2025 Annual White Paper on PV Power Station Quality and Multi-Scenario Module Selection Reference

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Preface

Against the backdrop of accelerating global energy transition, the long-term revenue and safe operation of photovoltaic power stations increasingly rely on the scientific selection of their core equipment – PV modules. Different application scenarios (such as deserts/Gobi, mountains, water surfaces, rooftop distributed systems, etc.) impose differentiated requirements on modules in terms of weather resistance, power generation efficiency, degradation rate, etc. However, the industry has long lacked a systematic selection reference based on actual operational data, leading some projects to face underperformance and high reliability risks due to inappropriate module selection.

This report is grounded in empirical evidence, based on extensive field testing data and typical case studies. It focuses on the real-world performance of modules in multiple scenarios, deeply analyzing key indicators such as low-irradiance characteristics, bifacial gain, power degradation, and environmental adaptability. It also proposes targeted selection recommendations based on the core challenges of each scenario. Concurrently, the report releases for the first time the "2025 SOLARBE TEST Awards for PV Module on Specific Performance Index". Through a systematic evaluation protocol, it discloses module products that excel in specific performance dimensions, providing global investors, project developers, designers, and O&M personnel with quantifiable and comparable selection criteria.

We believe that this summary and insight based on real operational data will assist overseas clients in optimizing their module selection strategies more scientifically and rationally, effectively reducing project risks and enhancing full-lifecycle investment returns. We look forward to working with industry peers worldwide to promote the practice and progress of high-quality PV power station development.

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1. Guidelines for PV Module Selection in Different Scenarios

1.1 Analysis of Module Selection for Desert/Gobi Power Stations

1.1.1 Core Challenges of the Scenario

Desert/Gobi regions refer specifically to desert, Gobi, and barren land areas. Such scenarios feature extremely harsh natural environments, presenting multiple extreme challenges for PV module operation: First, strong wind and sand erosion. Gale-force winds of level 8 or above accompanied by dust are common in these areas. High-speed sand particle impact can easily cause abrasion on module surfaces and damage to frames. Simultaneously, sand accumulation can obstruct the light-receiving surface of modules, leading to hot spot issues and reducing power generation efficiency. Second, extreme temperature, humidity, and high ultraviolet radiation. The average summer surface temperature can reach up to 70°C, while winter lows can drop to -40°C. The thermal stress from such drastic temperature variations can easily cause frame corrosion and encapsulant cracking. Prolonged high UV radiation accelerates the aging of packaging materials and reduces cell efficiency. Third, high surface albedo characteristics. The surface albedo in desert/Gobi regions typically ranges from 25% to 30%. While this characteristic provides gain potential for rear-side power generation of bifacial modules, it also imposes higher demands on the evaluation of comprehensive module power generation efficiency. Fourth, harsh O&M conditions. The sparse vegetation and inconvenient transportation in these areas make module cleaning and fault repair difficult and costly, imposing stringent requirements on the self-cleaning capability and long-term reliability of modules.

1.1.2 Core Requirements for Modules

Based on the core challenges outlined above, the desert/Gobi large base scenario imposes core requirements on PV modules of "high reliability, high efficiency, easy O&M, and strong adaptability":

Wind-sand resistance and mechanical load capability: Modules need excellent impact resistance against wind-blown sand. After continuous operation in an environment with a dust concentration of 5g/m³ and wind speed >20m/s, the appearance should show no abrasion, cells no micro-cracks, and power degradation should be controlled within a reasonable range. Simultaneously, mechanical load-bearing capacity must be strengthened, withstanding at least 6000Pa on the front side and 4000Pa on the rear side to cope with pressure impacts from strong winds.

Stability under extreme environments: Modules must possess excellent resistance to high and low temperature cycling. Use low-temperature resistant encapsulants suitable for -40°C and corrosion-resistant frame materials (such as zinc-aluminum-magnesium coating) to avoid structural damage caused by temperature variations. Encapsulation materials need strong UV resistance; by optimizing the cell passivation layer structure and encapsulant material formulation, degradation caused by UV radiation should be minimized.

High comprehensive power generation efficiency: To adapt to the high surface albedo characteristics of desert/Gobi regions, prioritize modules with high bifaciality rates to fully utilize rear-side reflected light for increased power generation. Considering the higher latitudes of these areas, the impact of the angle of incidence on power generation efficiency must be taken into account. Also, excellent low-irradiance performance is required to maintain stable power output under low-light conditions such as dawn/dusk and during dusty weather, aligning with revenue needs during high electricity price periods under market-based power trading.

