PV Technology Roadmaps and Trends in Advanced PV Technologies

JA High Efficiency TOPCon: DeepBlue 5.0

Ignacio Espinosa

Head of European Technical Team

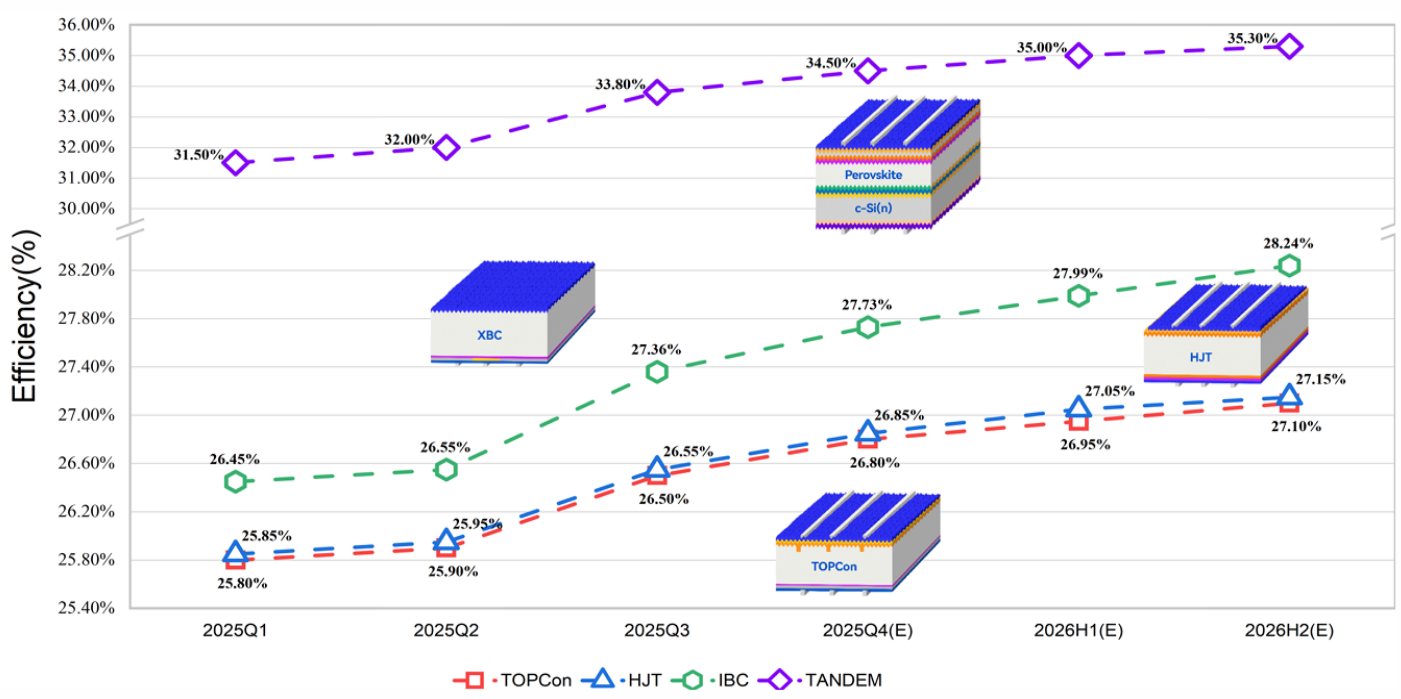
30.10.2025

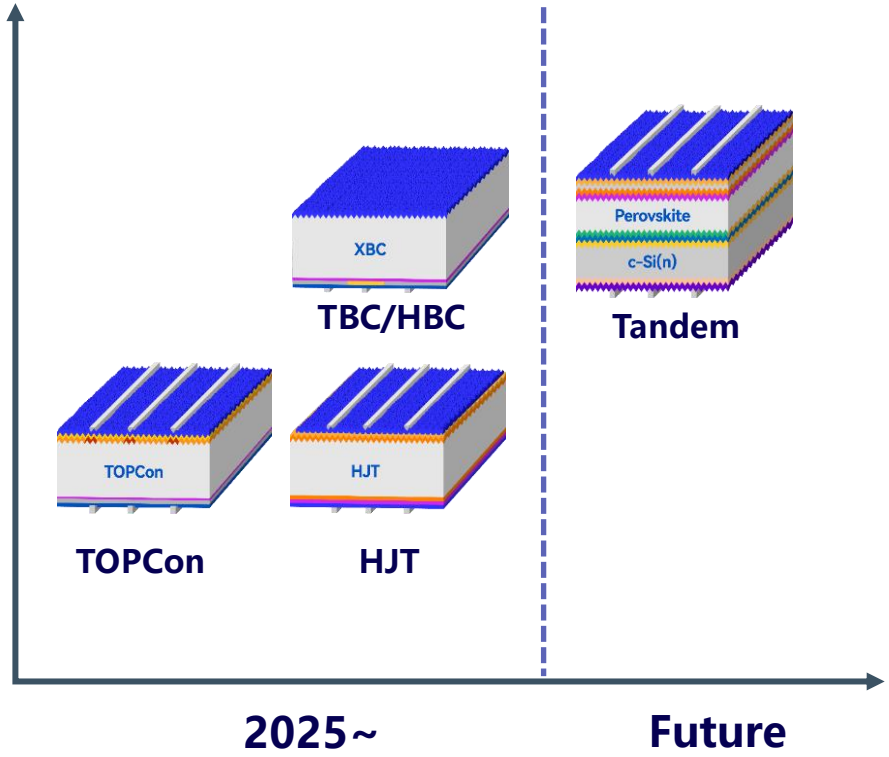
JA SOLAR

CONTENT

JA Cell Technology Roadmap

Cell Efficiency



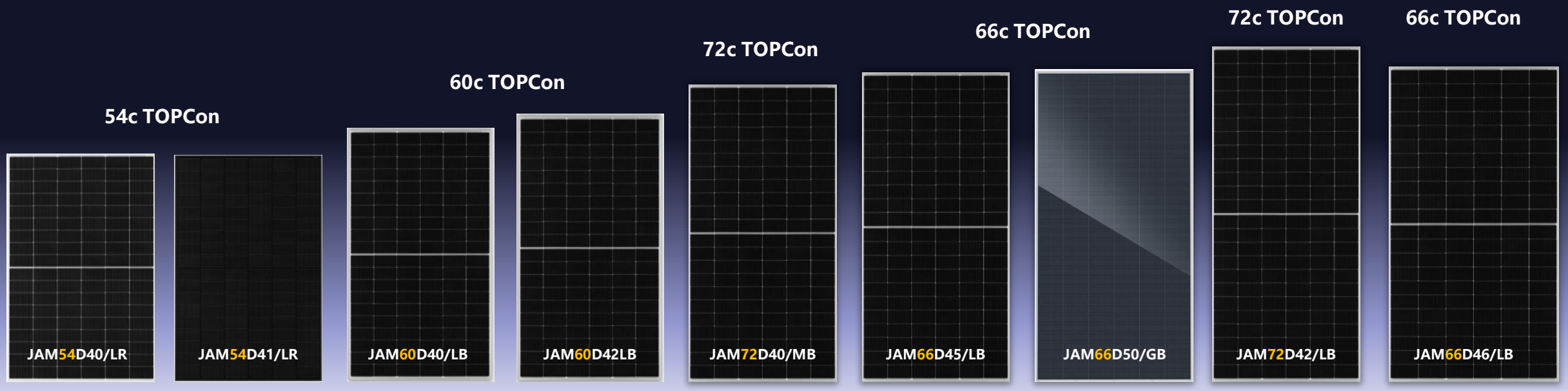


- The efficiency of n-type cells holds significant potential for development in the future, and the current JA’ s main route is TOPCon while continuously exploring other new technology cells
- TOPCon cell technology will occupy the main market position in the next few years.

MAINSTREAM MODULES

Our customer's choice.
The backbone of our success.

Residential	C&I	Utility



High power demand choose Dual-glass Monofacial (-LR)

