ASTRONERGY

Astronergy Products Roadmap

High Quality, High Performance, High Efficiency

Product Management Mar. 2026

ASTRONERGY

CONTENT

01 Company Overview

02 Product Iteration

03 Product Advantage

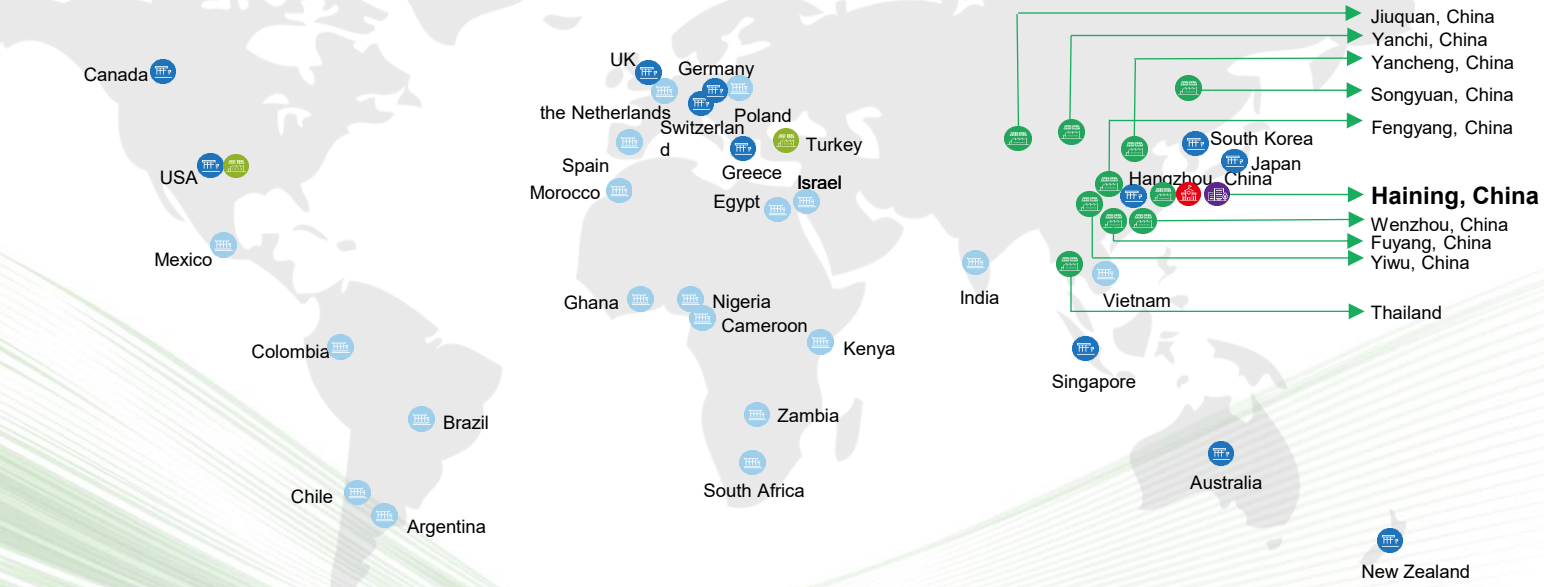
04 Power Forecast

05 R&D Strength

About Astronergy

Astronergy is an intelligent manufacturing enterprise founded in 2006 focusing on photovoltaic modules. With business footprints in over 140 countries, Astronergy has established intelligent manufacturing bases at **Haining、Yiwu、Fuyang、Jiuquan、Yanchi、Yancheng、Dafeng、Songyuan、Fengyang、Turkey、Thailand**. Astronergy has continuously launched bifacial and monofacial ASTRO modules based on big-size wafer, applied in utility-scale power stations, commercial & industrial (C&I) and residential PV systems.