Easy O&M and long lifespan: Modules need self-cleaning capabilities. Through technologies such as self-cleaning glass and nanostructured coatings, dust adhesion should be reduced, and cleaning cycles extended. Product warranties must meet the industry's high standards of 15 years for materials and 30 years for linear power output to lower long-term O&M costs.

1.1.3 Key Performance Data

(1) Bifaciality Rate Performance: Test data shows significant differences in bifaciality rates among different technology routes, directly impacting the potential for rear-side power generation gain. HJT (heterojunction) modules perform best, with bifaciality rates generally exceeding 85%, up to 89.47%. TOPCon (tunnel oxide passivated contact) modules follow, ranging from 75% to 85.74%. BC (back contact) modules have relatively lower bifaciality rates, around 57.65%.

(2) Angle of Incidence Response Performance: Low-angle sunlight (early morning, evening) accounts for a relatively high proportion in desert/Gobi regions. Module performance under low irradiance (200-400W/m²) can serve as a key reference for angle of incidence response. Measurements indicate that module performance under low light varies significantly; some HJT and TOPCon samples show low-irradiance loss rates controlled within 3% at 200W/m² irradiance, demonstrating better low-light power

generation capability.

1.1.4 Recommended Preferred Products

In desert/Gobi scenarios, HJT and TOPCon are more suitable choices. HJT has clear comprehensive advantages in bifaciality rate and low-irradiance performance; TOPCon is competitive in terms of bifaciality rate, weather resistance, and cost balance. If bifacial modules are selected, efficient automatic cleaning solutions must be deployed to maintain rear-side power generation efficiency.

1.2 Analysis of Module Selection for Mountainous and Hilly Power Stations

1.2.1 Core Challenges of the Scenario

Mountainous and hilly terrain features complex topography, with natural environments exhibiting significant fragmentation and diversity. This presents multiple unique challenges for PV module selection, installation, and long-term operation: First, undulating terrain and variable slopes. Some areas have steep slopes, limiting installation space and increasing layout complexity. Additionally, slope load-bearing capacity is limited, imposing high demands for lightweight modules and supports. Second, prominent shading issues. Trees and shrubs in mountainous areas, along with shadows cast by the terrain itself as the sun's altitude angle changes, can easily form dynamic shading. Combined with frequent cloud cover, modules are prone to partial shading, triggering hot spot effects that severely impact power generation efficiency and module lifespan. Third, complex temperature, humidity, and precipitation conditions. Most mountainous and hilly areas are at higher altitudes, with abundant precipitation and high air humidity. Some areas also experience harsh weather like acid rain or freezing rain, which can easily cause frame corrosion, encapsulant hydrolysis, and glass fogging. Fourth, difficult transportation and O&M. Narrow roads with many curves and steep slopes make large-module transportation costly and risky. Dense vegetation and rugged terrain reduce accessibility for module cleaning and fault repair, leading to long O&M cycles and high costs. Fifth, frequent local severe convective weather. Mountainous areas are prone to localized strong winds and thunderstorms, subjecting modules to instantaneous strong wind loads and lightning strike risks.

1.2.2 Core Requirements for Modules

Based on the core challenges, mountainous and hilly scenarios impose core requirements on PV modules of "lightweight, strong anti-shading capability, resistance to humidity and corrosion, ease of transportation and installation, and high reliability":

Lightweight and easy installation adaptability: Modules must strictly control weight. Considering mainstream sizes such as 182*210 and 210*210, the weight per module should not exceed 33kg. Priority should be given to lightweight designs like thin glass and lightweight frames to reduce slope load pressure and transportation/installation difficulty. Additionally, module dimensions must flexibly adapt to fragmented installation spaces and support various tilt angle adjustments to enhance terrain adaptability.

Strong anti-shading and hot spot suppression capability: Modules need excellent low-irradiance response performance to maintain stable power output under low-light conditions caused by cloud or tree shading. Employ efficient hot spot suppression technologies, such as optimizing cell interconnection layouts and incorporating bypass diodes, to minimize power loss and module damage from partial shading.

Resistance to humidity, heat, and corrosion, and environmental stability: Modules should use moisture-resistant encapsulating materials (e.g., POE, hydrolysis-resistant EVA) to prevent encapsulant hydrolysis and delamination in high-humidity environments. Frames should preferentially adopt corrosion-resistant materials such as zinc-aluminum-magnesium coating or stainless steel to cope with corrosion risks from acid rain and high humidity. Good resistance to high and low temperature cycling is also required to withstand thermal stress from drastic daily temperature variations.