High-power Mainstream Product

JA SOLAR

DeepBlue 4.0 Pro (Advanced) 640W+

High Efficiency & High Power

Using LRF+20BB+BPF and other technologies, improve optical absorption, reduce electrical loss, and increase power by 15-20W

Higher Bifacial Gain

Using BPF technology, the bifaciality has been further improved to 85±5% compared to DeepBlue 4.0, and higher rear gain increases the power generation per watt

Excellent Reliability

Low microcrack: Thinner ribbon reduces internal stress, lowering the risk of microcrack and reducing power loss caused by microcrack

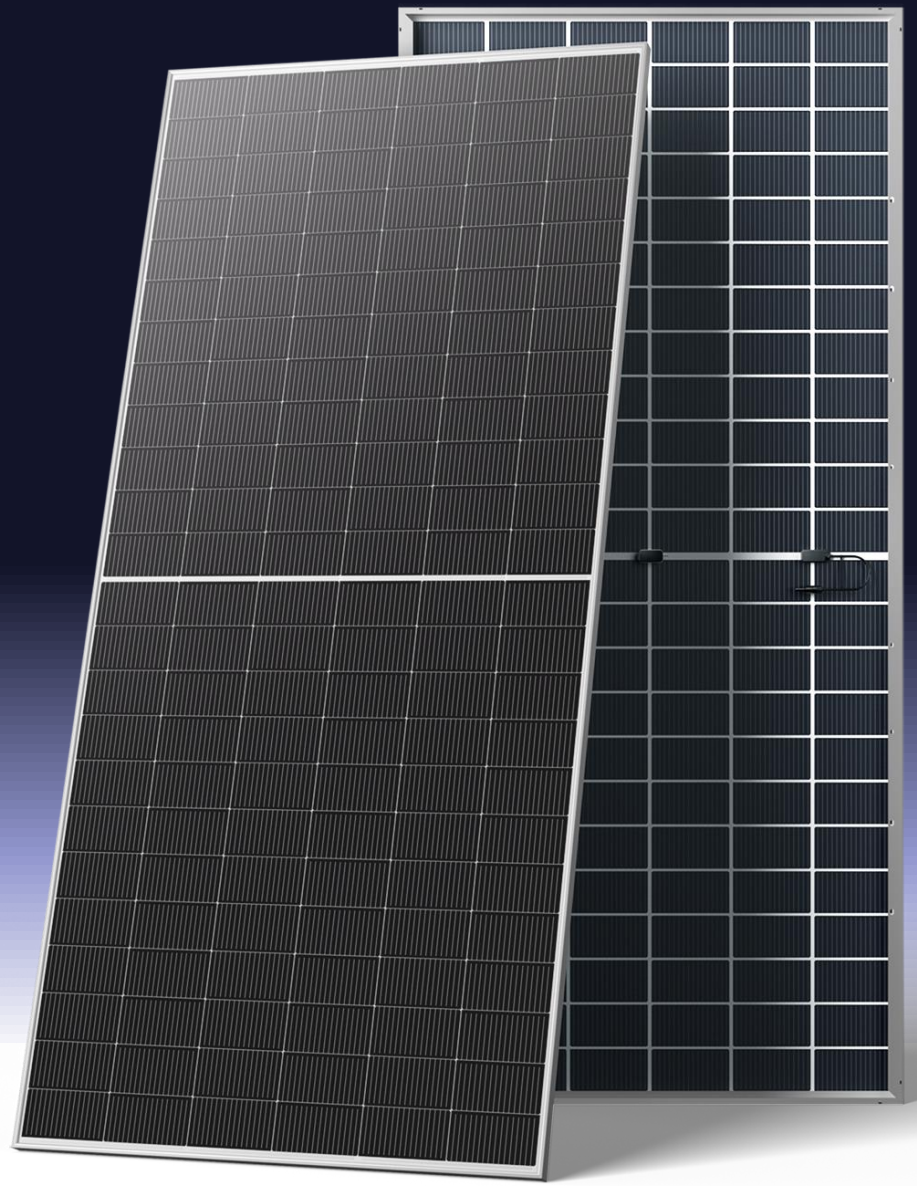
Higher Customer Value

High power reduces BOS costs, high bifaciality improves bifacial power generation, and reduces LCOE costs

