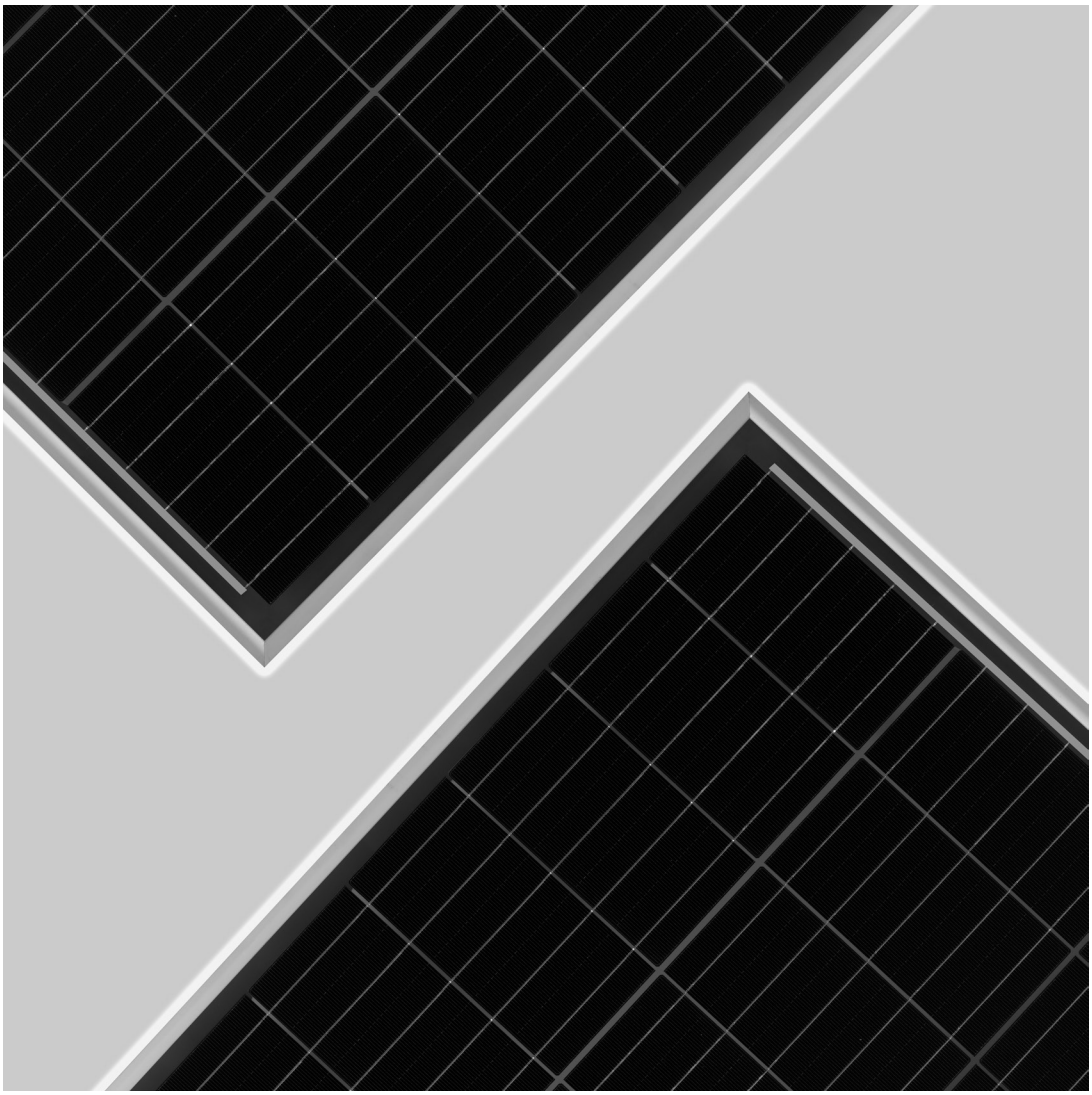
TRANSPARENT BACKSHEET VS. DUAL GLASS WHITE PAPER



Solar
JinKO

Bifacial modules are very popular in industry, but customers have a choice between transparent backsheet bifacial modules (TB) and dual glass bifacial modules (GG). This white paper evaluates advantages and disadvantages of both TB and GG, based on long-term outdoor performance testing carried out by JinkoSolar.