High reliability and resistance to extreme weather: Modules must strengthen mechanical load-bearing capacity, withstanding at least 5400Pa on the front side and 3600Pa on the rear side to cope with localized strong wind impacts in mountainous areas. Comprehensive lightning protection design should be incorporated to reduce failure risks during thunderstorms. Product warranties must meet the industry's high standards of 15 years for materials and 30 years for linear power output to lower long-term O&M costs.

Adaptability for bifacial power generation gain: Mountainous and hilly areas have abundant reflected light (e.g., from grass, rocks) and scattered light. Modules need a relatively high bifaciality rate to fully utilize rear-side light capture, enhancing comprehensive power generation efficiency and compensating for power loss caused by terrain shading.

1.2.3 Key Performance Data

(1) Low-irradiance and angle of incidence response performance: This is the primary indicator for this scenario. At 200W/m² irradiance, the low-irradiance loss rates among different modules vary significantly (ranging from 2.14% to 6.57%). Data shows that some HJT and TOPCon modules perform stably under these conditions, with loss rates below 3%, enabling more effective capture of scattered light and low-angle direct light.

(2) Mismatch resistance performance: The power tolerance and current sorting accuracy of modules are critical. Modules with positive power tolerance and consistent current grades within the same project should be selected to minimize the "series-parallel mismatch loss" highlighted in the report.

1.2.4 Recommended Preferred Products

Considering the core characteristics of mountainous and hilly scenarios—complex terrain, frequent shading, difficult transportation and installation, and high humidity—and aiming for "optimal terrain adaptability, lowest O&M costs, and maximized full-lifecycle returns," it is recommended to prioritize medium-sized TOPCon modules with high bifaciality rates as the preferred choice for mountainous and hilly power stations. Features: weight per module ≤33kg, bifaciality rate ≥80%, POE encapsulant + zinc-aluminum-magnesium frame design. This reduces transportation/installation difficulty and slope load pressure, minimizes project constraints due to terrain, and improves utilization of reflected light from the terrain.

In high-humidity (annual average relative humidity ≥80%) and rainy mountainous sub-regions in Southwest and Southeast China, HJT modules can be selectively used after evaluating the impact of their premium on project returns.

1.3 Analysis of Module Selection for Water Surface Power Stations (Fishery-PV Complementarity, Offshore PV)

1.3.1 Core Challenges of the Scenario

Water surface PV utilizes water bodies as installation carriers, primarily divided into two sub-scenarios: First, fishery-PV complementarity, built on freshwater bodies like lakes, ponds, and reservoirs, combining PV power generation with aquaculture. The environment is characterized by high humidity and freshwater vapor erosion. Second, offshore PV, deployed in nearshore or open sea environments, facing extreme harsh conditions such as high salt spray and strong winds/waves. A commonality between the two scenarios is the relatively low water surface albedo, limiting rear-side power generation gain. Power generation benefits mainly depend on front-side efficiency. Therefore, higher requirements are placed on front-side conversion efficiency; modules with high front-side efficiency can reduce the number of modules and installation area required per unit of power generation, helping to lower system costs. The differences lie in the corrosive medium, weather intensity, O&M conditions, etc. Notably, pile foundation investment for offshore PV is significantly higher than for land-based PV, so the need to reduce BOS (Balance of System) costs is even more urgent. This need further reinforces the preference for modules with high front-side efficiency.

1.3.2 Core Requirements for Modules

Strong corrosion resistance: Frames should preferentially use materials such as 316L stainless steel or high-corrosion-resistance zinc-aluminum-magnesium coatings. Glass should be equipped with anti-salt spray/anti-mold coatings. Encapsulation films should use highly hydrolysis-resistant POE/EVA. Junction boxes should adopt IP68-rated sealed and corrosion-proof designs to withstand high-humidity/salt spray erosion.

High mechanical reliability: Strengthen structural design. Fishery-PV complementarity scenarios require withstanding 6000Pa front-side and 4000Pa rear-side mechanical loads; offshore scenarios should withstand 7000Pa front-side and >5000Pa rear-side loads. Excellent vibration and impact resistance are also necessary.

