1.95% Yield Gain of TOPCon Over BC in an One-Year Comparison Rooftop System

Test Background:

Tunnel oxide passivated contact (TOPCON) cells (n-type) are currently the most efficient, reliable and widely used cell structures, with a total market share of approximately 80% in 2024. However, to differentiate themselves and sell at a premium price, various BC technologies have been marketed and targeted towards the rooftop market.

BC modules are assumed to be ideal for rooftop installation because of their higher front-side power relative to TOPCon module. Meanwhile, the bifaciality disadvantage of BC cells can be minimized in rooftop scenarios. Therefore, this study compared the performance of TOPCon PV modules and BC modules to determine their energy yield in real-world conditions and their potential for rooftop applications.

Figure 1: Project Picture

Test Introduction:

This study aimed to determine the potential of TOPCon and BC in rooftop scenarios in terms of energy yield and LCOE. To do so, 18 pieces of Jinkosolar' s 575 Wp TOPCon modules and 18 pieces of BC modules with rated power of 575Wp were installed on a factory rooftop system in Jiangxi, China (N 27° 48' -29° 42', E 116° 13' - 118° 29'). All the modules were installed on a fixed structure with a tilt of 0 ° , which enabled a higher energy yield. The irradiance, ambient, and module temperature were recorded, and the performance of the two types of technologies was monitored and compared. Over the course of one year, sensors measured real-time ambient temperature, irradiance, the temperature of modules, DC voltage, current, power, wind speed, wind direction, relative humidity, air pressure, and energy yield.

Type of sample	JKM575-72HL4-BDV	BC Module
Type of cell	TOPCon	BC
Specification	2278X1134X30mm	
Quantities	18 pcs	18pcs
(W)	575	575
Voc(V)	51.27	52.06
Isc(A)	14.31	14.14
Vmp(V)	42.44	43.91

Table 1. Sample component parameters

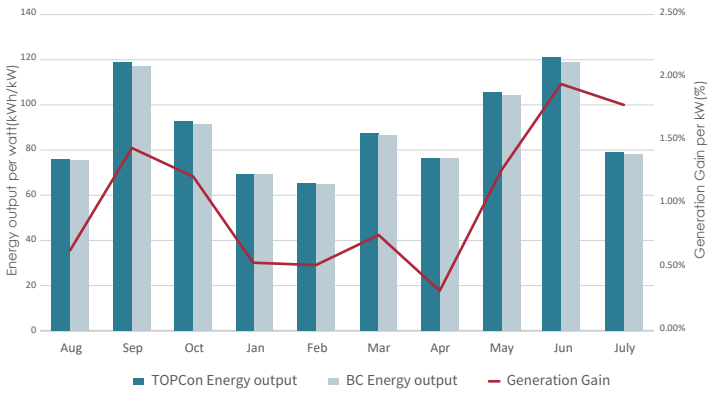
Results :

During the past 11 months, (August 14, 2023 - July 15, 2024), the highest daily average irradiance of 273 W/m was recorded in June, and the highest temperature of 39.7 °C in July. The lowest irradiance of 104 W/m and ambient temperature of -5 °C was recorded in January and February, respectively.

Throughout the year, irradiance and energy yield exhibited a strong linear correlation. The total annual energy yields of the TOPCon and BC modules were 894.5 and 884.6 kWh/kWp, respectively. The energy yield of the TOPCon module was at most 1.95% higher than that of the BC module. Thus, even without considering the bifacial factor of the rear side, TOPCon module can be better used in rooftop scenarios to reduce initial investment cost and LCOE while enhancing energy yields and overall product performance throughout all four seasons.

The rain-filled April (20 rainy days in April 2024) resulted in decreased irradiance and a decreased yield gain of TOPCon by 0.33% over BC. Conversely, the high ambient temperatures and prolonged daylight in June resulted in increased energy production gain of TOPCon up to 1.95% over BC. The snowy winter season from January to February exhibited both low irradiance and ambient temperature, resulting in 0.52-0.53% yield gain of TOPCon against BC.

Both types of modules exhibited a strong linear correlation between irradiance, temperature and energy yield. The energy yield of the TOPCon module was at most 1.95% higher than that of the BC module due to its higher generation capability (kWh/kW) and robust reliability throughout the entire period.



Analysis:

BC modules are the same size as TOPCon modules but have more power because their electrical contact are moved from front to the rear side. In principle, this method increases front side power and efficiency of BC cells, particularly in rooftop systems where bifaciality is not a key consideration. However, in real world conditions, concentrated tension and stress on the rear side result in regional temperature rises. This phenomenon is more evident in the summer, especially in June and July. Additionally, the significant leakage of electricity in BC cells due to their cell structure leads to poorer low-light performance, which explains why in the morning and before dusk, the yield gain of TOPCon over BC is higher than during the rest of the day.

Conclusions:

This study recorded and compared the performance of TOPCon modules with BC modules installed on a rooftop over the course of a year to determine the competitiveness in terms of cost and energy yield. It can be concluded:

1.The total energy yield of TOPCon solely contributed by front side was at most 1.95% higher than that of BC modules due to TOPCon's higher generation capability (kWh/kW). Putting aside its advantage of bifaciality, TOPCon still has more potential than BC for rooftop applications.

2.Both types of modules exhibited a strong linear correlation between irradiance, temperature and energy yield. The stronger the irradiance and temperature, the higher the yield gain of TOPCon.

3.TOPCon showed better low light performance in the morning and dusk.

Based on these data, further research on the testing and monitoring of energy yield will be conducted in the future.