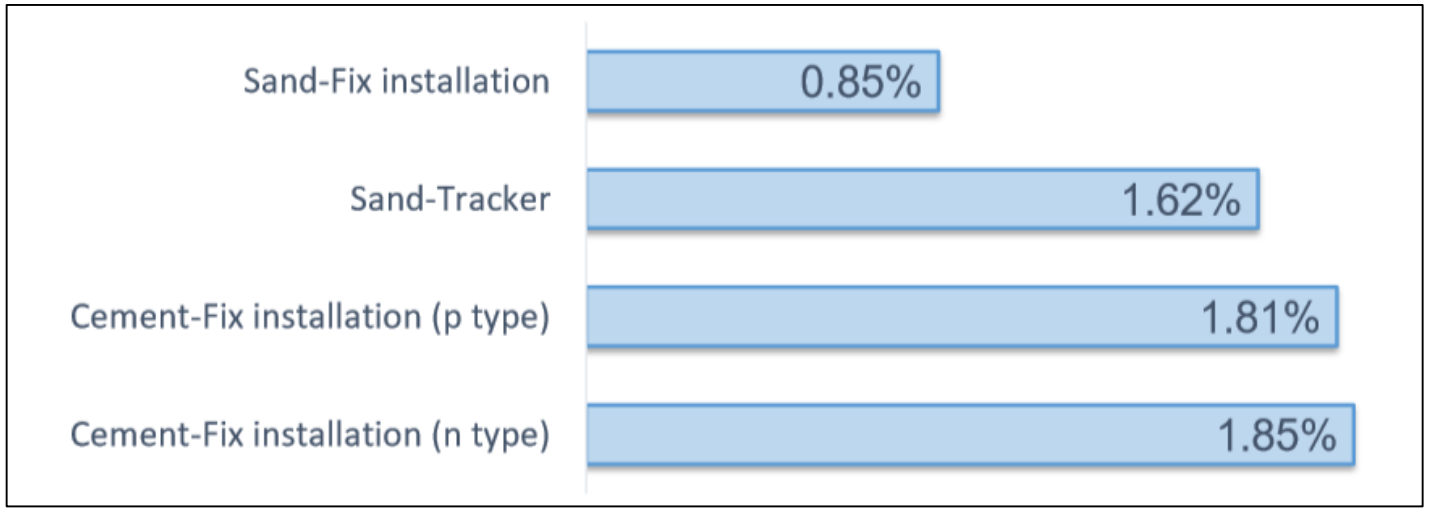


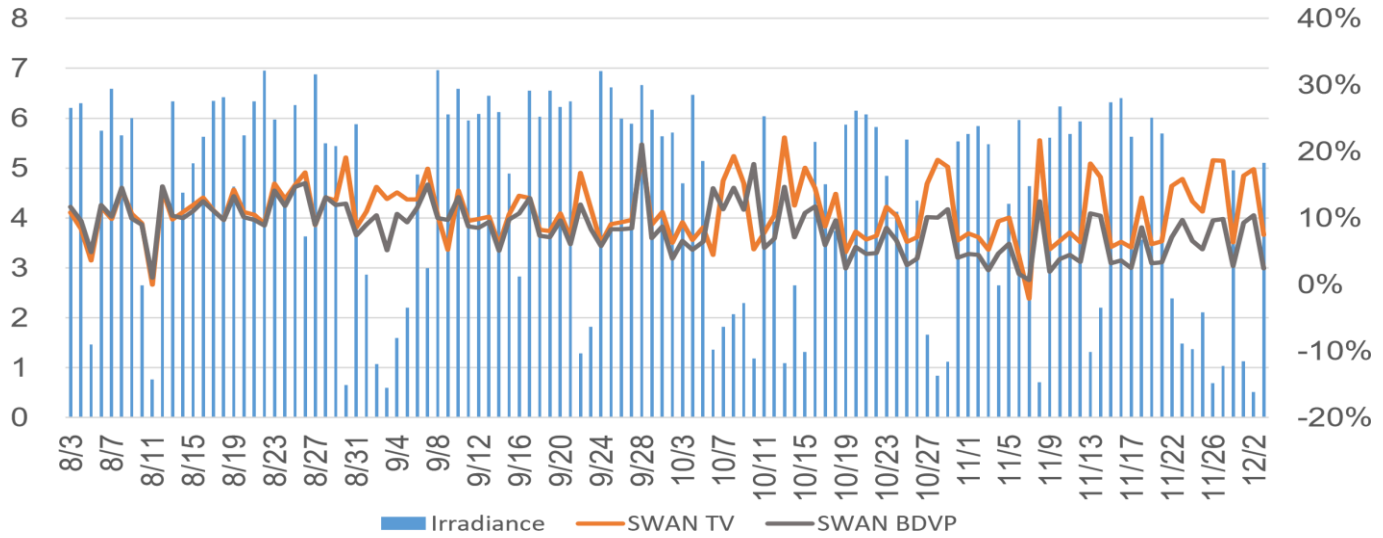


- Tedlar® film is hydrophobic and stain-resistant
  - Requiring less frequent cleaning of the rear side of the panels

Higher Power Generation

- Comparative power evaluation of bifacial panels in the field
- Panels with Clear Tedlar® backsheet vs dual glass
- Several configurations tested
  - Soil, mounting, cell type