High front-side efficiency and shading resistance: Adapting to low water surface albedo and limited rear-side gain, priority must be given to ensuring high front-side conversion efficiency. This not only boosts core power generation benefits but also reduces the number of modules required per unit of energy yield, minimizing installation area occupation—aligning with the core need to lower BOS costs in offshore PV. Simultaneously, optimize bypass diode layout and cell structure to enhance shading resistance and low-irradiance response performance (low-irradiance performance ratio ≥0.98), coping with light intensity fluctuations and partial shading.

Easy O&M and long lifespan: Possess self-cleaning properties to reduce contaminant adhesion and extend cleaning cycles. Product warranties must meet industry standards of 15 years for materials and 30 years for linear power output, reducing long-term O&M costs.

Additionally, for offshore PV scenarios: Must pass 1000-hour neutral salt spray test and 500-hour acidic salt spray test; use UV-resistant enhanced encapsulating materials.

1.3.3 Key Performance Data

(1) Front-side measured power: Preferably reaching 23.8% or higher to amortize costs of pile foundations, construction, O&M, etc.

(2) Weathering performance: Reliability data under harsh conditions must be provided. Modules must provide a complete report for passing the "double 85" plus bias voltage (e.g., 85°C, 85% humidity, -1500V) PID test. The junction box waterproof rating should be IP68 or above.

1.3.4 Recommended Preferred Products

BC modules, with their high front-side efficiency, perfectly align with the core needs of offshore PV to reduce BOS costs and adapt to low-albedo scenarios. Current BC modules have achieved mass production. Their full rear-side electrode design reduces metal exposure area by over 90%, fundamentally enhancing resistance to salt spray corrosion. Laboratory data indicates a power degradation rate below 8% after 30 years of operation in a simulated marine environment, significantly outperforming conventional modules. Simultaneously, their high power density per unit area can reduce the number of support structures and piles by 15%, substantially lowering balance-of-system costs. Mass-produced models with optimized encapsulation should be selected, ensuring they pass the 1000-hour neutral salt spray test. Pair with wind-wave-resistant floating platform systems, and choose manufacturers with offshore O&M capabilities to ensure after-sales response.

In addition, some high-efficiency TOPCon and HJT products with front-side efficiency exceeding 23.8% can also serve as important options.

1.4 Analysis of Module Selection for Rooftop Distributed Power Stations

1.4.1 Core Challenges of the Scenario

Rooftop distributed PV utilizes building roofs as installation carriers, primarily divided into two sub-scenarios: First, close-roof-mounted scenarios (including color steel tile roofs, concrete flat roofs, glazed tile roofs, etc.), where modules are laid flat or at low tilt angles. The core requirement is to maximize the use of limited roof space, adapt to roof morphology, and minimize impact on roof load-bearing capacity and original functions. Second, solar canopy scenarios (including residential terrace canopies, industrial/commercial building passageway canopies, etc.), where modules are installed via elevated supports, serving both power generation and auxiliary functions such as shading, passage, and storage. The core requirement is to balance power generation efficiency, structural safety, and functional compatibility.

In close-roof-mounted scenarios, there may be obstructions around the roof such as parapet walls, vents, chimneys, and ducts, which can create partial shading, inducing hot spot effects and affecting power generation efficiency and module lifespan. Some roofs (e.g., glazed tile roofs) are uneven themselves, which may also cause partial shading of modules. Additionally, the load-bearing capacity of color steel tile roofs imposes requirements on module selection.

In elevated installation scenarios, the module and support system must jointly withstand wind loads and snow loads (in northern regions), requiring high mechanical reliability and support compatibility to avoid structural sway or collapse under strong winds.

1.4.2 Core Requirements for Modules

Requirements: high conversion efficiency and high power density to maximize installed capacity within a limited area; good low-irradiance power generation capability to cope with partial shading and urban lighting conditions; highest safety standards (fire protection, electric shock prevention); aesthetic coordination with the building.

1.4.3 Key Performance Data

(1) Low-irradiance performance: For roofs with shading or non-optimal tilt angles, the module's output capability in the common irradiance range of 400-800W/m² is more important than peak power. Attention should be paid to whether the module's efficiency curve in this range is flat.

(2) Safety and reliability performance: Verify whether the module has obtained higher fire safety certifications for distributed scenarios. For color steel tile roofs, also evaluate the module's corrosion resistance in a metal roof environment.

1.4.4 Recommended Preferred Products

For close-roof-mounted scenarios, where rear-side power generation is not a consideration, priority should be given to BC modules with higher conversion efficiency to fully utilize the limited roof area.