DEEP BLUE 4.0 Pro

640W+

2382*1134mm

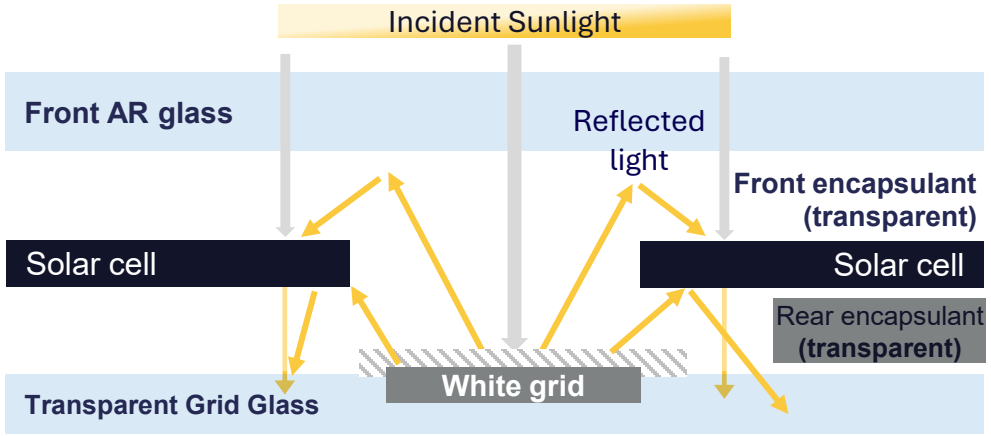


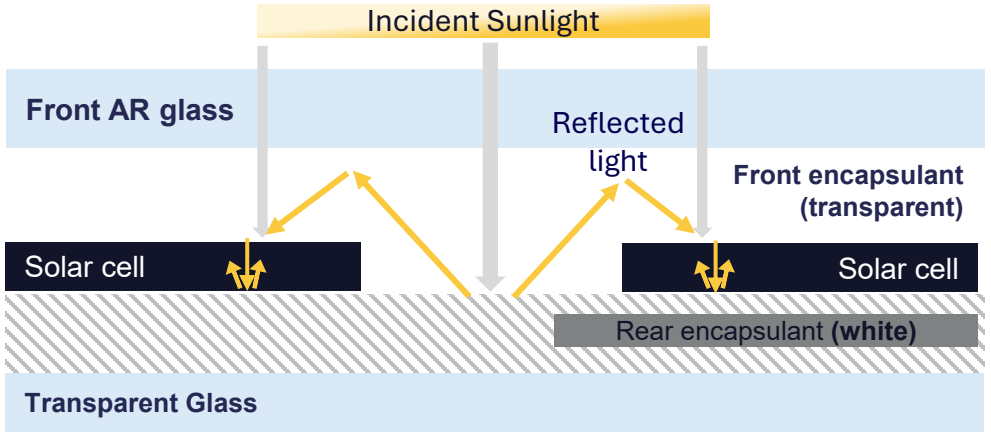
Never Stop Evolution

Better Power Output with Double Glass Monofacial Modules

Double glass monofacial modules enhance power output by replacing the transparent encapsulant at the rear with the white encapsulant, maximizing utilization of frontal irradiance.

	Double Glass Bifacial Module	Double Glass Monofacial Module
Structure	Front glass / front encapsulant / cells / rear encapsulant (**transparent**) / transparent **grid glass**.	Front glass / front encapsulant / cells / rear encapsulant (**white**) / transparent glass.
Characteristics	To fully utilize rear-side power generation, **frontal power** is slightly **reduced**.	Maximizes absorption of frontal incident light, **increasing frontal power** by approximately 5W.
Application Scenarios	Better suited for **utility-scale PV** plants and other scenarios leveraging bifacial gain.	Ideal for **rooftop PV**, particularly flushed-mount monofacial installations.





Product Advantages

Our double glass monofacial modules offer several benefits to our customers.

25-Year Warranty

Lower **Investment** Costs

High **Power Class** and **Power Generation**

High **Reliability**

Higher **Comprehensive Returns**

Higher **Installation Capacity**

JA SOLAR

CONTENT

DeepBlue 5.0 650W+

DeepBlue 5.0 Pro uses Multi-shard Cut technology and GFI to achieve a high-power level of 650W+, creating higher value for customer

Enhanced with advanced technology, higher power generation and superior reliability

Higher Power Higher Efficiency

Bycium+ 5.0 Cell Technology

(Including 20BB, BPF, etc.)

High Density Packaging

Increasing the effective power-generating area by 1.82%

Enhanced Reliability

Anti-Dust Frame Design

JA Solar patent: short frame perforated design, lower risk of hot spot failure

CSE(Composite Structure Enhancement Technology)

Excellent consistency in module thickness, enhanced edge corrosion resistance

DEEP BLUE 5.0

Higher Power Generation

Degradation: 1%/0.35%
High Bifaciality: 85%±5%,
Better Temperature Coefficient(-0.26%/℃),
Better low-light power generation performance

Lower LCOE, Higher Customer Value

Higher Power

Enhanced Reliability

Higher Power Generation

Intelligent · Quality · Evolution

IV. DeepBlue 5.0 – JA New Technology Product

JA SOLAR

JAM66D50 GB

DeepBlue 5.0 enhance the aspect of optical and electrical performance, from wafers to cells and modules, to maximize value for clients

670W
Module Power up to

24.8%
Efficiency up to

85%
Bifaciality

-0.26%
Temperature Co. of Pmax

0.35%
Annual Degradation Over 30 years

Premium Wafers

- More concentrated resistivity and improved uniformity
- Higher minority carrier lifetime
- Providing high-quality substrates for modules