Source: JinkoSolar

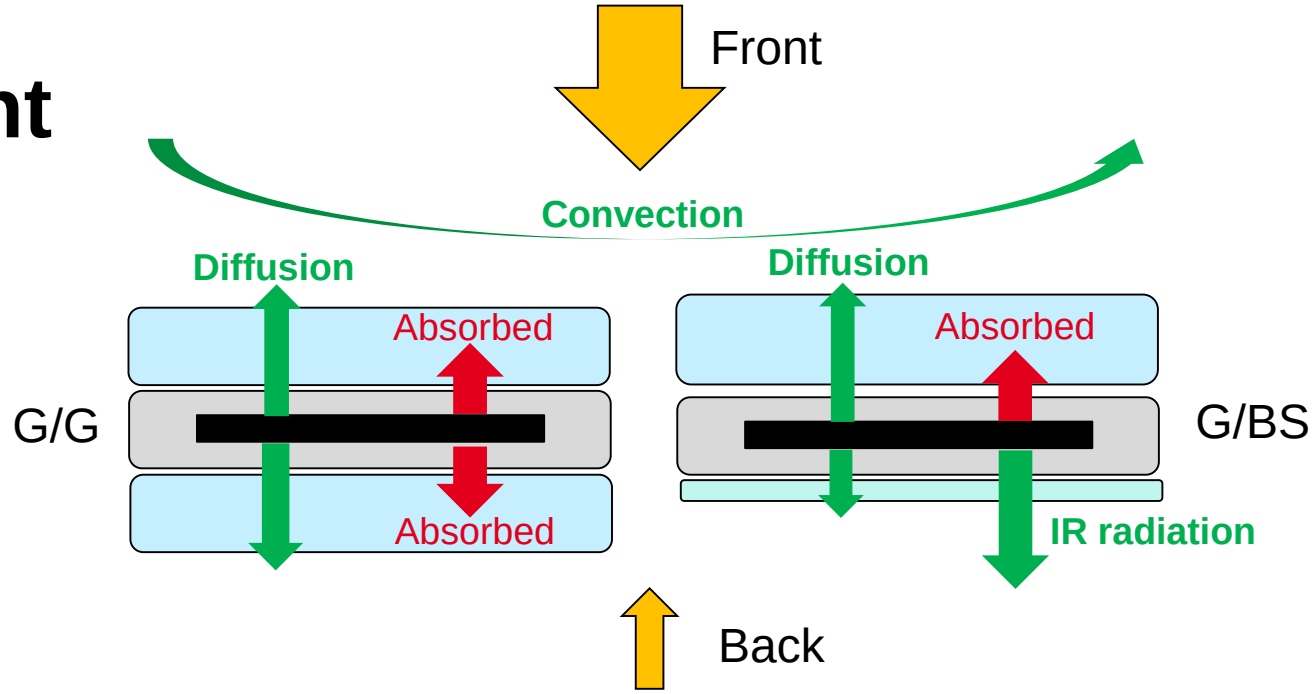
Power gain of Clear Tedlar® based backsheet: 0.85% - 1.85%

Heat Dissipation Improvement

- Sun power is absorbed by the PV cell
- Mostly absorbed & converted into heat (black body)
- PV cells then radiate in the infrared (IR)
- Glass absorbs most of the IR
- Clear Tedlar® BS is transparent to IR and lets it go through
- This facilitates heat dissipation, adding thermal radiation to the diffusion process

➡ NOCT(*) can be reduced by 1 to 3 °C with a transparent backsheet

(*) NOCT = Nominal Operating Cell Temperature



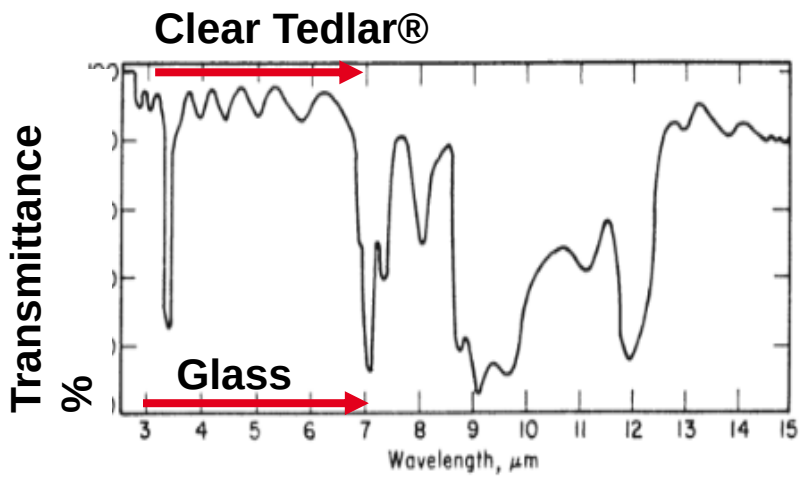


Figure 5.7.2 Infrared spectral transmittance of Tedlar film. Courtesy of du Pont.

Summary

Lower
Total Cost of Ownership

Proven
Module Structure

- Glass/Backsheet structure has **35yrs+ field proven record**
- Stronger module, **tempered glass, thicker aluminum frame**
- **Lower risk of PID**

Higher
Power Output

- **Higher power output,** lower cell operating temperature

Lower
Installation, O&M Cost

- **Similar BoS design,** mounting and tracking
- **Lower weight**, easier installation, lower labor cost
- **Easier cleaning**, lower O&M cost

Mature
Manufacturing Process

- **Compatible** with incumbent manufacturing equipment & process
- **Higher production yield**
- **Higher throughput**, added capacity

CLEAR DuPont™ Tedlar®

DUPONT