For elevated installation scenarios, while considering rear-side power generation, a comprehensive evaluation of levelized cost of energy (LCOE) should be conducted, giving preference to TOPCon modules offering better cost-effectiveness.

Appendix 1: Announcement of 2025 SOLARBE TEST Awards for PV Module on Specific Performance Index

I. Evaluation Background

The 2025 SOLARBE TEST Awards for PV Module on Specific Performance Index aim to end the industry's "parameter involution." Carbon Discovery Research Institute and Solarbe, in collaboration with the authoritative third-party testing laboratory Gsolar Test, conducted a horizontal evaluation of participating modules under harsh conditions approaching reality, focusing on "single-point limit performance." Through this event, we seek to identify the "single-event champions" that excel in each specific dimension such as low-irradiance response, bifaciality rate, high-temperature power generation, and mechanical load. It is hoped that these modules can achieve maximum power generation in the environments they are best suited for. This is like establishing clear lighthouses for the industry, providing crucial data navigation for end-users to make scientific selections under complex scenarios.

II. Evaluation Protocol

This evaluation primarily focuses on mainstream domestic module manufacturers, covering mass-produced flagship products of current mainstream technology routes including TOPCon, HJT, and BC. Conclusions were determined through various forms of sampling and sample submission, followed by laboratory testing data. The evaluation comprises indoor testing and outdoor validation. Indoor testing mainly examines four items: low-irradiance response, bifaciality rate, efficiency at 800W/m² irradiance, and total power performance. Outdoor validation is currently underway with a one-year testing period.

III. Announcement of Evaluation Results

3.1 Champion of PV Module Low-irradiance Performance

3.1.1 Test Objective

To comprehensively evaluate the power generation performance of PV modules under real-world conditions, especially under insufficient sunlight, providing key data for module design, system design, and investment return calculations.

3.1.2 Test Method

Measure PV module power under Standard Test Conditions (STC: irradiance 1000W/m², temperature 25°C, AM1.5G) and under Low Irradiance Conditions (LIC: irradiance 200W/m², temperature 25°C, AM1.5G).

3.1.3 Value of the Award

This honor recognizes exceptional performance of PV modules under low-irradiance conditions. Products with top-tier low-irradiance response capability can efficiently capture scarce light energy during dawn and dusk, significantly extending the daily effective power generation hours and bringing tangible power output increases to power stations. It signifies that PV technology has progressed from pursuing peak power under laboratory standard test conditions to striving for full-time energy capture in real power generation scenarios. It is one of the key innovations for reducing the levelized cost of energy (LCOE) over the full lifecycle.

3.1.4 Award-Winning Company

Trina Solar Co., Ltd.

3.1.5 Evaluation Data

200W/m² Low-Irradiance Rankings

Date	Company	Module Model	ID	200W/m² Irradiance	Size (m²)	Pmax [W]	Isc [A]	Voc [V]	Ipm [A]	Vpm [V]	FF [%]	T_Object [℃]	**Low-irradiance performance**	
2025/11/19 11:51	Trina Solar	TSM-710NEG21C.20	A12251000100800-L200	L200	3.106	139.04	3.61	46.67	3.42	40.61	82.53	24.1	0.1984	99.18%
2025/11/19 11:48	Trina Solar	TSM-710NEG21C.20	A12251000100802-L200	L200	3.106	139.09	3.61	46.66	3.43	40.61	82.50	24.0	0.1983	99.14%
				L200	3.106	127.98	3.61	43.11	3.44	37.17	82.14	22.6	0.1976	98.82%
				L200	2.703	121.87	3.12	46.64	3.00	40.56	83.62	24.1	0.1962	98.08%
				L200	2.703	121.49	3.12	46.62	3.00	40.55	83.50	24.1	0.1961	98.03%
				L200	2.795	123.92	2.76	54.90	2.62	47.36	81.71	22.5	0.1961	98.03%
				L200	2.795	122.62	2.73	54.79	2.59	47.43	81.86	23.8	0.1956	97.82%
				L200	2.795	122.95	2.75	54.68	2.60	47.25	81.80	20.6	0.1952	97.59%
				L200	3.106	137.46	3.62	46.25	3.44	39.95	82.04	19.8	0.1951	97.57%
				L200	2.795	122.51	2.73	54.59	2.60	47.21	82.09	21.0	0.1946	97.28%
				L200	2.701	122.34	3.13	46.65	3.02	40.57	83.72	24.0	0.1938	96.90%
				L200	2.701	122.22	3.13	46.65	3.01	40.56	83.83	23.8	0.1937	96.85%
				L200	3.106	137.07	3.60	46.21	3.43	39.94	82.44	20.6	0.1935	96.75%
				L200	2.795	121.45	2.72	54.40	2.58	47.04	81.99	20.8	0.1934	96.70%
				L200	2.795	125.68	2.82	55.59	2.62	48.01	80.13	20.4	0.1915	95.73%
				L200	2.701	121.28	3.15	46.42	3.02	40.18	82.87	24.1	0.1914	95.71%
				L200	2.701	121.12	3.15	46.45	3.01	40.25	82.87	24.4	0.1911	95.57%
				L200	2.701	121.15	3.15	46.43	3.01	40.23	82.71	24.2	0.1909	95.45%
				L200	2.701	120.86	3.16	46.41	3.01	40.16	82.44	23.9	0.1908	95.41%