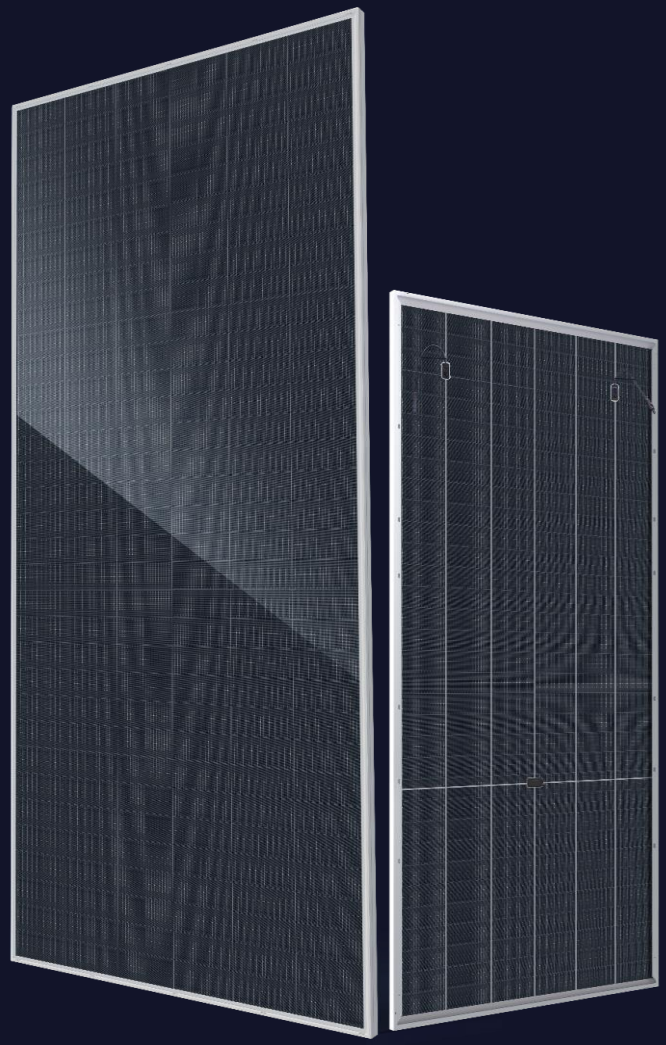
Bycium+ 5.0 Cells

- High-efficiency n-type passivated contact cell technology
- BPF: Optimized structure for enhanced light absorption
- Defect compensation to reduce recombination losses
- Ultra-high open-circuit voltage 749 mV
- MC (Multi-shard Cut)

Innovated Modules

- GFI (Gapless Flexible Interconnection)
- HDP (High-Density Packaging)
- UTM (Ultra-Transparent Material Optimization)
- CSE (Composite Structure Enhancement)

DEEP BLUE 5.0



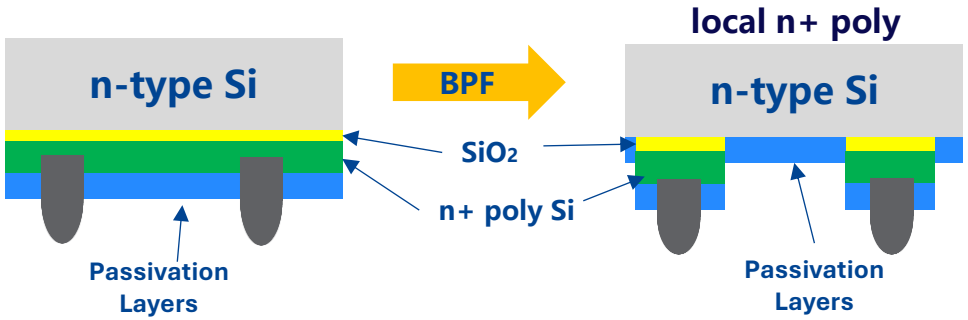
IV. DeepBlue 5.0 – JA New Technology Product
Cell Level

BPF

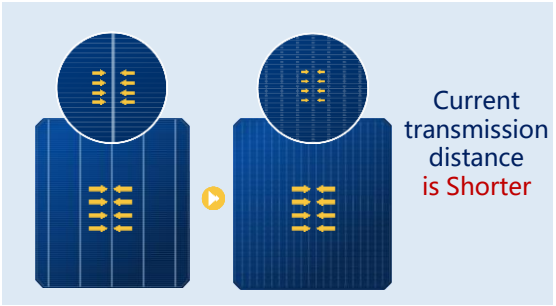
Less energy loss: Local thin poly Si lets more light through, generating more power.

Utilize light reflection: Increase utilization of rear reflective light

Higher power generation: Improve cell efficiency and bifaciality

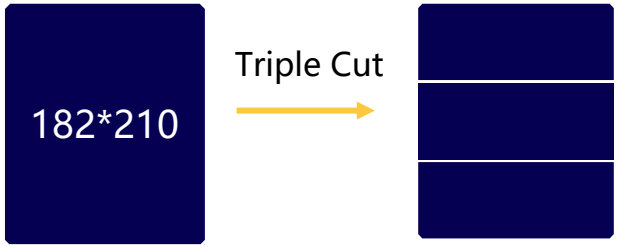


20BB More busbars reduce cell Rs and improve module power



Multi-shard Cut

Cell is cut into smaller cells to achieve lower current loss and higher module power



- **Full Screen**
- **Low loss of cells overlay**
- **Higher manufacturability**
- **High reliability**

IV. DeepBlue 5.0 – JA New Technology Product
Module Level

GFI (Gapless Flexible Interconnection)

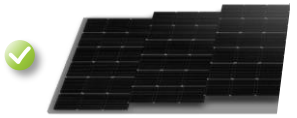
To improve the power, overlapping technology is used to achieve negative cell space

To prevent the microcracking of the overlapping area between the cells, a film is first attached to the cell to play a buffer role

Regular connection

- ✓ High yield
- ✓ Reliability
- • Lower module efficiency

GFI Technology (JA patented)



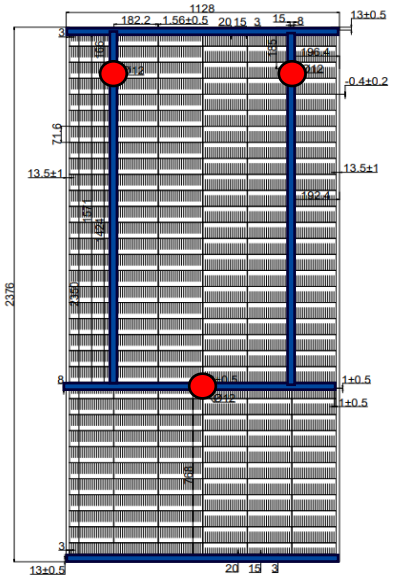
- ✓ Higher yield
- ✓ Better reliability
- ✓ Higher module efficiency