Global layout

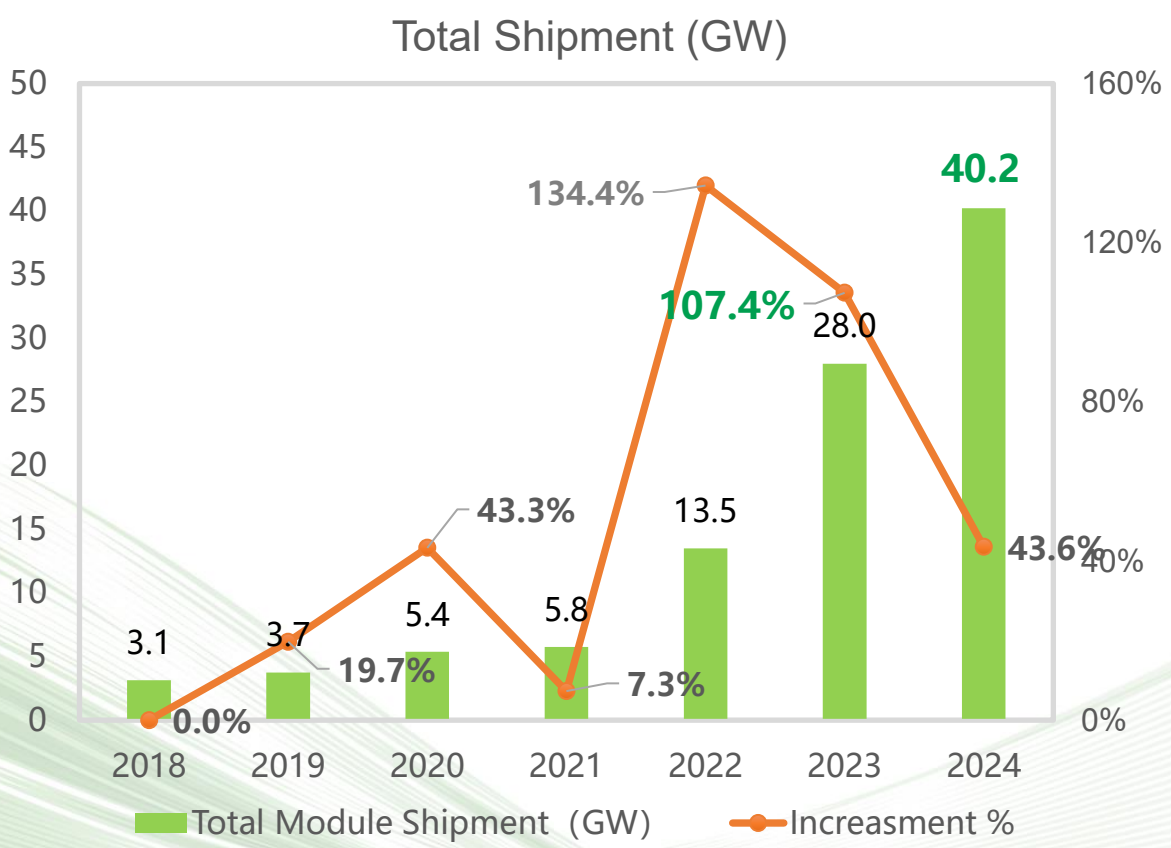


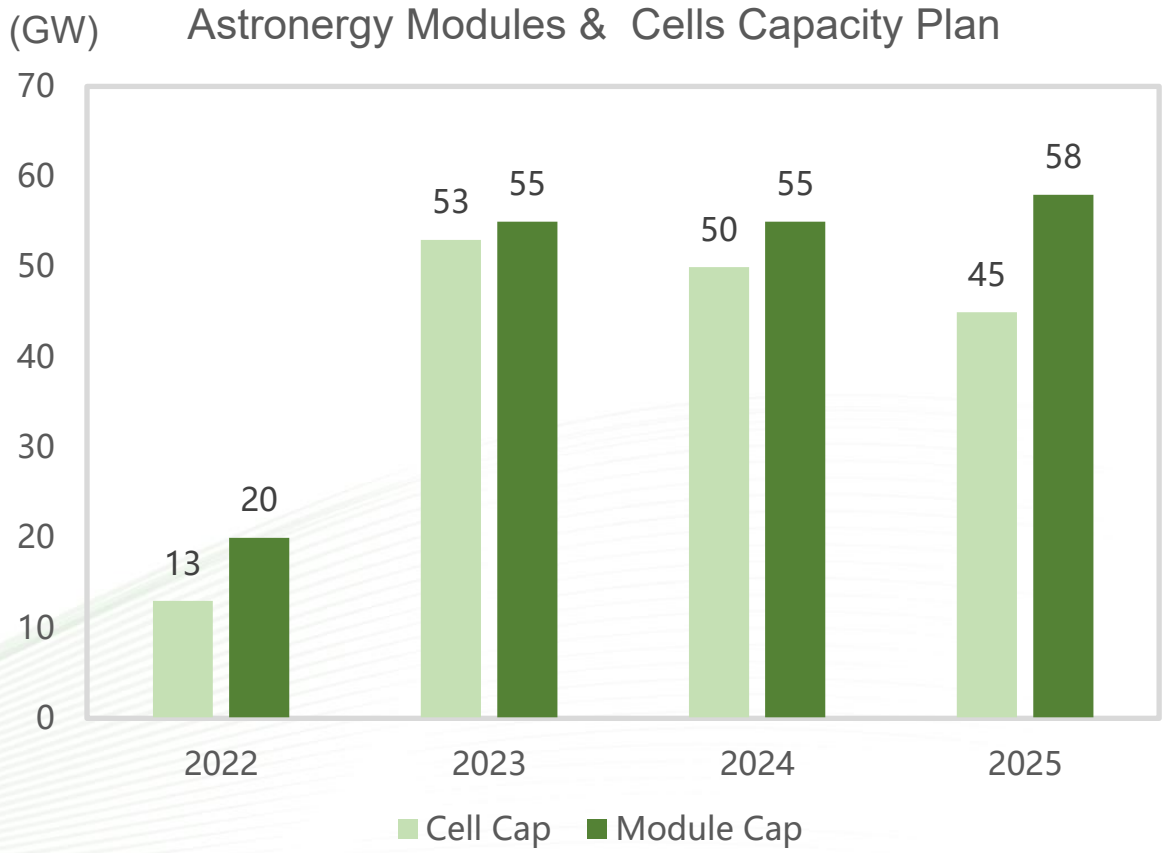
Global Headquarters
Global R&D Center
Global Sales Offices
Global Manufacturing Bases (mass production)
Global Sales Channels
Global Manufacturing Bases (under construction)

Factory Bases

Shipment & Capacity

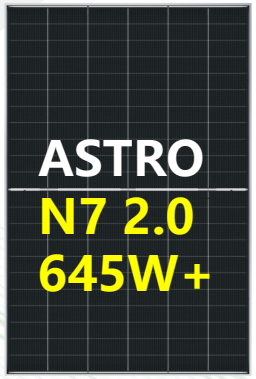
- Total Global Shipments (as of December, 2024): **130 GW+.** A high record of **40.2GW** with **43.6%+** growth rate in 2024.
- By 2025, the cells capacity and modules capacity is expected to reach **45GW** and **58GW** respectively.





Product Iteration

2025 2024 2023 2022 2021 2020 2019 2018 2017 2016



- TOPCon 5.0 Mass Production Efficiency 26.6%
- ZBB Rectangular Silicon Wafer
- Light Redirecting Film
- Non-destructive Cuttiing

- TOPCon 4.0 Mass Production Efficiency 26.4%
- 18BB Silicon Wafer
- Light Redirecting Film
- Non-destructive Cuttiing

- TOPCon 4.0 Mass Production Efficiency 26.4%
- 16BB Rectangular Silicon Wafer
- Light Redirecting Film
- Non-destructive Cuttiing