3.2 Champion of PV Module Conversion Efficiency at 800W/m² Irradiance

3.2.1 Test Objective

To assess the real-world performance of modules under a common medium irradiance level, shifting module performance evaluation from an ideal "laboratory peak" back to a more common "real-world summit."

3.2.2 Test Method

Measure the front-side efficiency of PV modules under irradiance of 800W/m², temperature 25°C, and AM1.5G.

3.2.3 Value of the Award

This honor recognizes top-tier efficiency performance of PV modules under 800W/m² irradiance. It not only represents the performance pinnacle under irradiance levels commonly found in real-world power stations but also signifies that the module can maintain efficient and stable power output throughout multiple irradiance intervals during the day, precisely meeting the diverse power generation needs of different regions and scenarios.

3.2.4 Award-Winning Company

GCL System Integration Technology Co., Ltd.

3.2.5 Evaluation Data

800 W/m² Efficiency Rankings

Date	Company	Module Model	ID	800W/m² Irradiance	Size (m²)	Pmax [W]	Isc [A]	Voc [V]	Ipm [A]	Vpm [V]	FF [%]	T_Object [℃]	Eff [%]
2025/12/22 19:12	GCL	GCL-NTI2R/66GDF625	562510118210017-800	Z800	2.701	506.35	12.60	48.47	12.02	42.13	82.91	24.1	0.23432
2025/12/22 19:27	GCL	GCL-NTI2R/66GDF625	562510118210019-800	Z800	2.701	505.95	12.55	48.50	12.00	42.17	83.11	24.4	0.23413
2025/12/22 18:27	GCL	GCL-NTI2R/66GDF625	562510118210015-800	Z800	2.701	505.87	12.58	48.48	12.02	42.10	82.94	24.1	0.23410
2025/12/22 17:30	GCL	GCL-NTI2R/66GDF625	562510118210016-800	Z800	2.701	505.69	12.57	48.54	12.03	42.02	82.88	24.3	0.23401
				Z800	2.701	505.13	12.54	48.74	11.97	42.18	82.68	23.8	0.23375
				Z800	2.701	504.99	12.51	48.66	11.97	42.19	82.93	23.7	0.23369
				Z800	2.703	498.90	12.50	48.64	11.96	41.73	82.03	24.5	0.23068
				Z800	2.703	497.28	12.49	48.72	11.94	41.64	81.74	23.9	0.22993
				Z800	3.106	566.84	14.37	48.30	13.69	41.40	81.68	20.6	0.22810
				Z800	3.106	565.63	14.46	48.69	13.72	41.23	80.35	24.0	0.22761
				Z800	3.106	565.59	14.44	48.32	13.69	41.31	81.03	19.8	0.22760
				Z800	3.106	565.06	14.44	48.69	13.71	41.21	80.35	24.5	0.22738
				Z800	2.795	507.36	11.01	57.45	10.41	48.72	80.25	22.5	0.22688
				Z800	2.795	505.75	10.94	57.14	10.40	48.62	80.91	20.4	0.22616
				Z800	2.795	504.76	10.91	57.14	10.35	48.75	80.95	21.2	0.22572
				Z800	2.795	503.09	10.91	57.35	10.35	48.63	80.43	23.7	0.22497
				Z800	2.795	502.82	10.83	56.97	10.29	48.85	81.49	20.9	0.22485
				Z800	3.106	520.93	14.38	45.44	13.70	38.04	79.70	22.7	0.20962

3.3 Champion of PV Module Bifaciality Rate

3.3.1 Test Objective

To accurately measure the inherent rear-side power generation capability of modules and quantify it into a single metric (bifaciality rate) comparable to front-side power. This metric is the cornerstone for bifacial technology to move from "concept" to "commercialization," providing indispensable key data for module trading, system design, energy yield prediction, and financial analysis.

