Field Performance Comparison Test of N-type TOPCon and P-type PERC Bifacial Modules in Haikou by CGC

Project Background:

To study the power generation gain, temperature variation and power degradation of Jinko N-type modules, a project is carried out outdoors at the Haikou field test base (Latitude: 20 °; Longitude: 110°) by China General Certification(CGC) starting from July 2022. The experimental groups were monitored and analyzed (July 2022- April 2023) the power generation performance and operating temperature of different Jinko N-type TOPCon and P-type PERC modules by controlling the orientation of the modules and the type of mount to maintain consistency.

Experiment Methodology & System Design:

The PV module samples used in this field test project are shown in table 1, including 10 pieces Jinko N-type bifacial modules (JKM560N-72HL4-BDV), 10 pieces Jinko P-type bifacial modules (JKM540M-72HL4-BDV)

Table 1. Sample component parameters

The inverters used are Solis GCI-80K-5G string inverters, with the specific inverter parameters shown in table 2. There were no limiting factors such as over-matching or current limiting that affected the test results for each test array during the use of the inverters.

The Haikou field test base is located in Meilan District, Haikou City, Hainan Province, which is at the northern edge of the low latitude tropics and belongs to the tropical monsoon climate. The annual sunshine duration is long, the radiation energy is significant, the average yearly total radiation amount reaches 2043.8 kWh/m2, the average annual temperature is 25.2 ℃, the average wind speed is 2.9 m/s, and the relative humidity reaches 89.3% RH.

The test station is equipped with an automatic high-precision environmental monitoring system for meteorological data monitoring and recording, such as irradiance (GHI, DNI, DHI, POA), temperature, humidity, wind speed, wind direction, rainfall, etc.

The study is designed with 2 PV arrays, each consisting of 10 PV modules of the same type connected in series, fixed mounted, with 2.9 m row spacing and 0.5 m mounting height above the ground.

The DC side of each PV array is connected to an inductive DC meter for collecting voltage, current and power data on the DC side of each array, followed by a separate 1-way MPPT channel for each array to the inverter to avoid array mismatch losses. The Haikou field test base is equipped with professional meteorological equipment to monitor the meteorological data of the base module arrays. Data acquisition and storage frequencies are referenced to IEC 61724-1 requirements. The sensor data is transmitted via data collectors and data servers to the CGC field test cloud plat form. During the test period,

Indoor Electrical Performance Testing

Laboratory electrical performance tests on N-type modules prior and after this field test carried out at CGC Jiaxing Laboratory. The test is purposed to test the degradation of modules and their criteria are shown in table 4

	No.	Test item	Test standard/method	Clause
Test items & Test standards/ methods	1	Visual inspection	IEC 61215-2:2021Crystalline silicon photovoltaic modules for terrestrial applications - design qualification and sizing	4.1 MQT01
	2	STC test		4.2 MQT06.1
	3	EL test	IEC TS 60904-13:2018	
Assessed measurement uncertainty	Urel(Isc)=2.3%(k=2) Urel(Voc)=0.8%(k=2) Urel(Pmax)=2.5%(k=2)			

Table 4. Summary of indoor electrical performance tests

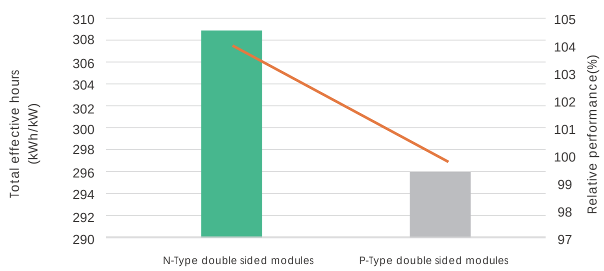
Result:

1.Power generation performance (Period: 2023.2~2023.4)

Comparison of the power generation performance of N-type bifacial and P-type bifacial module is shown in table 3-1 and Figure 1. The daily power generation data from 8:00-17:00 is selected and the P-type double-sided module is used as the performance baseline. From the data in Figure 1, it can be seen that the power generation performance of N-type double-sided module is better than that of P-type double-sided modules, with the cumulative power generation of N-type double-sided module reaching 1740.52kWh and the cumulative power generation of P-type double-sided modules reaching 1611.07kWh. Compared to the power generation performance of the P–type double sided module, the N-type double sided module achieves a power generation gain of 4.22 %.

Experimental group	Type	Cumulative electricity production (kWh)	Total effective hours (kWh/kW)	Relative performance (%)
A	N-type bifacial	1740.52	308.88	104.22
B(Baseline)	P-type bifacial	1611.07	296.37	100.00

Table 5. Comparison of the power generation performance of N-type bifacial modules and P-type bifacial modules



	N-Type double sided modules	P-Type double sided modules
Total effective hours (kWh/kW)	308.88	296.37
Relative performance(%)	104.22	100.00

Figure 1. Comparison of the power generation performance of N-type double-sided modules and P-type double-sided modules

2.Module Operating Temperature

In order to accurately monitor and analyze the temperature changes of Jinko modules during the field test process, thermocouples were attached to the top and bottom of one module at the same location in each array to monitor the module operating temperature changes through thermocouple sensors. The temperature data is selected from 8:00-17:00 daily, and the abnormal data points were screened out and statistically analysed. The temperature variations of the modules in the experimental group at the Haikou base in the third quarter are shown in table 6.

Experimental group	Type	Average temperature/°C	Max. temperature/°C	Average temperature/°C
A	N-type bifacial	34.81	69.10	-0.56
B(Baseline)	P-type bifacial	35.37	69.10	0.00

Table 6. Temperature variation of the experimental group component operation at the Haikou base

Using the P-type double module as the temperature reference, the average operating temperature of both the N-type double module and the N-type single-sided module is lower than that of the P-type double module, with the average operating temperature of the N-type double module being 0.56℃ lower than that of the P-type double module and the average operating temperature of the N-type single-sided module being 0.66℃ lower than that of the P-type double module. The average operating temperature of N-type single-sided modules is 0.10℃ higher than that of N-type single-sided modules, and the operating temperatures are basically the same.

Before (July 01, 2022) and after the field test (April 30, 2023), the experimental group samples were statistically tested for electrical performance under standard conditions and their test results are shown in table 7

560N sample serial#	Initial Power Test at July 01,2022(W)	Period Power Test at April30,2023 (W)	Degradation
1	561.65	560.39	-0.22%
2	563.85	560.04	-0.68%
3	561.32	561.11	-0.04%
4	563.48	559.73	-0.67%
5	564.55	559.89	-0.83%
6	564.18	560.52	-0.65%
7	563.47	559.14	-0.77%
8	564.2	559.74	-0.79%
9	564.26	559.68	-0.81%
10	564.16	560.81	-0.59%
Subtotal	**5635.12**	**5601.05**	**-0.60%**

Table 7. Electrical performance test results of the experimental group samples under STC

Conclusion:

1) The power generation performance of N-type bifacial modules being **4.22 %** higher than that of P-type bifacial modules.

2) The average operating temperature of N-type bifacial is **0.56** lower than that of P-type bifacial modules

3) The degradation of N-type TOPCon modules in first year is **0.60%**