- **26.4%** TOPCon 4.0 Cell
- Multi-busbar
- Optimized Frame

- G12 210
- 23.2%+ PERC
- Multi-busbar
- Non-destructive Cutting
- High-density

- M10 182
- 23%+ PERC+
- Multi-busbar
- Non-destructive Cutting

- M6 166
- 22.5%+ PERC+
- Multi-busbar

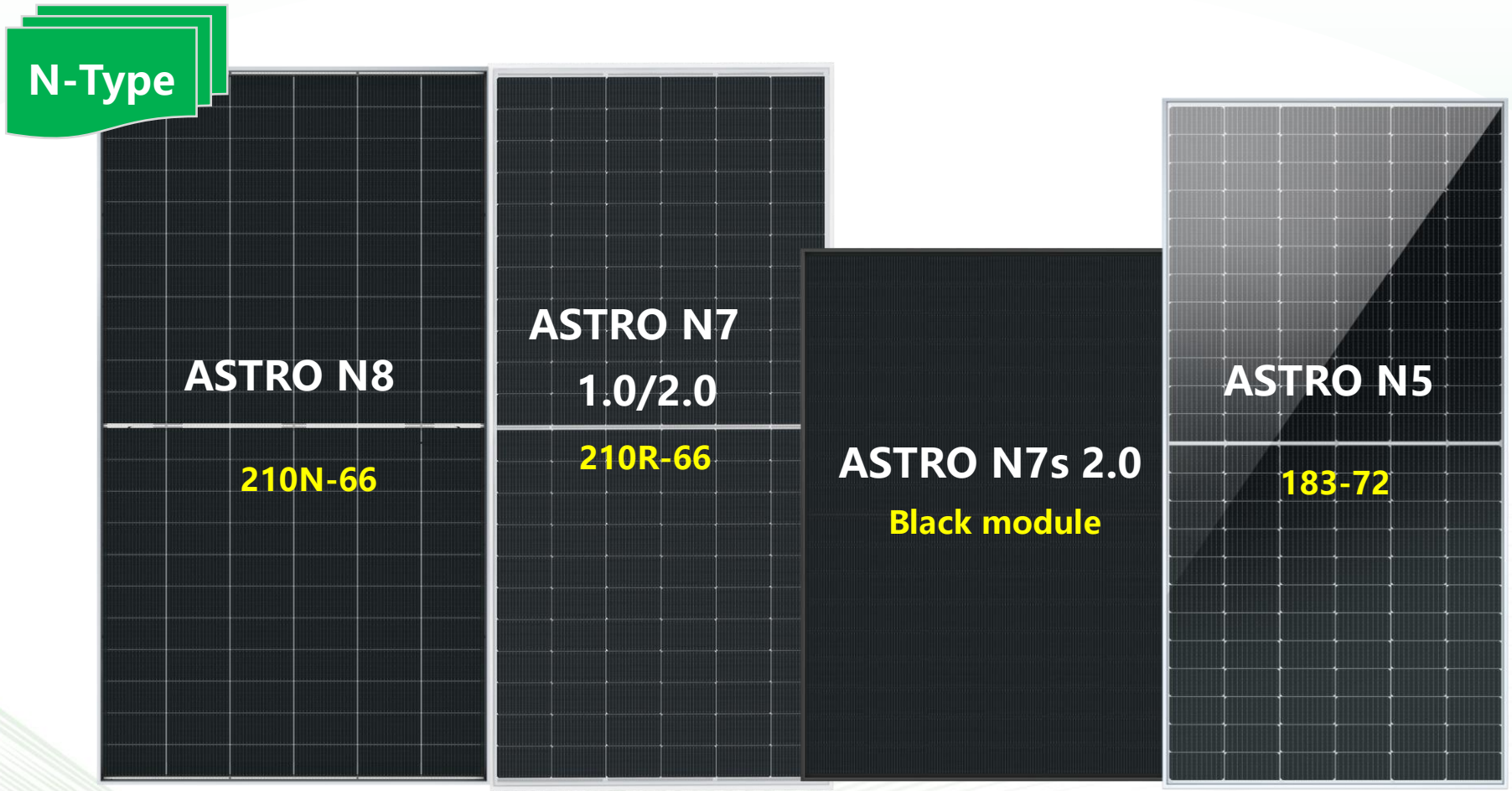
- G1 158.75
- PERC
- SE
- Half Cut

- 5BB
- Mono PERC

- 4BB
- Ploy PERC
- Black Silicon

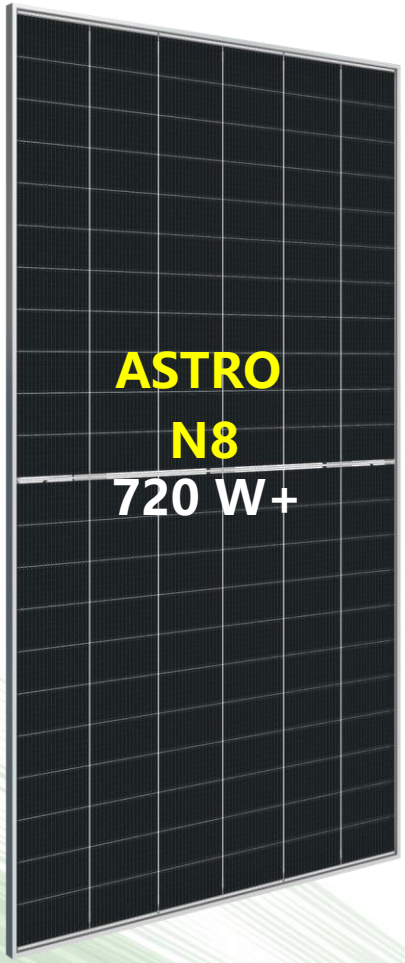
ASTRO N Energizes A Green World

Promoted Product



Application Utility-scale power, large C&I, residential rooftop PV systems

Features & Advantages — ASTRO N8



2384mm*1303mm*33mm

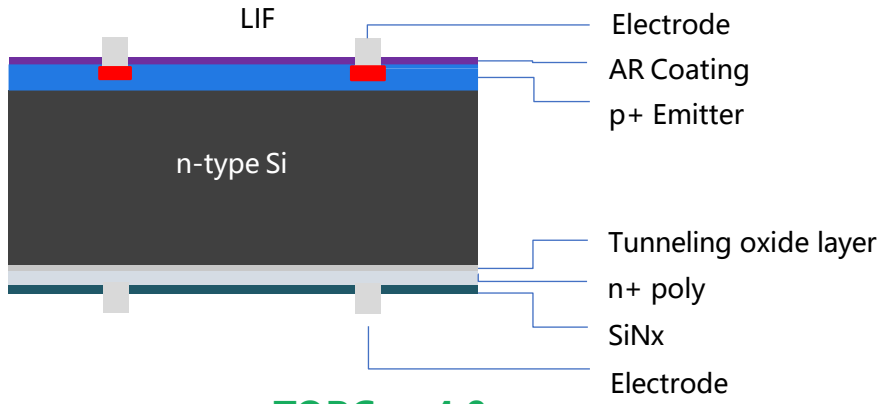
01 High Max Power
Up to 720W+

02 High Eff.
23.2% + / TOPCon 4.0

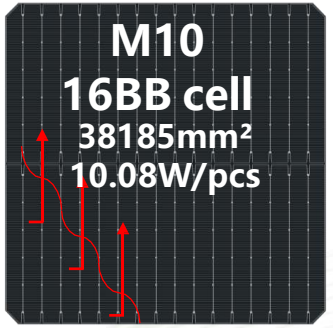
03 High Reliability
SMBB/ double glass

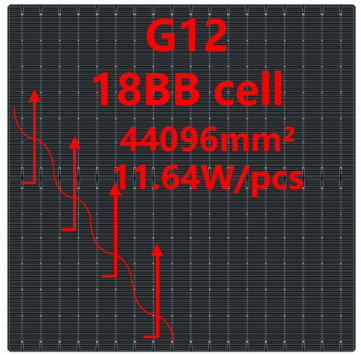
04 High kWh/w
Low temperature coefficient
Light redirecting film

05 LOW BOS&LCOE
Reduced System Cost

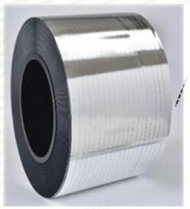


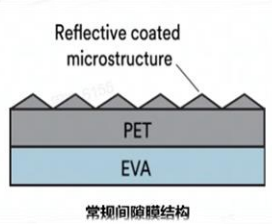
n-TOPCon 4.0



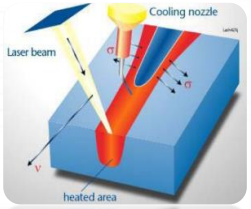


TOPCon cell eff. : 26.4%





Light redirecting film



Non-destructive Cutting

Features & Advantages — ASTRO N7 1.0

2382mm*1134mm*30mm

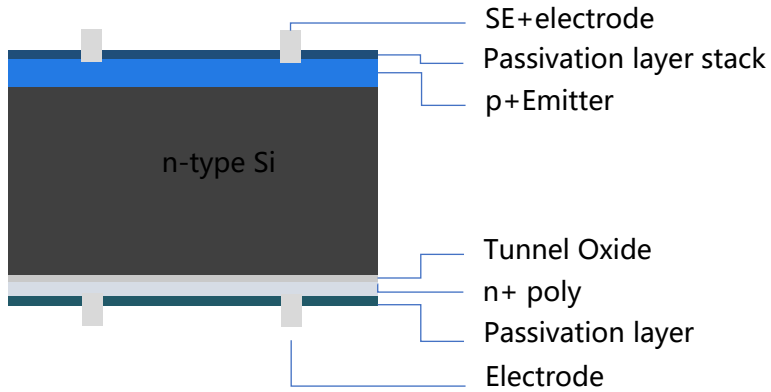
01 High Max Power
Up to 630W+

02 High Eff. 23.3% +
TOPCon4.0+ Light redirecting film

03 High Reliability
SMBB Transparent back glass

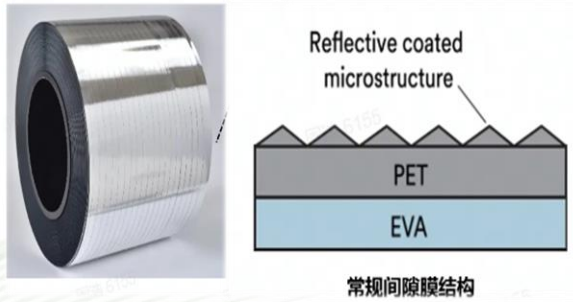
04 High kWh/w
Low temperature coefficient
Light redirecting film

05 LOW BOS&LCOE
Reduced System Cost

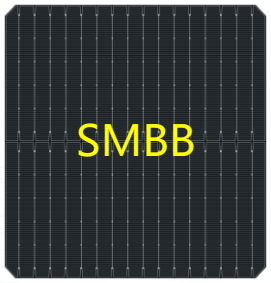


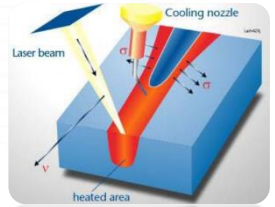
n-TOPCon 4.0

Rectangular Silicon Wafer 210R



Light redirecting film





Non-destructive Cutting

Features & Advantages — ASTRO N7 2.0

2382mm*1134mm*30mm

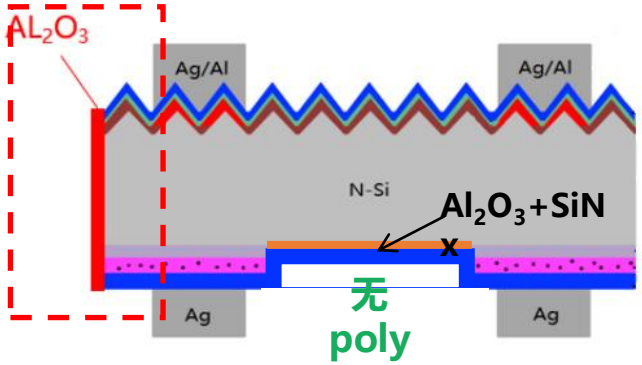
01 High Max Power
Up to 645W+

02 High Eff. 23.9% +
TOPCon5.0+ Light redirecting film

03 High Reliability
ZBB Transparent back glass

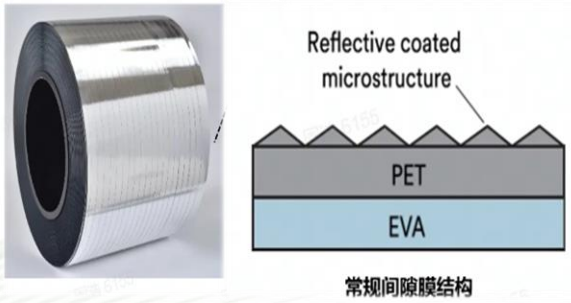
04 High kWh/w
Low temperature coefficient
Light redirecting film