1. Weight

The push for higher power modules has led to larger modules. As the size of the modules has increased, module weight has also increased. TB is an important counter to this trend, and the weight difference between TB and GG increases as the module size increases. For a 410Wp module, the weight difference is only 3.3kg, but for future modules up to 560Wp, the difference can be 6kg. TB can keep module weight under 30kg with modules up to 2.7 m^2. This cuts down on BOS, labor, and transportation costs.

The difference in weight increase as module size increases for TB vs GG is illustrated below in Table 1 and Figure 1.

Power (W)	405	445	465	500	560
Area (m^2)	1.98	2.21	2.28	2.41	2.70
Weight of Module with TB (kg)	23.3	24.8	25.7	27.1	30.3
Weight of Module with 2.0mm GG (kg)	26.6	29.7	30.0	32.4	36.3
Weight of Module with 2.5mm GG (kg)	30.8	34.4	35.5	37.5	42.0

Table 1. Weight Calculation based on different module size

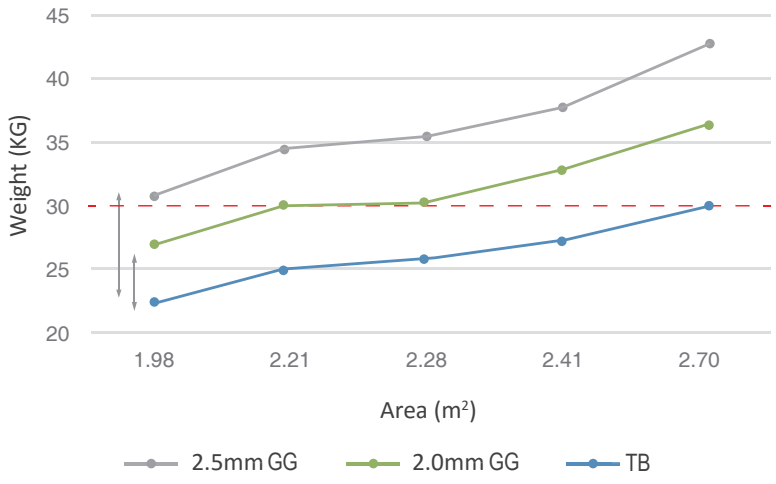


Figure 1. Weight changes with different module size

2. Mechanical properties

The front side glass in a TB is 3.2mm tempered glass, whereas the front side glass of a typical GG is 2.0mm heat strengthened glass. Because tempered glass has higher impact strength, TB is a safer choice in regions with hail. Due to the symmetrical setup of GG, where both front and back glass contribute to mechanical strength, GG may be rated to higher wind loads. In some high wind speed regions with loads higher than 2400Pa, GG is a lower risk choice, though TB can also be reinforced with the proper racking.

Type	Bifacial with Transparent Backsheet	Bifacial with Dual Glass
Structure	3.2mm Tempered Glass Bifacial Cell Transparent Backsheet	2.0mm Heat strengthened Glass Bifacial Cell 2.0mm Heat strengthened glass
Features	• Higher impact strength • Lower wind load • Lower dynamic mechanical load	• Lower impact strength • Higher wind load • Higher dynamic mechanical load
Impact Strength (Drop ball test)	4.76 N-m	Front side: 4.28 N-m Black side (with holes): 3.28 N-m
Maximum static load	+5400Pa /-2400Pa	+5400Pa /-2400Pa
Dynamic load	±1000Pa, 1000 times Slight micro cracks, no power degradation	±1000Pa, 1000 times No micro cracks, no power degradation

Table 2. Mechanical properties of bifacial TB and bifacial GG

3. Reliability in extreme weather

GG is known for excellent vapor-resistance, making it a good choice for extreme humidity such as Southeast Asia, offshore areas, and floating projects. JinkoSolar's TB is nevertheless an equally compelling option with the same 30-year warranty as GG. The TB uses a transparent backsheet with fluoric materials on both sides combined with vapor-resisting POE. The outer layer of the TB uses DuPont™ Tedlar® film, which has significant anti-aging and anti-corrosion properties and is the only film documented to have lifetimes beyond 30 years. The inner layer has a fluoric coating thicker than 10μm, which can effectively block UV and maintain the backsheet's excellent mechanical properties in extreme environments. POE is a polymer material with a more stable molecular chain and better water resistance than EVA. The combination of DuPont™ Tedlar® PVF-based transparent backsheet and POE in the TB contributes to excellent performance in strict reliability testing up to DH3000, with degradations all within 4%.