3.3.2 Test Method

Under Standard Test Conditions (STC: irradiance 1000W/m², temperature 25°C, AM1.5G), measure the electrical performance parameters of the module's front side and rear side respectively, and calculate the module's bifaciality rate (power bifaciality rate, current bifaciality rate, etc.).

3.3.3 Value of the Award

This honor focuses on the ultimate level of bifacial power generation capability of PV modules. A higher bifaciality rate means the module can more efficiently utilize ground-reflected light and scattered light, creating substantial additional power generation revenue for power stations, especially in high-albedo environments like deserts and Gobi. It represents a profound shift in PV value assessment from single front-side power to systematic power generation gain, reflecting the precise adaptability of products to specific application scenarios, and is a core technical factor driving improved return on investment for PV power stations.

3.3.4 Award-Winning Company

Trina Solar Co., Ltd.

3.3.5 Evaluation Data

Bifaciality Rate Rankings

Date	Company	Module Model	ID	Rear Irradiance	Size (m²)	Pmax [W]	Isc [A]	Voc [V]	Ipm [A]	Vpm [V]	FF [%]	T_Object [°C]	Bifi
2025/11/19 14:17	Trina Solar	TSM-635NEG19RC.20	A12251000100805-B1000	B1000	2.701	534.70	13.11	48.77	12.65	42.27	83.64	24.7	0.8474
2025/11/19 14:04	Trina Solar	TSM-635NEG19RC.20	A12251000100806-B1000	B1000	2.701	534.78	13.13	48.76	12.66	42.23	83.54	24.9	0.8471
2025/11/19 14:39	Trina Solar	TSM-710NEG21C.20	A12251000100802-B1000	B1000	3.106	574.65	14.87	48.65	13.81	41.61	79.43	24.1	0.8192
2025/11/19 14:51	Trina Solar	TSM-710NEG21C.20	A12251000100800-B1000	B1000	3.106	574.16	14.96	48.74	13.77	41.68	78.72	24.8	0.8191
				B1000	2.703	506.22	12.78	48.70	11.97	42.30	81.33	24.7	0.8170
				B1000	3.106	575.31	14.87	48.39	13.78	41.74	79.93	17.6	0.8167
				B1000	2.701	513.7	13.18	48.56	12.14	42.31	80.23	24.5	0.8095
				B1000	2.701	511.7	13.19	48.54	12.10	42.30	79.92	24.3	0.8076
				B1000	2.703	500.23	12.66	48.69	11.79	42.45	81.14	24.6	0.8051
				B1000	2.701	508.2	13.12	48.54	12.02	42.30	79.80	23.8	0.8024
				B1000	2.701	504.0	13.16	48.40	11.95	42.18	79.10	23.3	0.7953
				B1000	2.795	493.33	10.76	57.04	10.07	48.97	80.36	17.4	0.7871
				B1000	3.106	555.05	14.27	48.24	13.38	41.49	80.61	17.2	0.7836
				B1000	2.795	494.50	10.65	57.18	10.03	49.28	81.22	17.8	0.7824
				B1000	2.795	492.47	10.89	57.25	9.98	49.34	78.98	18.9	0.7821
				B1000	2.795	489.74	10.61	57.10	9.95	49.22	80.82	17.7	0.7775
				B1000	2.795	482.73	10.37	57.06	9.81	49.19	81.56	18.7	0.7687
				B1000	2.795	463.87	10.11	57.61	9.34	49.65	79.66	17.7	0.7067

3.4 Champion of PV Module Total Power Performance

3.4.1 Test Objective

To transition from "laboratory power" to "on-site power," and from "nominal value" to "actual value." This makes module performance evaluation more realistic and significantly reduces investment uncertainty.

3.4.2 Test Method

Simultaneously flash-test the PV module's power under the following conditions: front side under Standard Test Conditions (STC: irradiance 1000W/m², temperature 25°C, AM1.5G); rear side under irradiance levels of 200W/m², 300W/m², and 400W/m² respectively.