05 LOW BOS&LCOE
Reduced System Cost

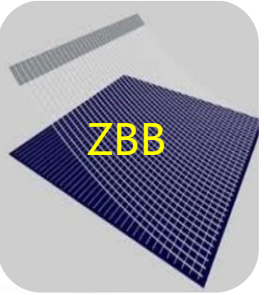


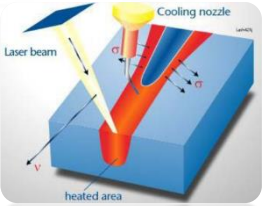
n-TOPCon 5.0

Rectangular Silicon Wafer 210R



Light redirecting film





Non-destructive Cutting

ASTRO N7 Pro Introduction

ASTRONERGY

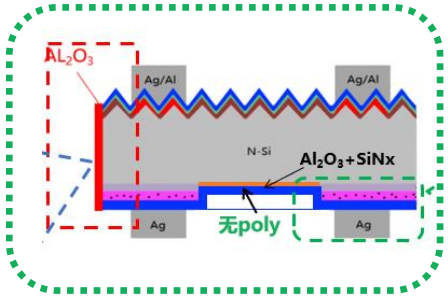
01 **High Power Output**
Up to 670W+

02 **High Efficiency**
24.8% +, Multi-Cut Cell Technology and TOPCon 5.0 Technology

03 **High Reliability**
Dual-Diode junction box and Quad-Cut cell layout design, reduces hotspot risk

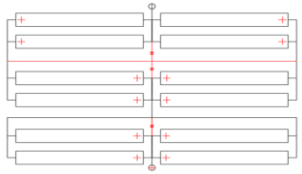
04 **High kWh/w**
Higher Temperature Coefficient
Higher bifaciality

05 **Low BOS&LCOE**
Reduced System Cost

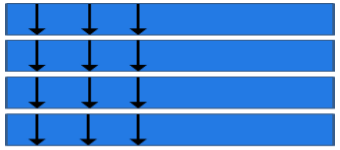


TOPCon 5.0+

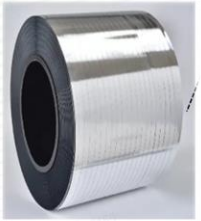
Rectangular Silicon Wafer 210R

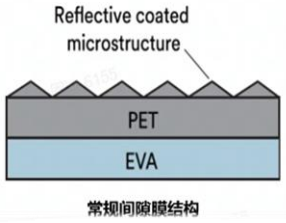


Quad-Cut Cell Layout Design

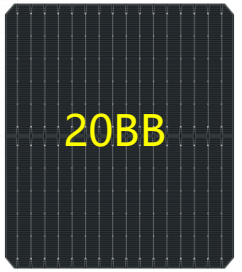


Multi-cut cell technology





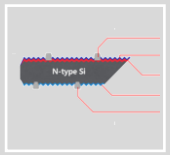
Light redirecting film



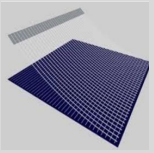
Features & Advantages — ASTRO N7s 2.0

ASTRONERGY

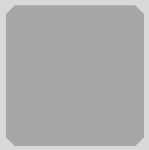
CHSM48RN(DG)(BLH)/F-BH
CHSM48RN(DG)/F-BH



26.6%+
TOPCon 5.0



ZBB
Zero busbar



Rectangular Wafer
182*210mm

Large spacing design

01 **High power**
Up to 470W+

02 **High efficiency**
23.5% +

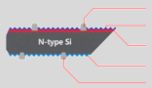
03 **Easy Installation**
≤2㎡， 21.6kg

04 **High Reliability**
Lower Attenuation

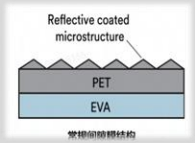
05 **Clean and uniform appearance**

Features & Advantages — ASTRO N5

ASTRONERGY

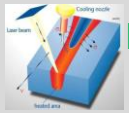


26.4%+ TOPCon Cell

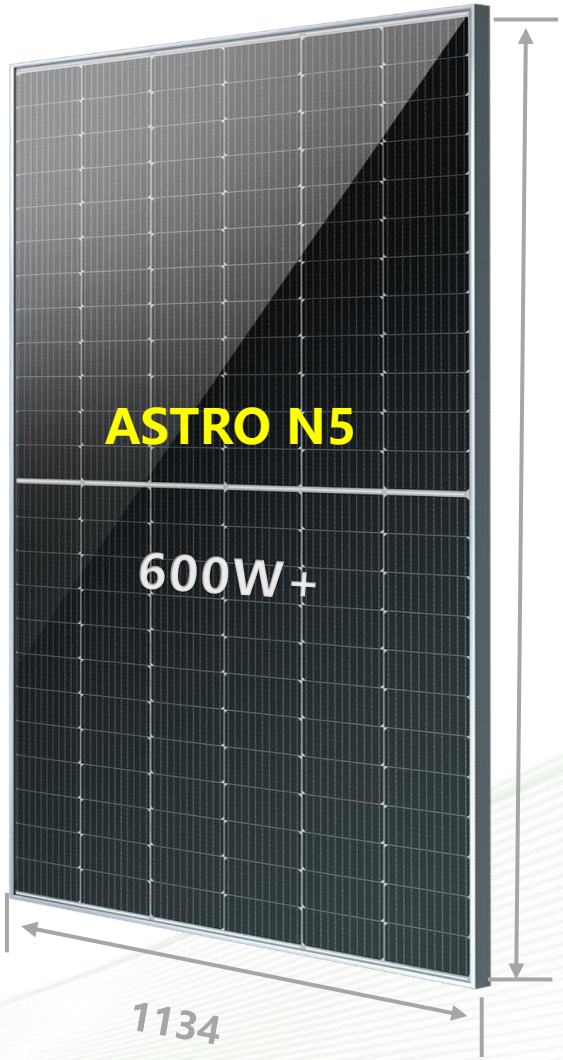


Light Redirecting Film

High-density Encapsulation



Non-destructive Cutting



01 High Max.Power
Up to 600W+

02 High Module Eff.
23.2%+

03 High Energy Yield
80% Bifaciality

04 High Quality
Lower Attenuation

05 More Aesthetic

ASTRO N8 & N7 — Large Silicon Wafer

S=33471mm²
8.84W/pcs
baseline

S=38185mm²
10.08W/pcs
The area is increased by more than **14.1%**

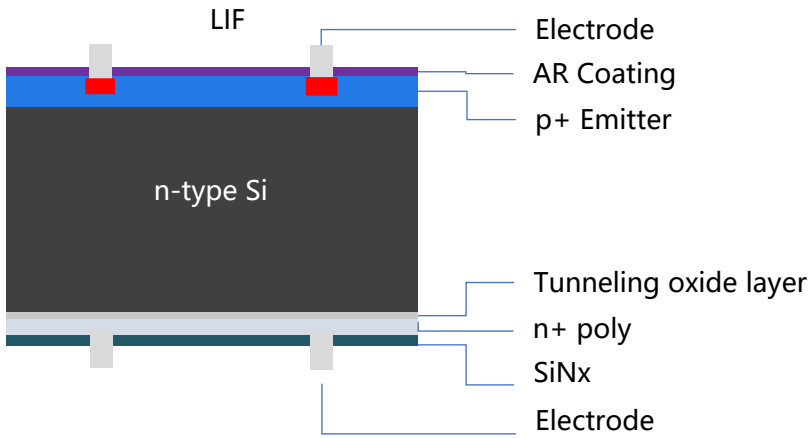
S=44096mm²
11.64W/pcs
The area is increased by more than **31.8%**

n-183.X	n-210R	n-210N
ASTRO N5	ASTRO N7/N7s	ASTRO N8
TOPCon	TOPCon 4.0	TOPCon 4.0
182mm×183.75mm	182mm×210mm	210mm×210mm
TOPCon cell eff. : 26.4%		TOPCon cell eff. : 26.4%

- ASTRO N5 use n-G10 silicon wafers, with longer minority carrier lifetime and increased power to 8.84W+/pcs per cell.
- ASTRO N7&N7s use rectangular silicon wafers, which increase the area of silicon wafers by more than **14.1%** compared with G10 183.X silicon and increased power to 10.08W/pcs.
- ASTRO N8 with independent-developed n-type TOPCon 4.0 high-efficiency cell, which increase the area of silicon wafers by more than 31.8% compared with G10 183.X silicon and increased power to 11.64W/pcs, improving module power and efficiency, and reducing the cost per W.