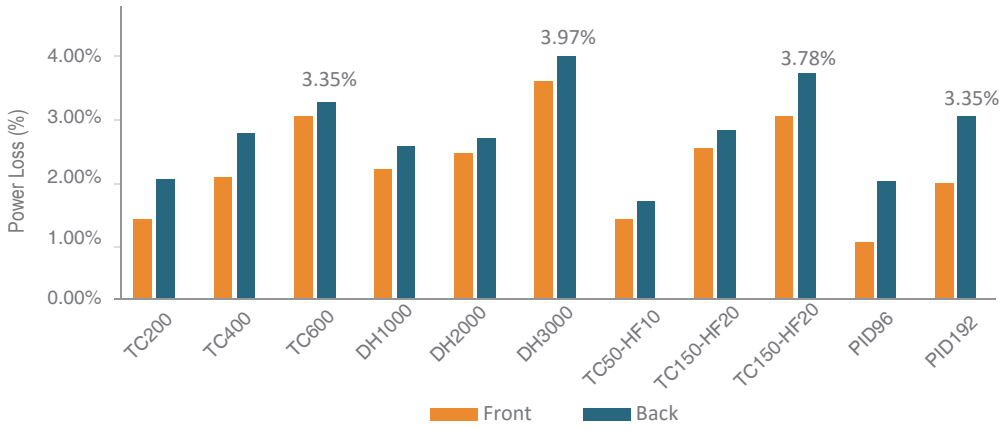


Figure 2. Degradation in strict reliability test of bifacial TB

In the DH2000 test, the degradation of the TB is slightly higher than that of the GG (POE is also used as the encapsulation material). In the PID192h test, the degradation of TB and GG is essentially the same, with degradation within 4%. In most regions, there is no appreciable difference in resistance to humidity between TB and GG. Only in the most extreme conditions will GG have an edge.

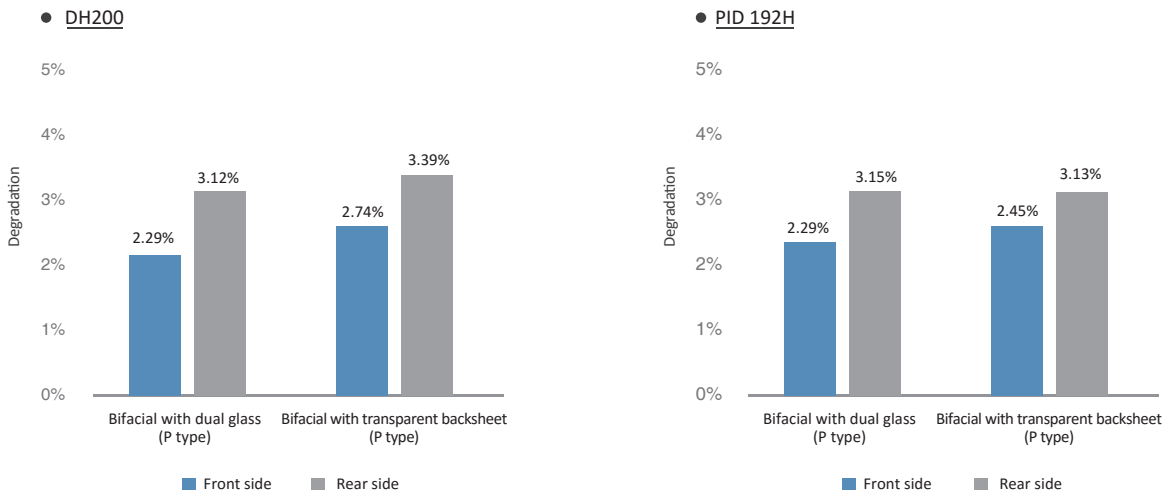


Figure 3. DH2000 and PID 192h test results

4. Anti-UV properties

There is an acute difference in ultraviolet transmittance of TB and GG. UV transmittance of transparent backsheets is less than 1%, whereas UV transmittance of glass is 40-50%. Both TB and GG use high-transparency POE, but the glass in GG cannot prevent UV damage to the backside of the cells, while TB can effectively block UV and thus protect the cells.

