Integrating bifacial - New system design and bespoke products

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8 AM – 9 AM | CDT, México
9 AM – 10 AM | EDT, New York
3 PM – 4 PM | CEST, Berlin
9 PM – 10 PM | CST, Beijing

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Lower Cost of Ownership with Clear Tedlar® Film Based Backsheet
Advantages of Bifacial Module with Tedlar® Based Transparent Backsheet

- Proven Material Reliability
- Higher Power Output
- Lower Installation, O&M Cost
- Mature Manufacturing Process
- Lower Total Cost of Ownership
Advantages of Bifacial Module with Tedlar® Based Transparent Backsheet

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  - Glass/Backsheet structure has **35yrs+ field proven record**
  - Robust **UV protection** and **stable mechanical properties**
  - Excellent durability in **accelerated sequential test**

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- **Lower Total Cost of Ownership**
## Long-term Field Proven Record of Tedlar® Based Transparent Backsheet

### System Information

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at Inspection</td>
<td>18 years</td>
</tr>
<tr>
<td>Location</td>
<td>Amsterdam, Netherlands Overhang of a building</td>
</tr>
<tr>
<td>Number of Modules</td>
<td>51 full-size</td>
</tr>
<tr>
<td>System Size</td>
<td>6.228 kWp</td>
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<tr>
<td>Backsheet ID</td>
<td>Tedlar® based transparent backsheet</td>
</tr>
<tr>
<td>Status</td>
<td>- No back-sheet yellowing</td>
</tr>
<tr>
<td></td>
<td>- No back-sheet delamination</td>
</tr>
<tr>
<td></td>
<td>- Slight ARC delamination</td>
</tr>
<tr>
<td></td>
<td>- Slight EVA yellowing</td>
</tr>
<tr>
<td></td>
<td>- Slight yellowing of insert used on junction box connection</td>
</tr>
</tbody>
</table>
New Clear Tedlar® Film Enables Transparent Backsheet for Bifacial Modules

Clear Tedlar® PVF Film
Clear Tedlar® PVF Film - PV3001

High transparency
Robust mechanical properties
Excellent UV protection for PET core layer

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>25 µm</td>
<td>Micrometer</td>
</tr>
<tr>
<td>Optical Transmission</td>
<td>94 %</td>
<td>ASTM D1003</td>
</tr>
<tr>
<td>MD Elongation at Break</td>
<td>150 %</td>
<td>ASTM D882</td>
</tr>
<tr>
<td>TD Elongation at Break</td>
<td>140 %</td>
<td>ASTM D882</td>
</tr>
</tbody>
</table>

Transparent Tedlar® PV3001 Transmission Spectrum
UV Performance of Tedlar® Based Transparent Backsheet

**Tedlar® based transparent backsheet**

- **Tedlar® PV3001 (25um)**
- **Transparent PET Film (250um)**
- **Transparent FEVE coating (10um)**

![Graph showing optical transmittance and yellowness increase](image)

Optical Transmittance

Yellowness Increase

**Xenon Exposure**

- **Optical Transmittance**: 0 50 100 150 200 250 300 350 400
- **Yellowness Increase ($\Delta b^*$):** 0 1 2 3 4

**Xenon Exposure**: 0.8 W/m²-nm @ 340 nm, 90 °C BPT
**Tedlar® Based Transparent Backsheet Keeps Stable Mechanical Property after UV and Damp Heat Aging Tests**

![Graph showing elongation vs. UVA exposure and damp heat (hrs)]

**UVA Exposure (kWh/m²)**
- Machine Direction: MD
- Transverse Direction: TD

**Damp Heat (hrs)**
- Machine Direction: MD
- Transverse Direction: TD

**Conditions**
- 0.8 W/m²-nm @ 340 nm, 90 °C BPT
- 85°C, 85% RH
Tedlar® Based Transparent Backsheet – Less PID Risk

- Bifacial p-PERC can have less robust back surface passivation. Sodium ion migration from rear glass can result in significant rear-side ion mediated PID and power loss.
- Tedlar® based transparent backsheet does not contain sodium ions and bifacial modules with the backsheet is more resistant to rear PID*.

* Comparison of Glass/Backsheet and Glass/Glass 60-cell bifacial modules, with identical POE encapsulant and bifacial p-PERC cells. 1500V, 85°C, 85%RH
Excellent Abrasion Resistance of Tedlar® Based Transparent Backsheet

Tedlar® based transparent backsheet showed little change in light transmission after sand abrasion test.

Tedlar® based transparent backsheet has high resistance to falling sand and is suitable for use in a high wind-sand area.