ASTRO N Core Technology — TOPCon4.0 cell

n-TOPCon 4.0

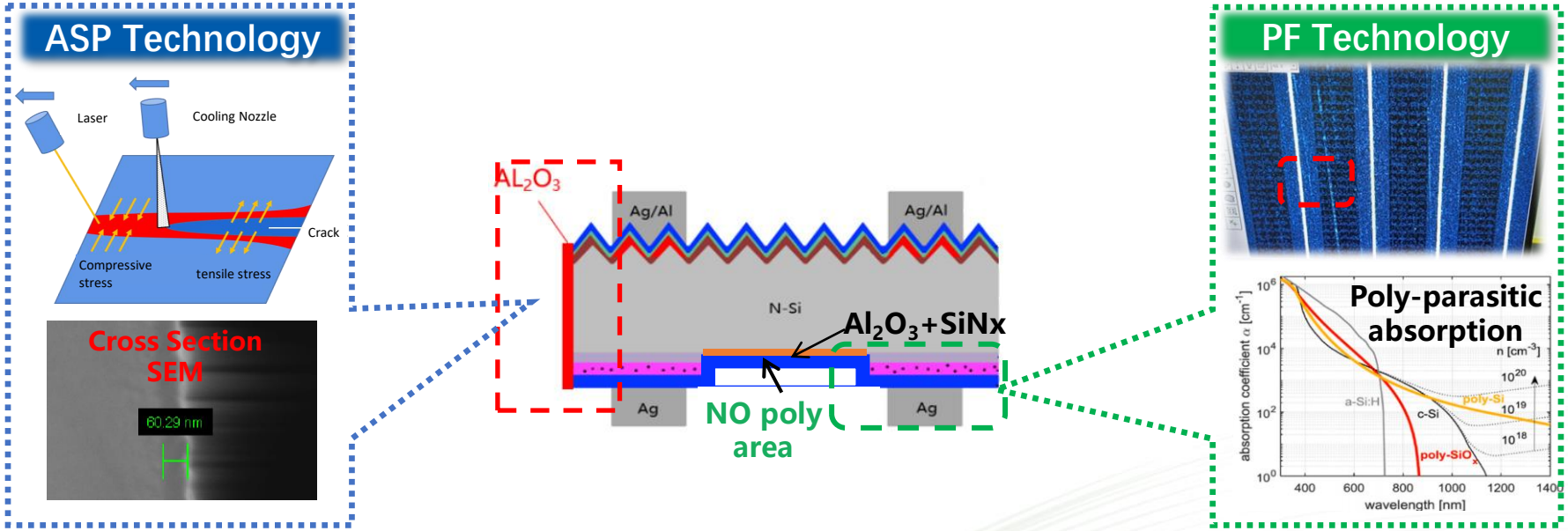


- **LIF (Laser induced firing)**: During LIF process, bias voltage + strong light injection produces high current density and localized high temperature, which allows silver and silicon to diffuses into each other to form ohmic contact. LIF reduces damage to the passivation layer while improving conductivity, thus increasing open circuit voltage and reducing contact resistance, improving cell efficiency by 0.3%-0.5%.
- **POML (Poly-Si multi layers)**: POML technology is the upgrade of the rear poly-Si layer. It improves the passivation performance and reduces parasitic absorption losses, hence increasing the cell efficiency.

- **The TOPCon 4.0 cell, with industry-leading low corrosion paste + LIF technology and multi-layer Poly-Si/POML technology, is fully upgraded on TOPCon 3.0 cell, resulting in a 0.3 - 0.5% increase in cell efficiency, with a top efficiency of 26.9%.**

TOPCon 5.0 Technology Introduction

- **Introduction:** TOPCon 5.0 is an industry-leading technological upgrade based on the TOPCon 4.0 Cell, and it achieves power enhancement of the module by introducing the Astronergy Side Passivation (ASP) and the backside passivation (PF) technology.



Astronergy Side Passivation(ASP)

➢ Depositing an oxide film on the cross-sectional surface for passivation repair can reduce surface recombination that result in enhancing the fill factor (FF) and achieving a cell efficiency improvement of approximately 0.25-0.3%.

poly-finger (PF)

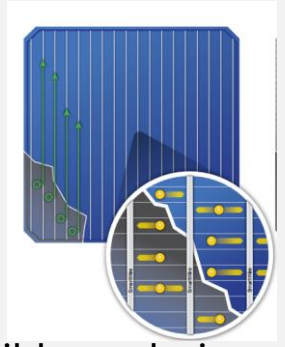
(*in technical reserve)

➢ Reducing the parasitic absorption of the rear-side doped Poly and improving the passivation of the non-Poly areas can increase the short-circuit current (Isc), thereby improving the cell efficiency by 0.1-0.15%, with a corresponding increase in the bifaciality rate of approximately 5%.

ASTRO N7&N7s 2.0 Core Technology — ZBB

The ZBB technique

- ✓ The cell gate line is no main gate, the number of ribbon further increases, and the ribbon replaces the main wire.
- ✓ The ribbon is pre-fixed by film covering (modified film) So that the electrical connection between the cell and the ribbon is completed in the lamination machine.
- ✓ The interconnection temperature drops below 150℃ to reduce the thermal stress and reduce the hidden crack of the module manufacturing process.

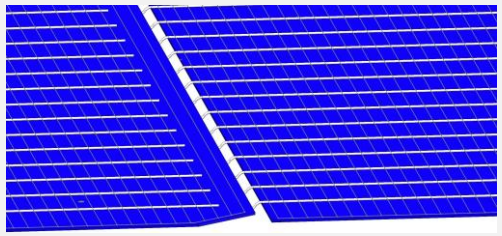


◆ 20 ribbons designed to raise current collection lift FF

◆ Low-temperature laminated interconnection-**no flux**

Cell Interconnection Mode

- ✓ Using ultra-dense grid low diameter ribbon, flexible interconnection, better compatible with large rectangle and large spacing, zero hidden crack is higher.



◆ 0.18mm ribbon+ **1.0mm~1.5mm** large spacing

ASTRO N7s Core Technology — ZBB

TOPCon 5.0 Technology

- Passivation of the cut oxide film increases the cell efficiency by 0.25-0.3%
- The partial passivation of the back side increases the efficiency by 0.1-0.15%, and the bifaciality increases by 5%

ZBB Cell Technology

- Number of welding wires were increased, current transmission path was reduced, series resistance was reduced
- 20 ribbons , more contact points can increase current collection and enhance the FF, improving power
- ZBB has a stronger current collection capability, making the module power more stable
- Cell shading area is reduced;

Technical Direction

Rectangular silicon wafer

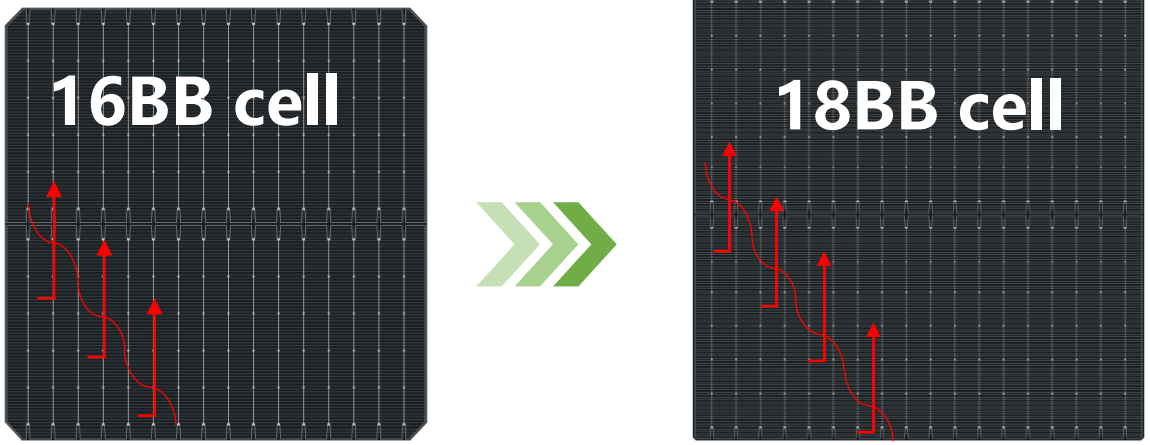
- Rectangular silicon wafer 182.3*210mm;
- The area is 15.6% higher than 182*182mm;
- Increase the power of the same type of the product, improve efficiency;

High Power

- 48-cell bifacial, double glass, black grid glass :465Wp+;
- 48-cell bifacial, double glass, white grid glass :470Wp+;
- 54-cell bifacial, double glass, white grid glass:525Wp+;