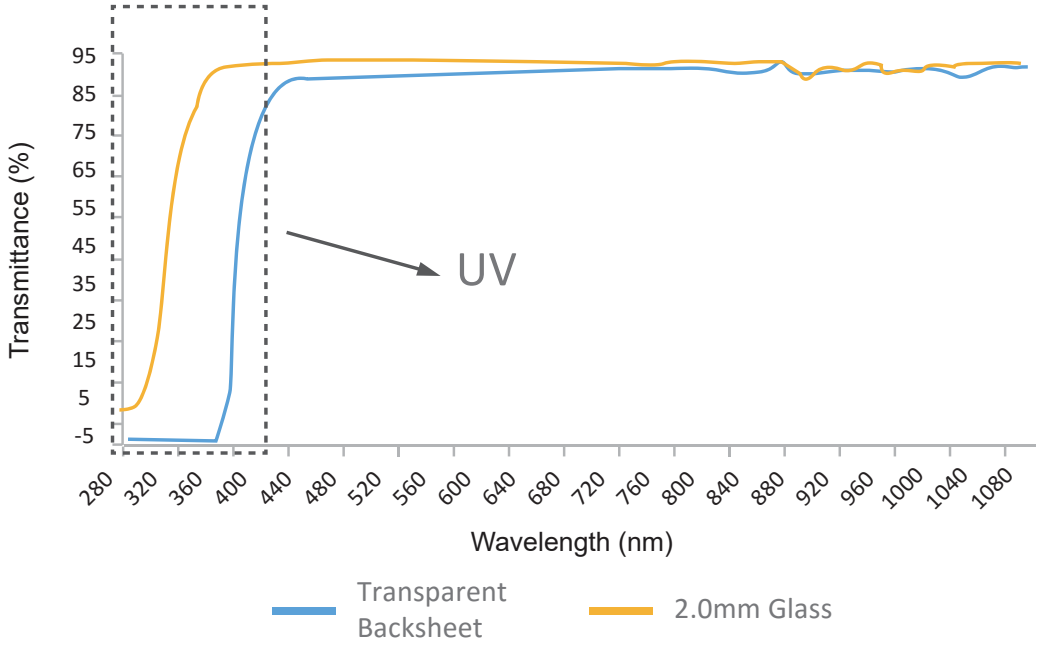


Figure 4. Transmittance of transparent backsheet and 2.0mm glass

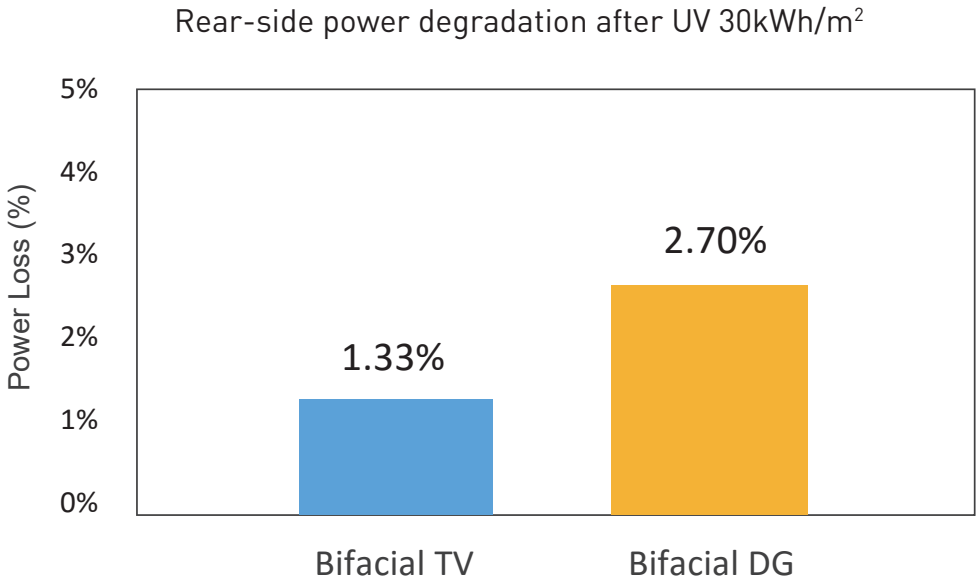
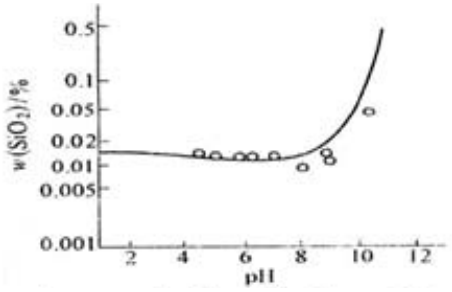


