Haikou field test site evidence report: TOPCon technology's comprehensive power generation efficiency is significantly 5.09% higher than that of N-type BC modules.

Recently, the report on the comparison of N-type modules conducted at the field test base in Haikou was officially released. The results show that, with the excellent advantages of high bifaciality and low-irradiance performance, the overall power generation performance of the tested N-type TOPCon modules in Hainan is significantly better than that of the N-type BC technology modules, with an average power generation gain of 5.09%. This significant performance improvement of the tested N-Type TOPCon is mainly due to the following two core advantages:

1、Excellent Low-Irradiance Performance
TOPCon modules have an excellent low-irradiance generation capability, especially in the early morning and late afternoon (irradiance less than 500 W/m²). This is due to the advantages of the TOPCon technology, which forms a tunneling oxide passivated on the surface of the TOPCon cell, which reduces leakage channels. In contrast, some other technologies have a high number of positive and negative grid lines on the backside of the cell, which increases the number of leakage channels and can have a more serious impact on cell performance at low irradiance. In addition, the shunt resistance (Rsh) of the cell is closely related to the low irradiation performance, the larger the Rsh, the better the low irradiation performance. the structure of TOPCon makes its shunt resistance relatively large, which can reduce the loss of current under low irradiation conditions, and maintain better power generation capacity.

2、High Bifaciality Advantage
In the rooftop application scenario of PV field-testing stations with limited installation height and area, TOPCon bifacial modules, with the advantage of bifaciality of up to 80%~85%, are able to keenly capture scattered and reflected light and efficiently convert it into electricity, thus significantly increasing the overall power generation capacity of the modules. This is due to the fact that TOPCon modules have a front-back bifacial contact structure, i.e., the grid lines and electrodes are distributed on both sides. In addition, the Poly-Si thickness of TOPCon modules is thin, which reduces parasitic absorption and increases the backside current. This unique structural design can significantly increase power generation and bring higher economic returns to customers.

Significance:
It means that under the post-531 new policy tariff mechanism, the tested N-type TOPCon modules can make full use of the morning and evening sunlight resources and the ground emitting light resources to enhance the power generation during the high tariff hours and maximize the revenue.

Test results:
This report compares and analyses the power generation performance, temperature variation of the tested TOPCon modules, N-type BC modules. The results of the quarter test are as follows(15/11/ 2024 to 28 /2/ 2025):

1) Based on the comparison of the power generation performance data of the tested TOPCon module and the N-type BC module, it can be concluded that the power generation performance of the tested TOPCon module is better than that of the N-type BC module, and the power generation performance of the tested TOPCon module is 5.09 % higher than that of the N-type BC module.

2) The PR value of the tested TOPCon module is 95.48%, and the PR value of the BC module is 90.89%. The PR value of the tested TOPCon module is significantly higher than that of the N-type BC module used in this demonstration, which indicates that its comprehensive losses (including temperature loss, line loss, dust shading, etc.) are lower and the system efficiency is better in actual operation.

3) According to the temperature monitoring data from November 2024 to February 2025, the average operating temperature of the tested TOPCon module was lower than that of the N-type BC module during the quarterly empirical demonstration period, in which the temperature difference in February 2025 was 0.34℃. The sustained temperature advantage indicates that the tested TOPCon module is somewhat advanced in its thermal management technology.

	TOPCon module	N-type BC module
Total yield（kWh/kWp)	300.91	286.34
Relative performance（%）	105.09%	100.00%

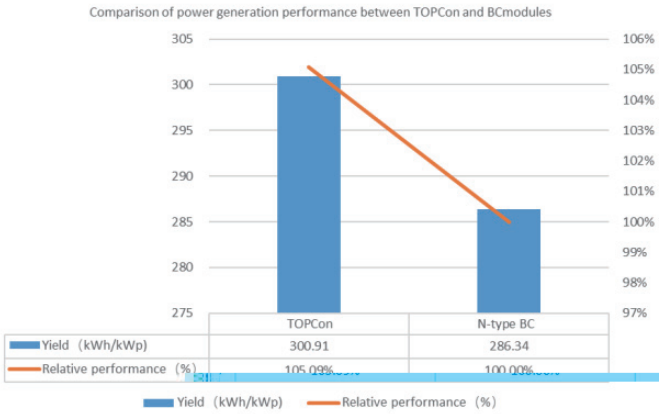

Figure 1: Comparison of power generation per watt between TOPCon and other BC II modules

Project Background
The project is implemented by the well-known third party appraisal agency, China General Certification Center. The evidence-based field test power station base is located in Meilan District, Haikou City, Hainan Province, covering an area of about 2,300 square metres, which belongs to the distributed photovoltaic field test power station, and the surrounding buildings do not obstruct the test arrays. The field test base is equipped with a fully automated high-precision environmental monitoring system to monitor and record meteorological conditions such as irradiance (GHI、DNI、DHI、GTI), temperature and humidity, wind speed and direction, and rainfall. Haikou is located in the northern part of Hainan Island, at the northern edge of the low-latitude tropics, and has a tropical monsoon climate, with no severe cold in winter, no scorching heat in summer, and four seasons of evergreen, warm and comfortable. With long sunshine hours and high radiation energy throughout the year, the average annual total irradiation reaches 2043.8 kWh/m², the average annual temperature is 25.2°C, the average wind speed is 2.9 m/s, and the relative humidity reaches 89.3 %RH.

Module Information
Two types of modules were chosen for this field testing: the N-type TOPCon module, with an average bifaciality of 83.0%, and the N-type BC version of another manufacturer's module, with an average bifaciality of 68.7%. There were 10 of each type of module. The modules

point of the module being 0.5 m above the ground, and the ground conditions being concrete. All modules are equipped with high-precision sensors to monitor power generation data in real time to ensure the accuracy and credibility of the test results.

Test situation
This project uses voltage and current collection and monitoring equipment with sampling accuracy of 0.5% level and sampling interval of 1 minute. Meanwhile, the Global Horizontal Irradiance、Direct Normal Irradiance、Diffuse Horizontal Irradiance、Array surface irradiance、and reflected irradiance, ambient temperature and humidity, atmospheric pressure, wind speed and wind direction of the field test power station were collected and recorded.

Module operation data results and analysis
The results of this field testing study show that the overall power generation performance of the tested N-type TOPCon modules in Hainan is significantly better than that of the N-type BC technology modules, with a 5.09% higher performance. Thanks to the higher bifaciality and excellent low operating temperature, the tested N-Type TOPCon modules can bring higher power generation and more stable performance to users in practical applications. TOPCon technology is undoubtedly a more competitive choice for PV field tested power plants pursuing high efficiency and reliable power generation.

Months	TOPCon module Average Temperature	N-type BC module average temperature
2024.11	27.67	27.88
2024.12	28.42	28.62
2025.01	22.51	22.64
2025.02	24.20	24.54

Table 2. 024.11-2025.02 TOPCon3.0 VS BC2.0 generation in Haikou