ASTRO N Core Technology — SMBB

Take full advantage of the strength of SMBB techonology



N7 N8

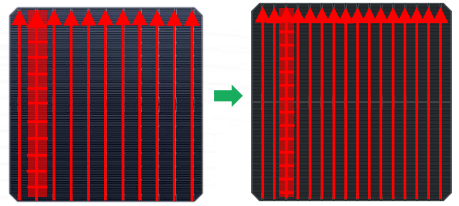
Cost Reduction

More and thinner grid lines reduce silver paste loss

Reliability Gain

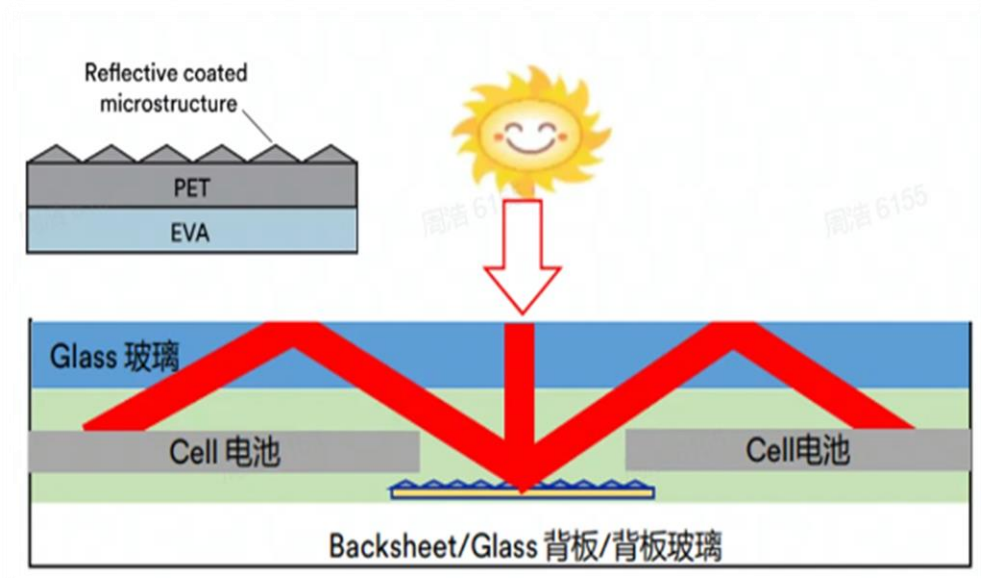
- Better tolerance for hidden cracks and broken grids
- More uniform stress distribution due to the increased number of weld joints in the main grid line

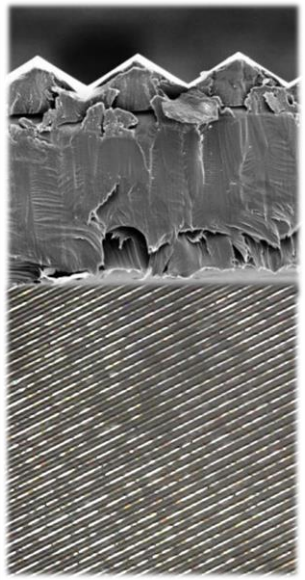
Electrical Gain



Shorten current transmission path, reduce series resistance, reduce cell power loss and improve module efficiency

ASTRO N Core Technology — Light redirecting film



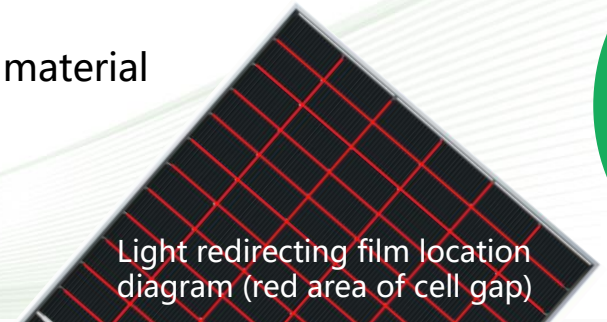


- **Light redirecting film structure:**

✓ **Reflective coated:** Alloy plating with high reflectivity and good weather resistance and adhesion

✓ **Support layer:** PET structure, low shrinkage material

✓ **Bonding layer:** EVA film



Light redirecting film location diagram (red area of cell gap)

High power

The front side of the light redirecting film is a wavy structure reflective layer, which can make full use of the sunlight between the cells and reflect the light to the front side of the module, increasing the module power by 2W+(182mm 72-cell module).

High power generation

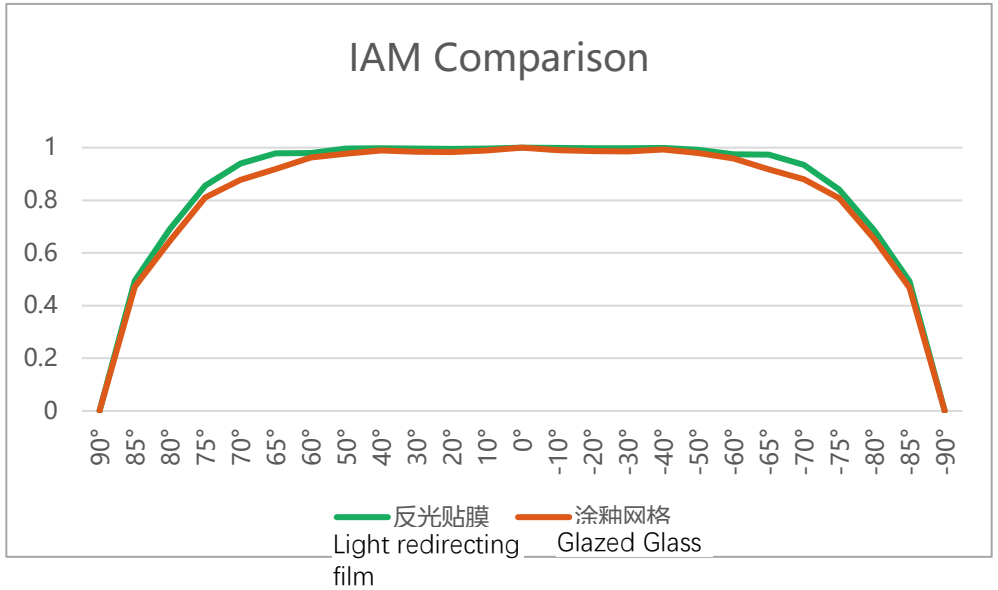
Modules with light redirecting film have a smaller backside shading area, which improves the bifacial rate and increases backside power generation.