HDP (High-Density Packaging)

Full Screen Technology:

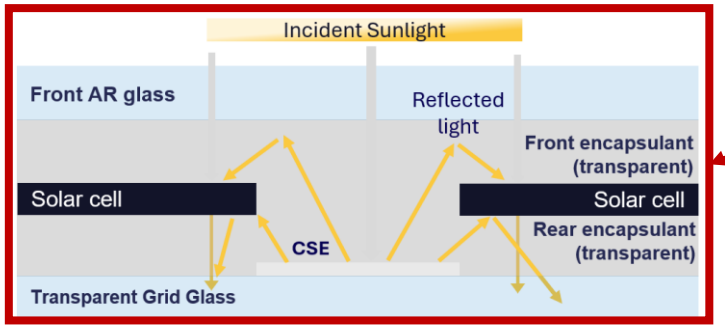
Interconnect ribbon is placed at the back, less connection usage and simpler layout

Increasing the effective power-generation by 1.82%



CSE (Composite Structure Enhancement)

Using white EVA strips (higher width and thickness), locate between different solar strings to increase the light reflection, replacement of the LRF



IV. DeepBlue 5.0 – JA New Technology Product

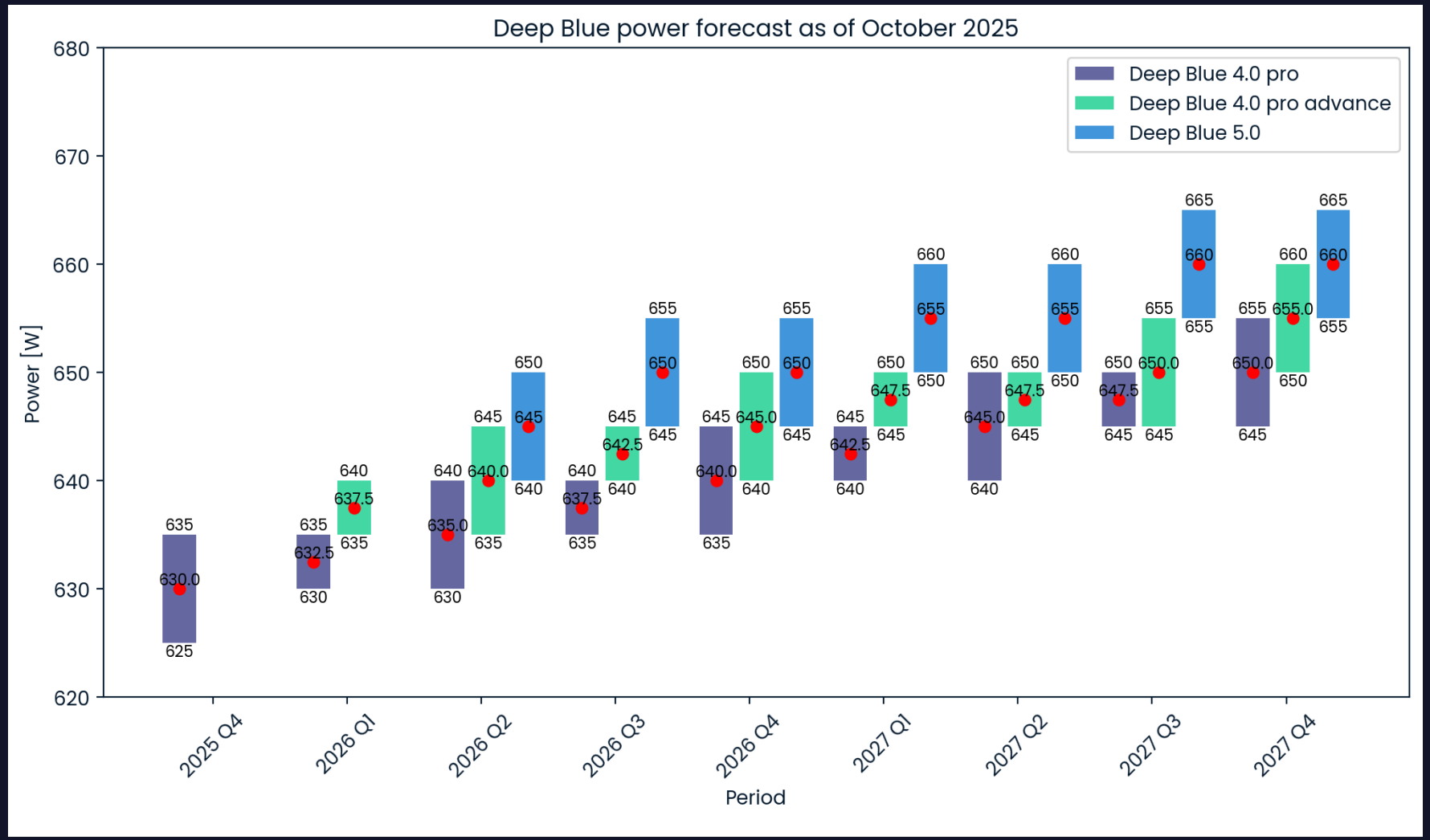
Product Performance Comparison

	Conv. DeepBlue 4.0 Pro[1]	DeepBlue 4.0 Pro Advanced[2]	DeepBlue 5.0
Power(W)	620-635	635-640	640-665
Efficiency	23.0 %	23.7 %	24.1 %
Warranty(y)	12-year product warranty 30-year linear power output warranty	12-year product warranty 30-year linear power output warranty	12-year product warranty 30-year linear power output warranty
Degradation	1% 1st-year / 0.4% annual	1% 1st-year / 0.4% annual	1% 1st-year / 0.35% annual
Temperature co. (Pmax)	-0.29%/℃	-0.28%/℃	-0.26%/℃
Bifaciality	80%±5%	85%±5%	85%±5%
Full-time hours in the first year (h)[3]	2190	2195	2211

1 – Deep Blue 4.0 pro: 66D45-LB 2382x1134 mm short cable
2 – Deep Blue 4.0 pro adv: 66D45-LB (20BB+BPF+ALD) 2382x1134 mm short cable
3 – Year 1 full-time hours are calculated as the total net energy yield in the first simulated year divided by the installed capacity. Simulation based on a location in Spain.