Figure 5. Rear-side degradation after 30kWh/m² UV exposure

5. Resistance to saline alkali corrosion

The main component in glass is silicate, which has certain solubility in alkaline solution. It is easily corroded in alkaline environments and forms white spots which are difficult to clean. The transparent backsheet, conversely, has excellent resistance to saline alkali corrosion; thus, TB is a better choice in saline-alkali soil and agricultural projects.



The main component of glass, silicate, has certain solubility in alkaline solution, so it is easy to be corroded in saline alkali enviornment

Clear Tedlar® film is PVF with excellent resistance to all kinds of corrosion

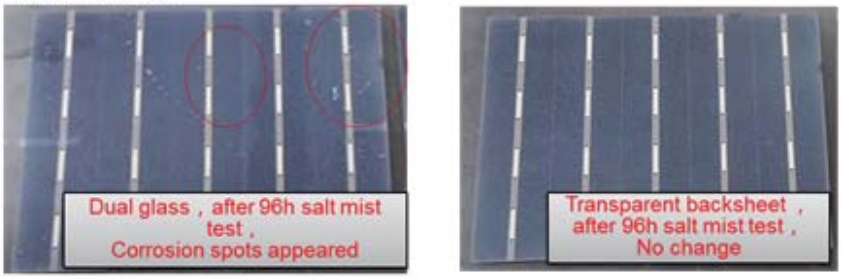
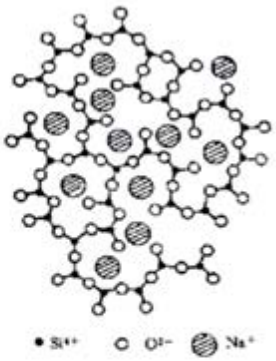


Figure 6. Anti-saline alkali comparison of transparent backsheet and glass

6. Resistance to abrasion

Both glass and transparent backsheet can withstand sand abrasion. Glass is a hard inorganic material impervious to sand abrasion. The outer layer of the transparent backsheet is DuPont™ Tedlar® film, which can withstand more than 50L of falling sand. This means transparent backsheets can withstand 30 years of sand abrasion in desert areas.



Glass is mainly composed of silicate and is an amorphous solid with a Mohs hardness of 5.5, which is not afraid of wind and sand abrasion in nature

velocity of flow: 95mL/s

Transparent backsheet with outer layer Tedlar® film has excellent resistance to abrasion, which can withstand more than 50L falling sand, equal to sand abrasion of more than 30 years in desert area

Figure 7. Resistance to abrasion of transparent backsheet and glass

7. Stain-resistance and easy to clean

The stain-resistance of transparent backsheet makes the rear side of bifacial modules easier to clean and maintain than glass. There are three soiling layers as shown in Figure 8 on the surface of modules operating outdoor.