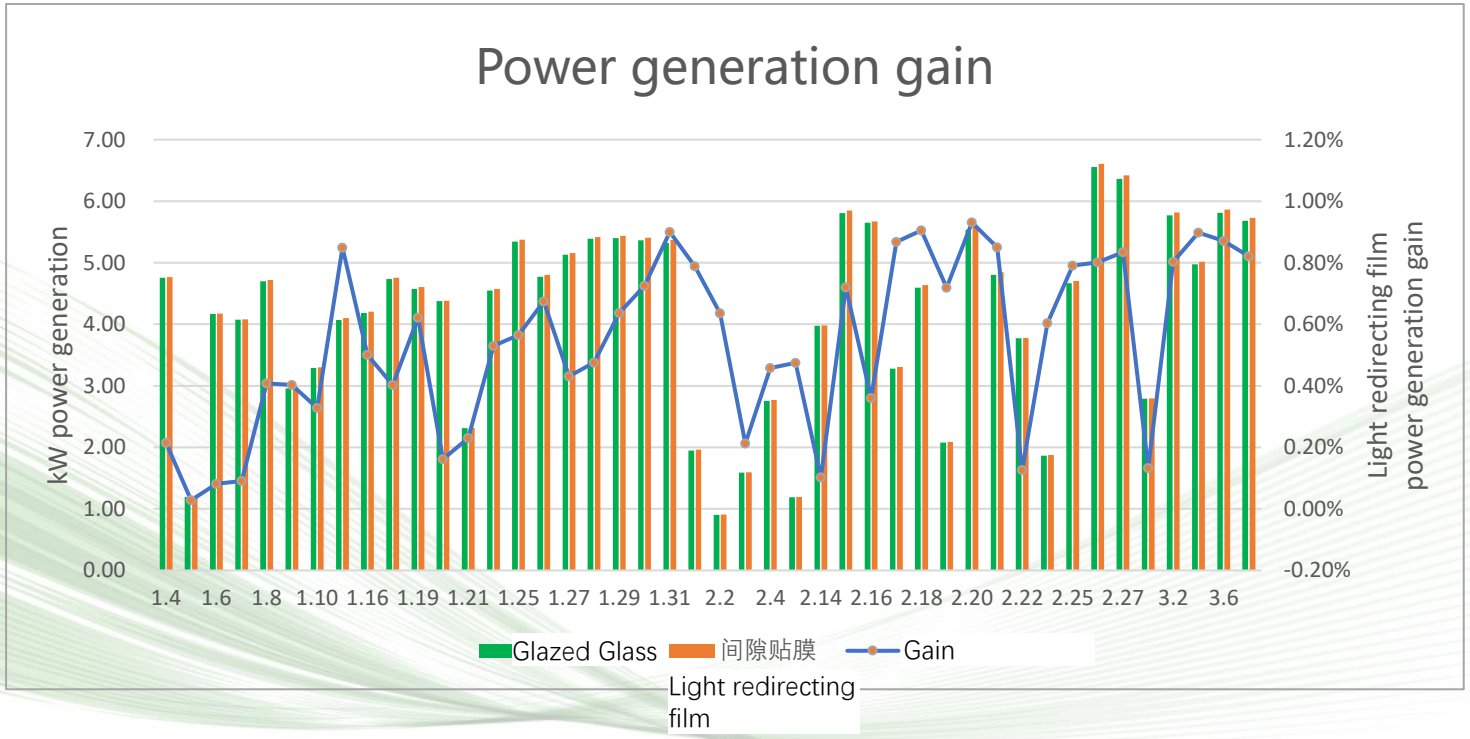
High reliability

non-glazed glass has good stress uniformity, higher strength, better mechanical load performance, and better impact resistance

ASTRO N Core Technology — Light redirecting film

- Light redirecting film modules outperform glazed glass modules in all angles of IAM.



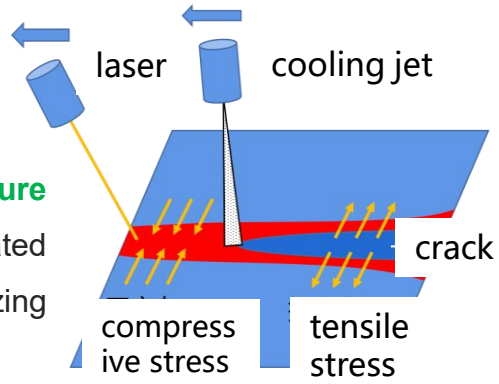


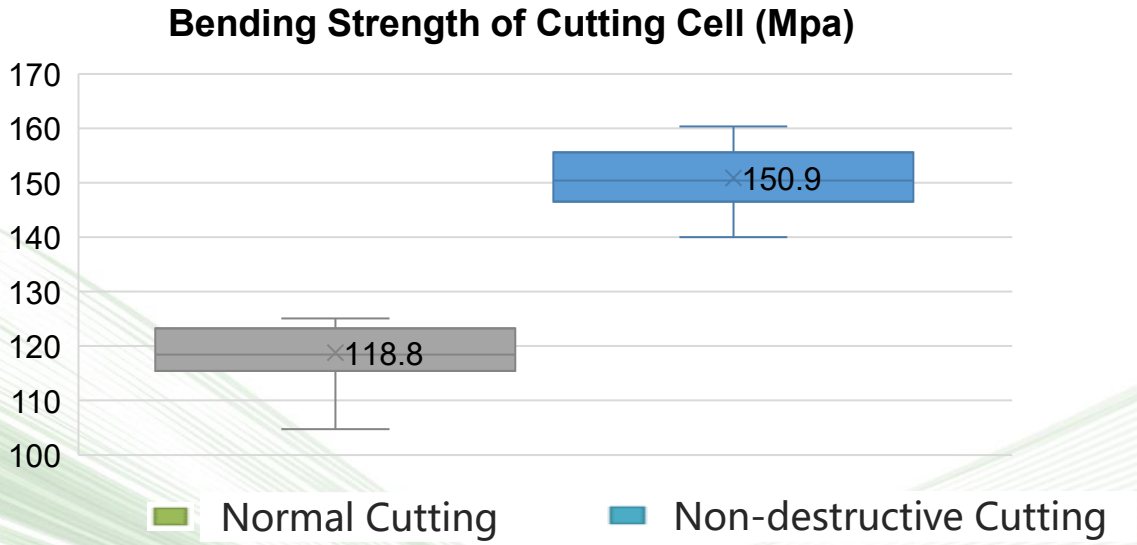
- Compared to glazed glass modules, light redirecting film modules can generate 0.48% more power per watt (IAM + bifacial gain)

ASTRO N — Non-destructive Cutting

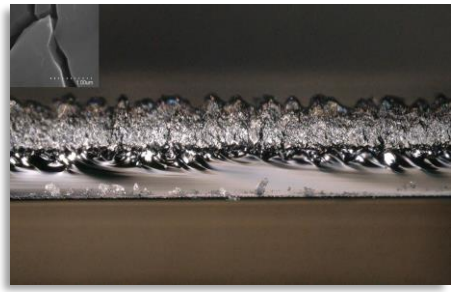
Non-destructive Cutting Principle

Based on **laser thermal stress control fracture technology**, the battery is cooled through laser heated and following split naturally by thermal stress, realizing the non-damage cutting.