3.4.3 Value of the Award

This honor focuses on the top-tier performance of PV modules in the total power dimension. It signifies that the product not only reaches performance peaks under standard test conditions but also delivers sustained and stable high power output across all scenarios of actual power plant operation, precisely adapting to the diverse needs of different environments and projects.

3.4.4 Award-Winning Company

Shenzhen Skyworth Photovoltaic Technology Co., Ltd.

3.4.5 Evaluation Data

Total Power Gain（1000+200）

Date	Company	Module Model	ID	Different Irradiance	Size（m²）	Pmax [W]	Isc [A]	Voc [V]	Ipm [A]	Vpm [V]	FF [%]	T_Object [°C]	Total Power Coefficient
2025/12/19 16:22	Skyworth	QM182THCD630-78	QMACTASWD012504137756-1000+B200	Z1000+B200	2.795	730.27	15.73	57.60	14.94	48.89	80.59	20.7	1.1628
				Z1000+B200	2.795	731.27	15.86	57.75	15.04	48.61	79.83	21.0	1.1613
				Z1000+B200	2.701	732.70	18.17	49.19	17.37	42.18	81.95	23.9	1.1612
				Z1000+B200	3.106	822.17	20.90	48.83	19.86	41.41	80.55	20.7	1.1607
				Z1000+B200	2.795	733.30	15.99	58.12	15.13	48.46	78.94	22.7	1.1602
				Z1000+B200	2.795	727.12	15.88	58.01	15.01	48.46	78.95	23.7	1.1602
				Z1000+B200	2.701	732.37	18.22	49.19	17.37	42.15	81.73	24.2	1.1601
				Z1000+B200	2.795	729.69	15.89	57.80	15.04	48.51	79.46	21.0	1.1584
				Z1000+B200	2.703	714.66	18.05	49.27	17.19	41.57	80.36	24.0	1.1533
				Z1000+B200	2.703	715.69	18.05	49.27	17.20	41.61	80.45	24.3	1.1519
				Z1000+B200	3.106	806.24	20.94	49.23	19.53	41.27	78.21	24.0	1.1493
				Z1000+B200	3.106	804.71	20.90	49.24	19.50	41.26	78.18	24.5	1.1480
				Z1000+B200	2.795	751.16	16.10	58.47	15.11	49.70	79.80	20.7	1.1444

Appendix 2: 2025 PV Module Shipment Ranking

Recently, to help the industry chain fully understand the current state of industry development, Solarbe & Solarbe Consulting conducted two weeks of intensive research, verification, and analysis, and released this ranking list of 2025 module shipments for 27 PV companies for reference.

Overall, the Top 4 brands remain stable, with shipments exceeding 300GW, accounting for nearly half of the market share, indicating further increased concentration. The Top 15 brands together shipped approximately 560GW, already constituting the absolute mainstay of market supply.

SOLARBE
Ranking of Chinese PV Companies by Module Shipments in 2025
Data Source: Solarbe & Solarbe Consulting

Rank	Company	Full-Year Shipment (GW)
1	JinKO Solar	85~90
2	LONGi	≈85
3	Trinasolar	65~70
3	JA SOLAR	65~70
5	TW SOLAR	45~47
6	ASTRONERGY	35.6
7	GCL SYSTEM INTEGRATION	25~26
8	CanadianSolar	24.5~24.7
9	DMEGC	23.2
10	YINGLI SOLAR	21~22
10	TCL SOLAR	21~22
10	DASOLAR	21~22
13	AIKO	14~15
14	risen	12~14
15	HuaYaoPV	10+
16	RONMA	7+
17	Gokin	6
18	CETC	5.5
19	RUNERGY	5.05
20	HY SOLAR	4.7
20	SUNREV SOLAR	4.7
22	Osda	4.5
23	Solargiga Energy	3.8~4
24	CECEP SOLAR	3.8
25	HANERSUN	3.1
26	ReneSola	2.918
27	ZNSHINESOLAR	2.367

Notes:
1. All data is compiled by Solarbe & Solarbe Consulting through channels including telephone surveys, supplier visits, and customer visits, combined with public news, announcements, investor communications, bidding information, and supply contracts. Reproduction must be attributed to the source.
2. The statistics represent brand shipment volume, including capacity used by the company's own downstream segments, but excluding:OEM production for other brands,Capacity used by downstream segments that originates from other companies' products.
3.Statistics only account for module shipments; separately sold cells are not included.
4.This data shall not be used as a basis for investment or procurement decisions. If the figures differ from a company's actual shipment volume, please refer to the official announcements of listed companies.