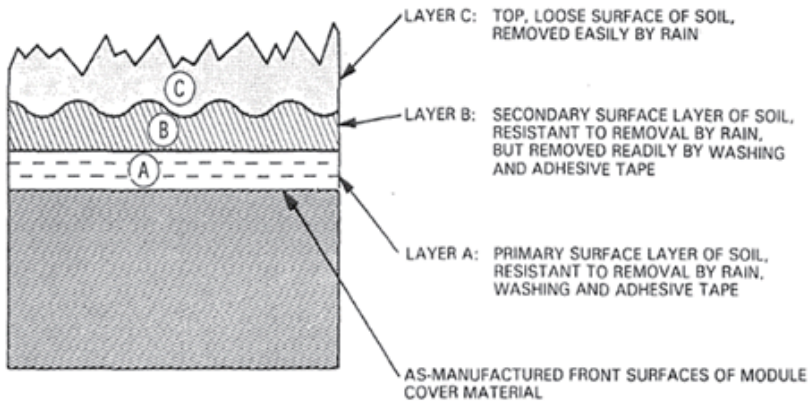
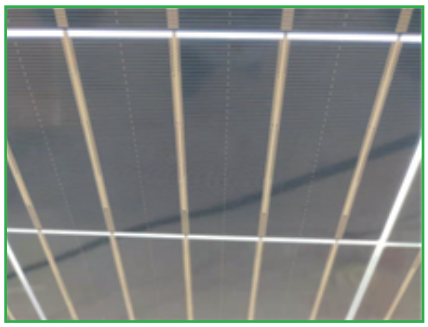


Figure 8. Three soiling layers

There are a lot of fluorine atoms on the surface of transparent backsheet, which makes the surface hydrophobic. As a result, water drops roll off easily and take dust with them. The soiling on the surface of the transparent backsheet is typically only dust which adheres to the backsheet though physical adsorption. The dust will not accumulate on the surface and have adverse effects on the energy generation. On the contrary, glass is hydrophilic, so water drops will spread and stay on the surface. During long-term operating, mud spots are formed by mixtures of dirt and rainwater that have dried on the surface of glass, while there is no obvious dirt on the surface of transparent backsheet, as shown in Figure 9.

Bifacial with transparent backsheet:
There is no obvious dirt, and very little dust in the middle area



Bifacial with dual glass:
There are dirt and mud spots which is not easy to clean

Figure 9. Outdoor soiling test

To test the ease of cleaning for transparent backsheet and glass, refer to GB / T 9780-2005, as shown in Figure 11. When washing transparent backsheets with water (flow rate 0.3-0.5m/s) for 10s, the dirt on the surface of the transparent backsheet is removed, while glass still retains many residues.

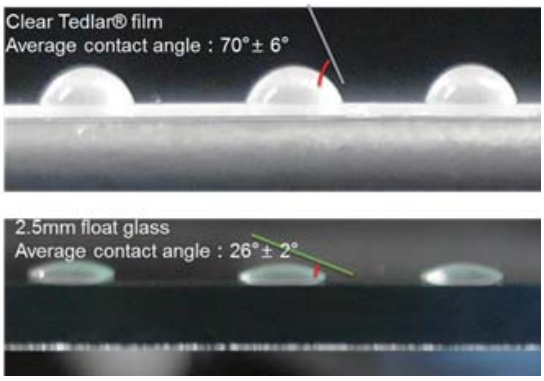


Figure 10. Tedlar® film is hydrophobic and glass is hydrophilic

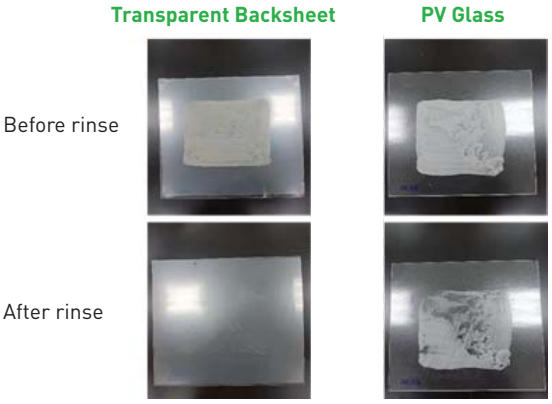


Figure 11. Clean test comparison

8. Energy generation

Energy generation is undoubtedly the most important variable. In 4 different field tests, TB generates more energy compared to GG. Figure 12 shows the differences.