Product Performance Comparison

Utility bifacial power generation situation



JA SOLAR

CONTENT

Field Test (TOPCon & BC)

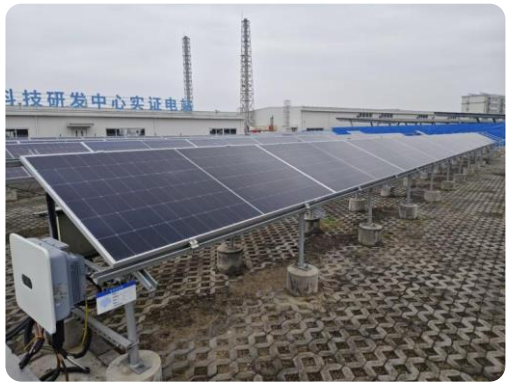
Field Test Details

Location	China-Yangzhou
Average Temperature	6-15℃ in Winter
Installation	Fixed support (parallel)
Installation Angle	25°
Height	0.5m
Ground	Cement (~13% reflection)
Period	24.12-25.4

Module Dimension	2382x1134mm	
Technology	TBC	JA - TOPCon
Power	650W	616W
Efficient	24.10%	22.80%
Bifacial Factor	68.9%	76.1%
Rsh(Ω)	906	1658
Capacity（MWp）	5.852	5.545
Module Number	9	9

* Only one string.

TBC

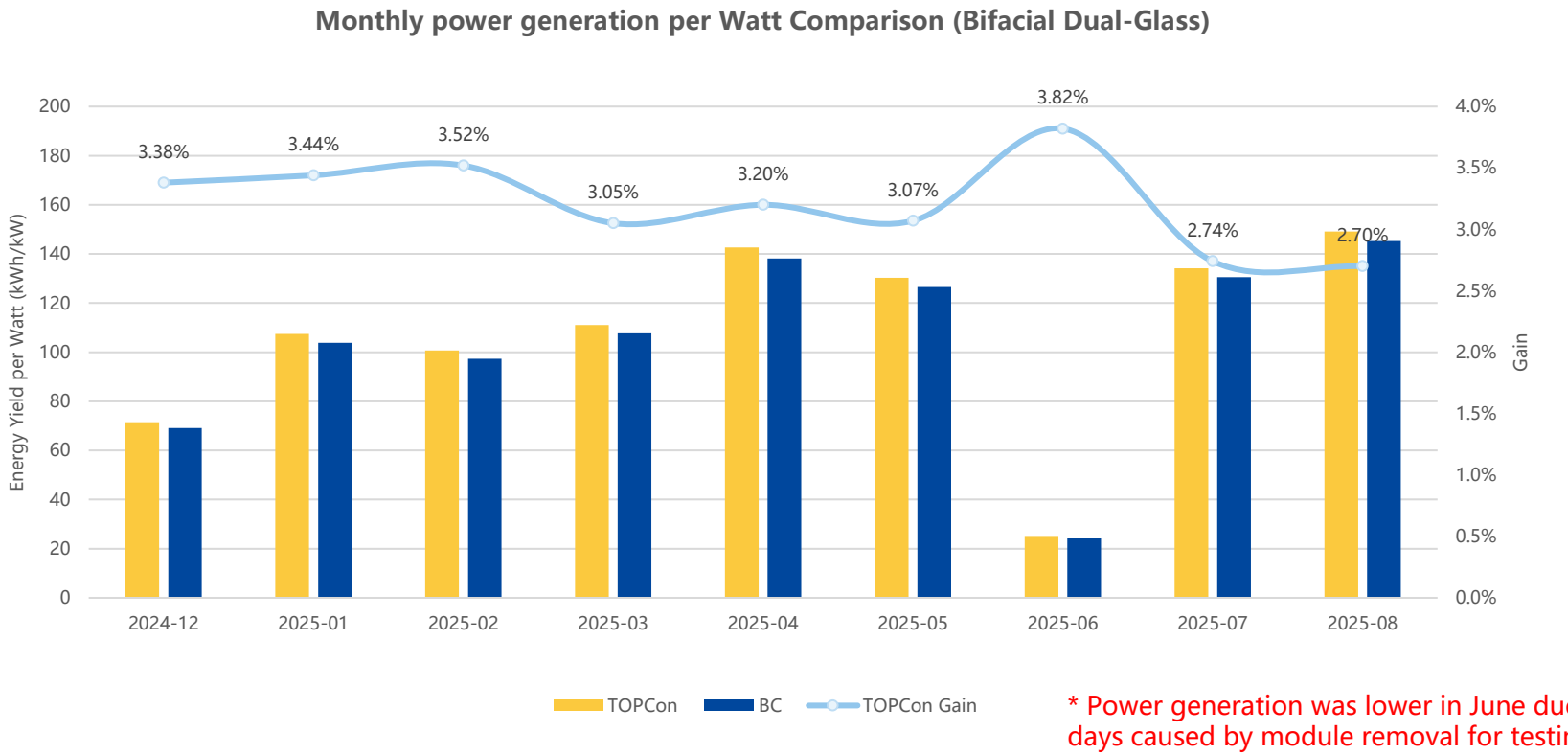


TOPCon

Field Test (TOPCon & BC): Power Generation Comparison

Power Generation Comparison: TOPCon & BC Modules

Compared to BC modules, TOPCon modules exhibit higher power generation and better low irradiance performance



* Power generation was lower in June due to fewer working days caused by module removal for testing.

From December 2024 to August 2025, JA's TOPCon bifacial dual-glass modules generated an average of **3.11% more power per watt** compared to BC modules.