ASTM E424, Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials
Wavelength: 400nm~780nm.
Backsheet samples after 100 liters of sand and surface cleaning

GB/T 23988-2009, Determination for abrasion resistance of - Coatings by falling abrasive
SGS report
The amount of sand refers to the amount required to wear through this layer
The outer layer of transparent PET back-sheet has 2um UV resistant coating
Tedlar® Based Transparent Backsheet Passed PVEL Sequential Test

When the backsheets of PV modules are made with substandard materials or poor-quality construction methods, they are likely to degrade – and ultimately cause solar asset underperformance. PV Evolution Labs (PVEL) provides buyers with the data they need to evaluate this critical component with the Backsheet Durability Sequence. This new backsheet test is now included with PVEL’s updated PV Module Product Qualification Program.

Tedlar® based transparent backsheet

No cracking, yellowing, or delamination observed in PVEL (UVA) and internal (UVX and UVMH) MAST testing

PVDF cracking in MAST testing of 60-cell commercial module by third party (DNV-GL)

PVDF cracking

Large MD crack 4 years in field

PVEL PQP BDS: DH1000+3x(UVA65 kwh/m²+TC50+HF10)+UVA6.5 kwh/m²
Advantages of Bifacial Module with Tedlar® Based Transparent Backsheet

- **Proven Module Structure**
  - Glass/Backsheet structure has 35yrs+ field proven record
  - Stronger module with fully tempered glass and thicker aluminum frame
  - Lower PID risk

- **Higher Power Output**
  - Higher power output due to lower cell operating temperature
    - Outlined in the Jinko presentation

- **Lower Installation, O&M Cost**
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Lighter Weight with Tedlar® Based Transparent Backsheet

400W module
Area: 2m²
Glass/Trans. Backsheet: 22 kg
2.5mm Double Glass: 32 kg
2.0mm Double Glass: 26 kg

450W module
Area: 2.3m²
Glass/Trans. Backsheet: 26 kg
2.5mm Double Glass: 36 kg
2.0mm Double Glass: 30 kg

500W module
Area: 2.4m²
Glass/Trans. Backsheet: 28 kg
2.5mm Double Glass: 38 kg
2.0mm Double Glass: 32 kg

- Less prone to breakage during transportation and handling
- No extra cost for handling during installation

Better Fit for Higher Power, Bigger Size modules
Less O&M Cost – Easy-cleaning for Tedlar® Based Transparent Backsheet

Soiling Resistance Test

Tedlar® based Transparent Backsheet
PV Glass

Before rinse

After rinse

Test Standard: GB/T 9780-2005 Test method for dirt pickup resistance of architectural coatings and paints
Dirt fineness: 0.045 mm square hole sieve (5.0±2.0)%
Suspension liquid: dirt: water = 1:0.9 (by weight)
Suspension liquid amount: ~2 g
Stain surface: 10 cmX10 cm
Dry time: 10 min
Water flush speed: 0.3-0.5 m/s
Water flush time: ~10 s
Excellent Solvent Resistance of Tedlar® Based Transparent Backsheet

### Solvent Resistance Test

<table>
<thead>
<tr>
<th>Transparent Backsheet</th>
<th>Tedlar® based</th>
<th>FEVE Coating</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of wipes to wear through outer layer</td>
<td>&gt;1000</td>
<td>35</td>
<td>180</td>
</tr>
</tbody>
</table>

*FEVE coating transparent back-sheet outer layer worn through after 35 times of wiping*

*PET transparent back-sheet outer layer worn through after 180 times of wiping*

*No change on Tedlar® backsheet after 1,000 times of wiping*

Transparent FEVE coating has poor chemical resistance and should not be cleaned with solvent

GB/T 13448-2006 Methods of test for color coated steel plates and strips - Part 10: resistance to organic solvents (MEK)
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- No loss in yield rate
- Faster line speed, more capacity

Mature Manufacturing Process
- Mature Manufacturing Process
Seamless Transition for Module Manufacturing Process

- Zero Capital Investment
  - No need for additional capital investment to upgrade production lines

- No loss in Yield Rate
  - Usual process control does not reduce production yield
  - G/G requires stricter process control and the industry lacks mass production experience, which leads to reduced production yield

- Faster Production Speed (More Capacity)
  - Improvements in manufacturing speed yields faster production
  - Thinner tempered glass in G/G modules needs longer time to raise and lower temperature to reduce cracking; this slows down lamination speed by 10-20%
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DuPont Photovoltaic and Advanced Materials
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