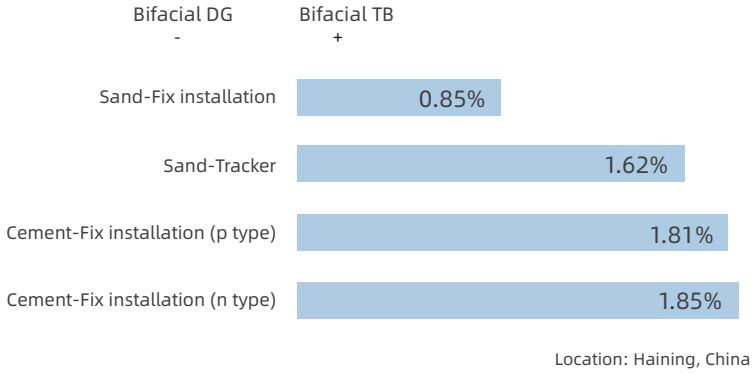


Figure 12. The energy gain of bifacial TB (benchmark: bifacial GG)

In a cement-fixed project, daily yield per watt of TB is higher than GG at high irradiance. The slope of the fitting function of the TB is larger, so the power generation difference between TB and GG increases under high irradiance. The higher power generation of TB results from lower operating temperature. Glass becomes opaque to wavelengths longer than approximately 3 μm, whereas the transparent backsheet remains clear, allowing heat to dissipate from the back of the module.

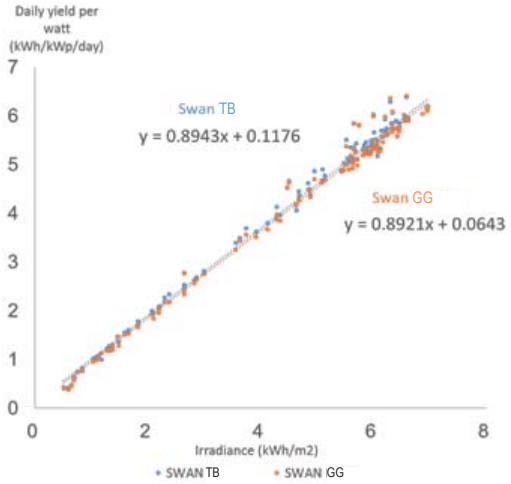


Figure 13. Daily yield per watt and irradiance relationship

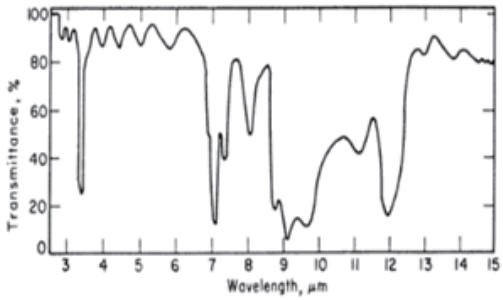


Figure 14. Infrared spectral transmittance of Tedlar® film

Summary

TB and GG each have advantages and disadvantages. The chart below can help customers evaluate those two products and their application scenarios more comprehensively. While GG slightly outperforms TB in extreme humidity, TB is otherwise the better all-around module.

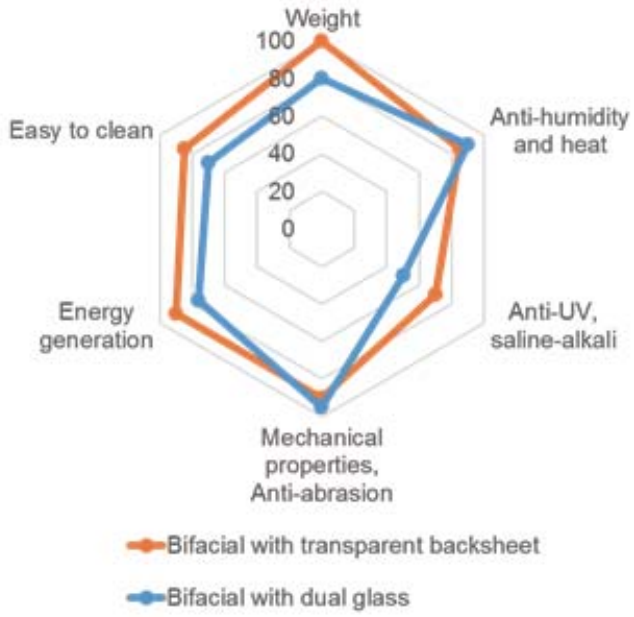


Figure 15. Comparison of bifacial with transparent backsheet and bifacial with dual glass