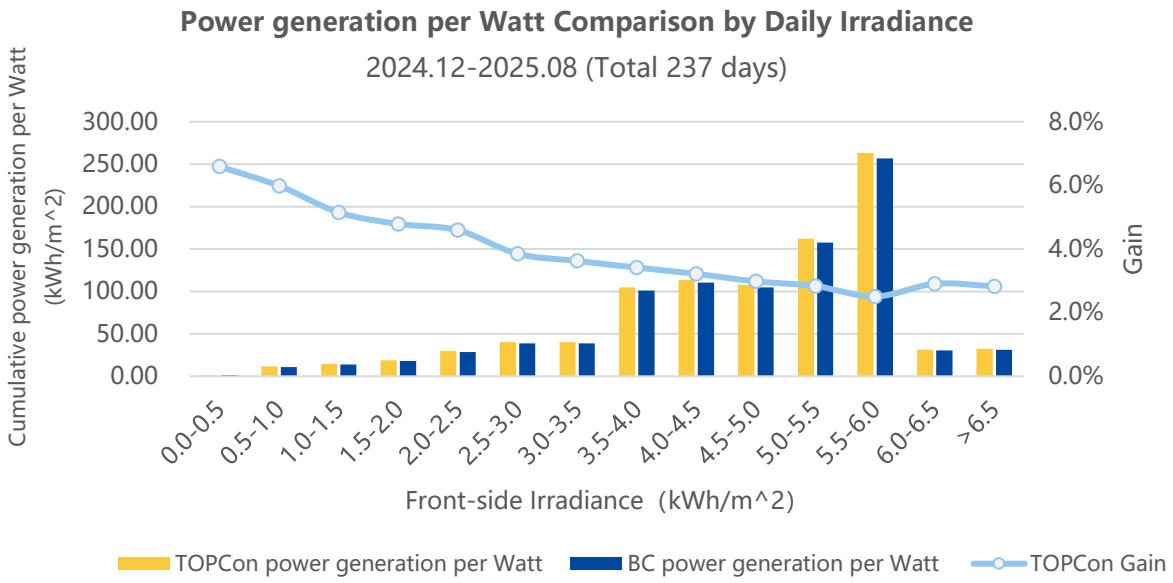
Field Test (TOPCon & BC): Power Generation Comparison

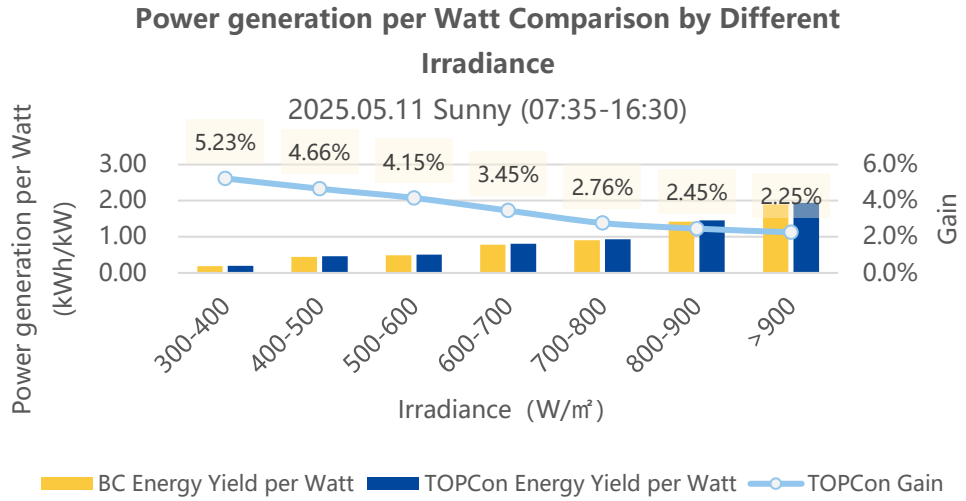
TOPCon (Bifacial dual-glass) had better low irradiance performance than BC

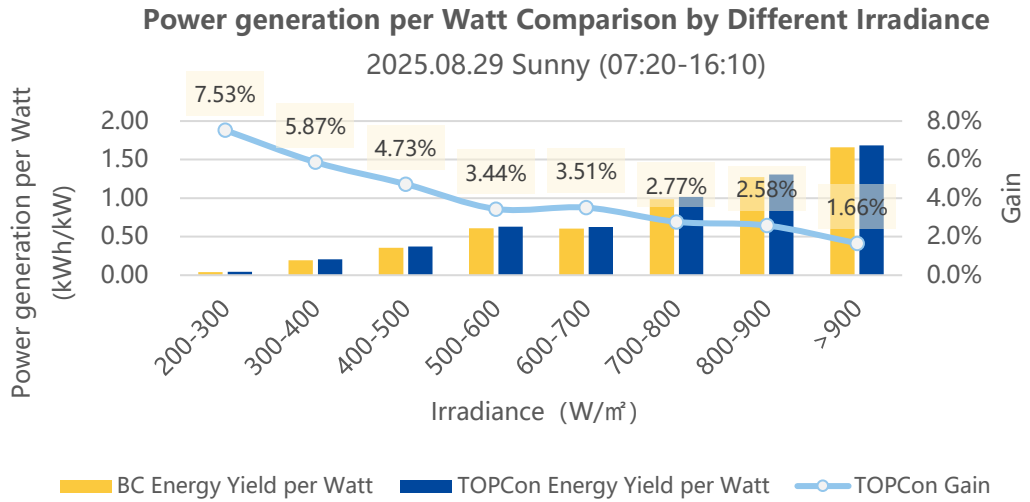
- Overall, the lower daily irradiance, the higher power generation gain per watt of TOPCon modules, **reaching a maximum of over 6%;**
- Within one day, the lower irradiance, the higher power generation gain per watt of TOPCon modules, **reaching a maximum of over 7%**.

The advantage in power generation per watt for TOPCon modules increases as irradiance decreases:

- When irradiance is above 800W/m², the gain is within 2.6%.
- When irradiance is below 500W/m², the gain exceeds 4.5%.
- When irradiance is below 300W/m², the gain exceeds 7.5%.





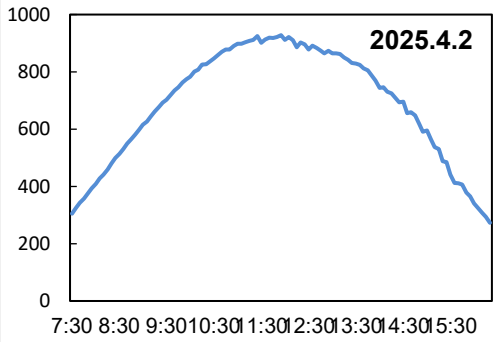
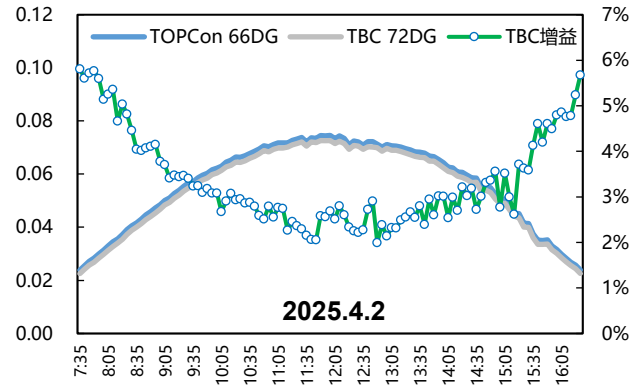
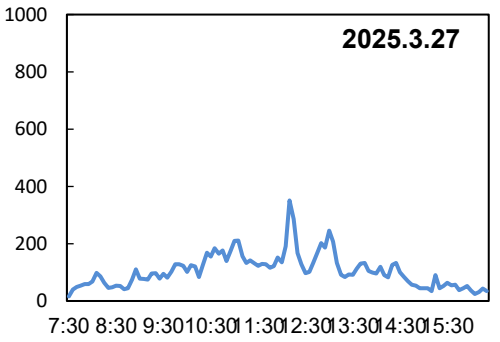
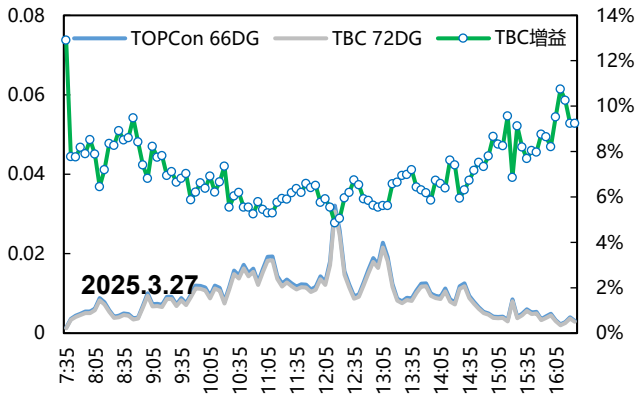
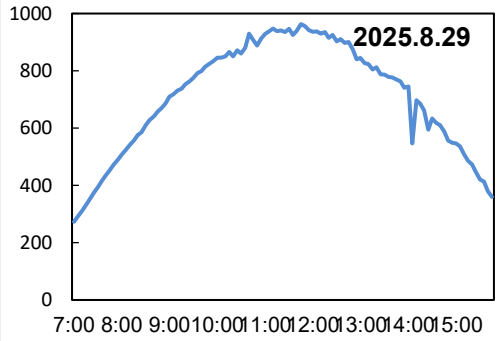
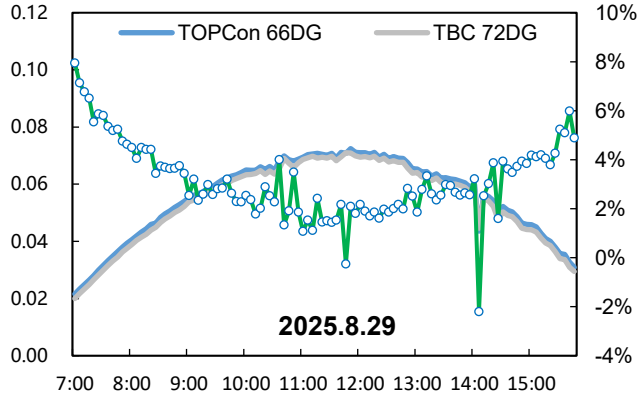
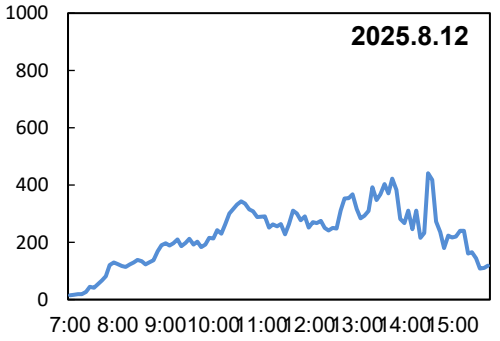
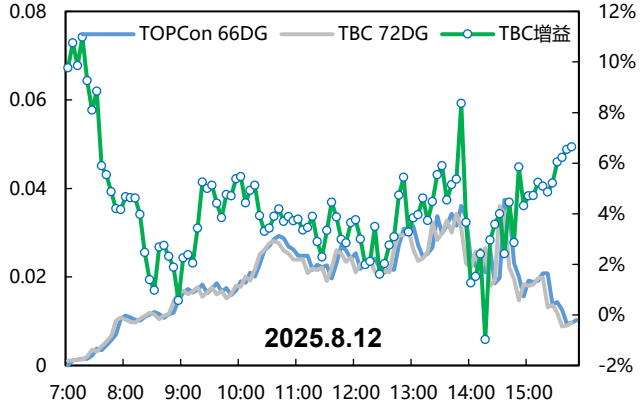


Note: Due to the unstable effects of shading, data was filtered when analyzing different daily irradiance intervals.

Field Test (TOPCon & BC): Power Generation Comparison

TOPCon modules exhibit higher power generation per watt than BC modules overall, with generation gains exceeding 10% during morning/evening hours.

TOPCon’ s better low-irradiance performance results in more obvious power generation advantages on cloudy/rainy days.

Sunny (4.2 & 8.29)		Cloudy (3.27 & 8.12)	
Irradiance (W/m²)	Power generation per Watt (kWh/kW) / TOPCon Gain	Irradiance (W/m²)	Power generation per Watt (kWh/kW) / TOPCon Gain
			
			

Thank you for your attention

JA Solar Delivers First Batch of 650W DeepBlue 5.0 High-Efficiency n-Type Modules