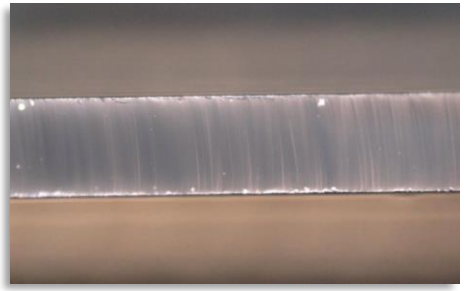


Normal Cutting

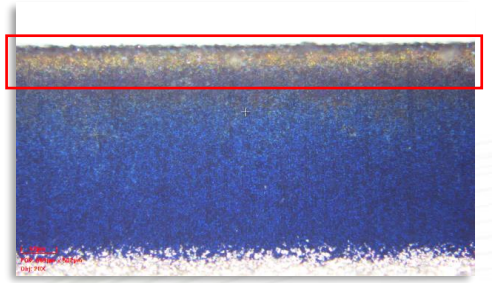


Rough cutting surface with micro-cracks

Non-destructive Cutting



Smooth cutting surface without any micro-cracks

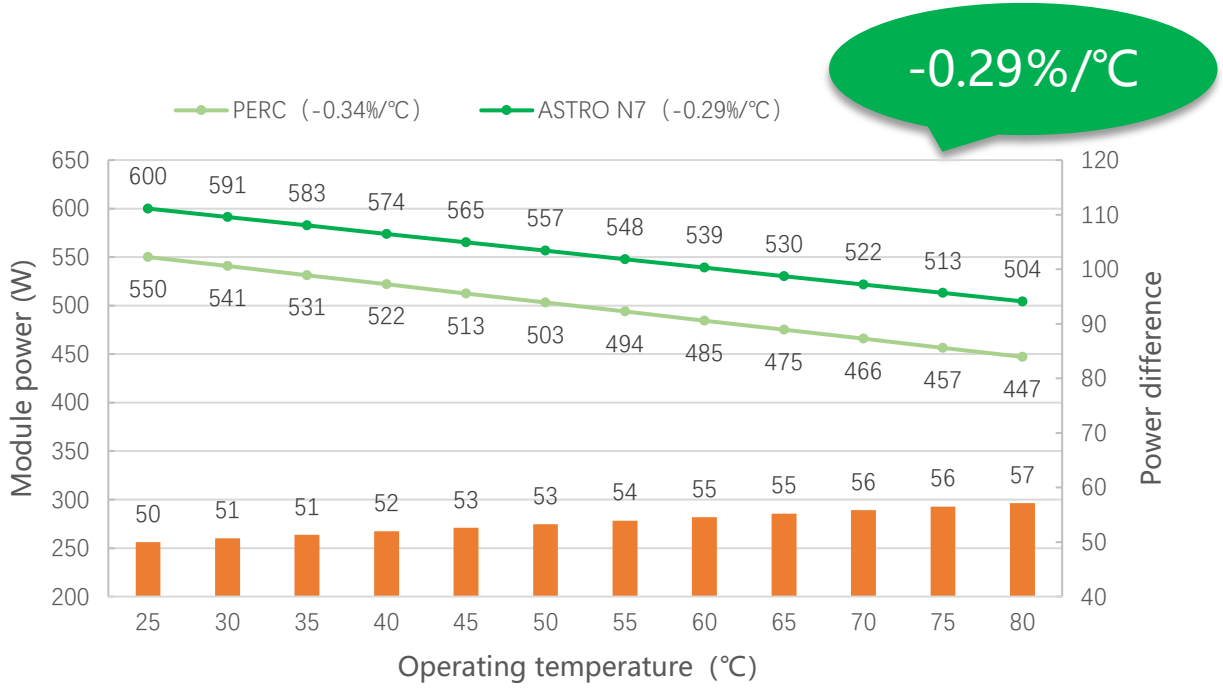


Heat affected zone: 80-150μm

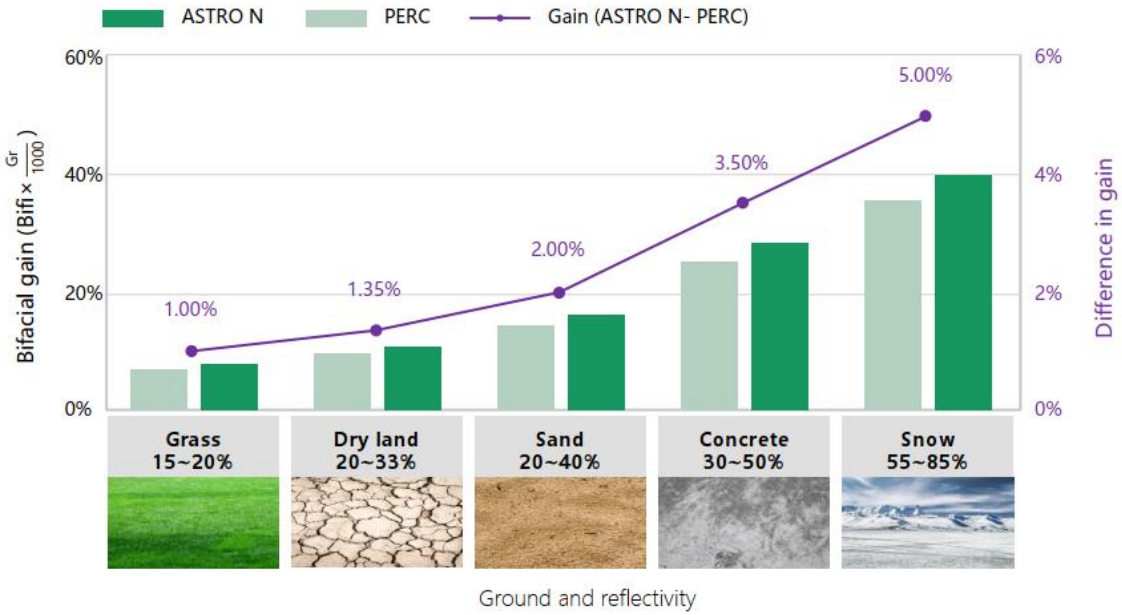
No heat affected zone

Cutting surfaces are smooth without cracks, improving **the bending strength of cells** and mechanical properties of modules.

ASTRO N Core Advantage — Better Temp.C & Bifacility



Relationship between the output power of ASTRO N and the temperature temperature coefficient of ASTRO N is only -0.29%/℃ tested by DEKRA

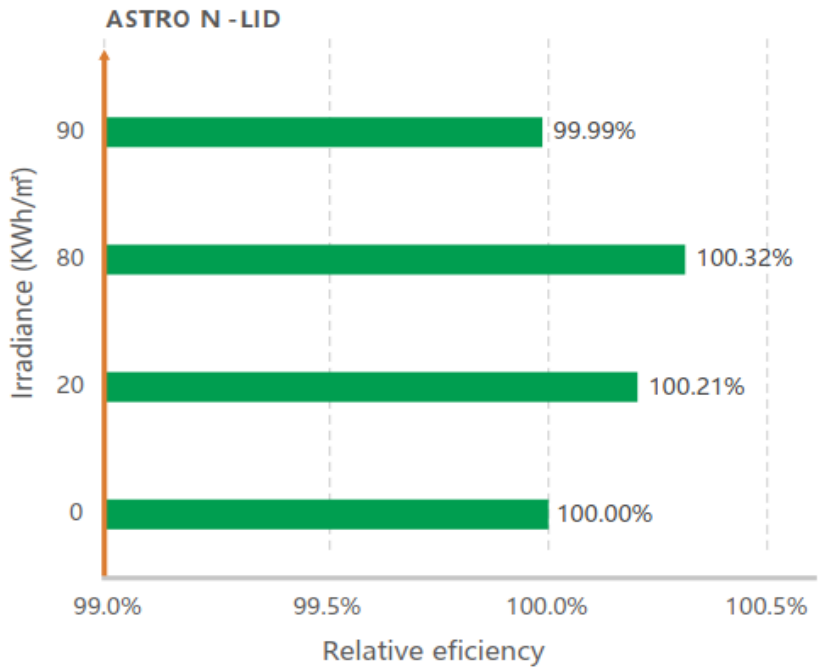


Comparison of bifacial gain between ASTRO N and PERC module under different ground

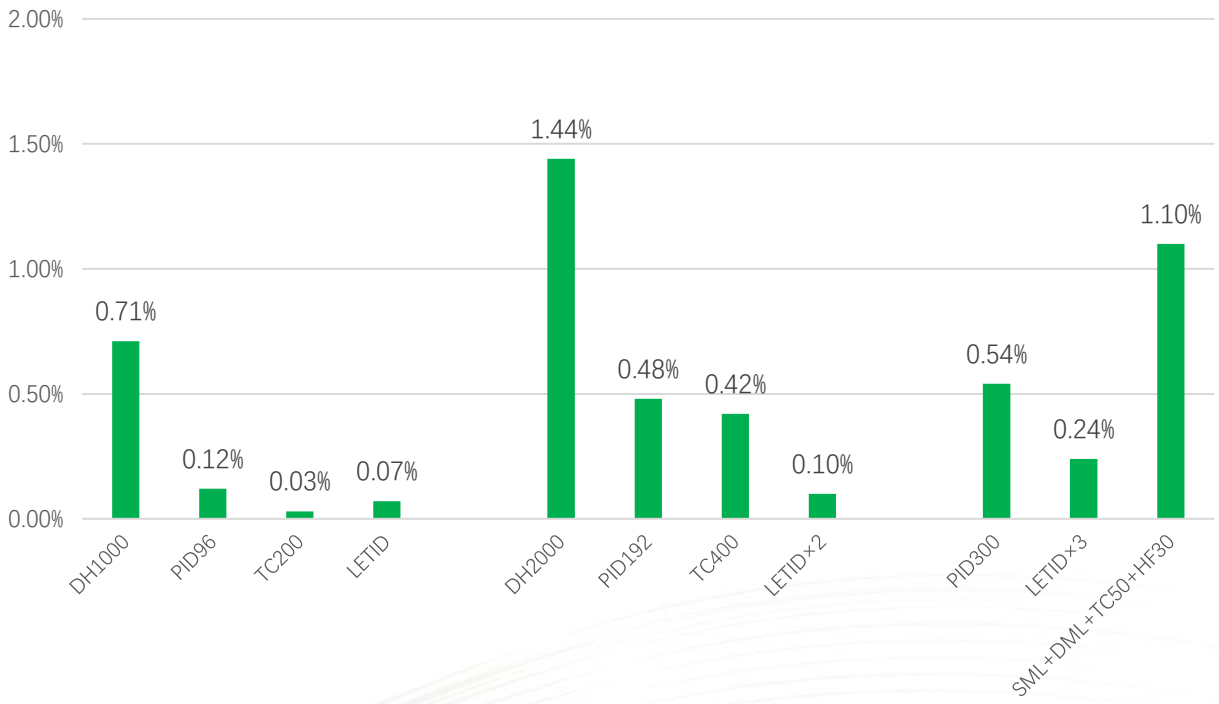
- Certified by **DEKRA**, the Pmax temperature coefficient of ASTRO N7&N5 is **only -0.29%/°C**, better than that of the p-type PERC module of -0.35%/℃.

- **High Bifacility**. Compared wit PERC, the bifacial gain is increased by 1-5% in different ground reflectance application field.

ASTRO N — Lower Attenuation & High Reliability



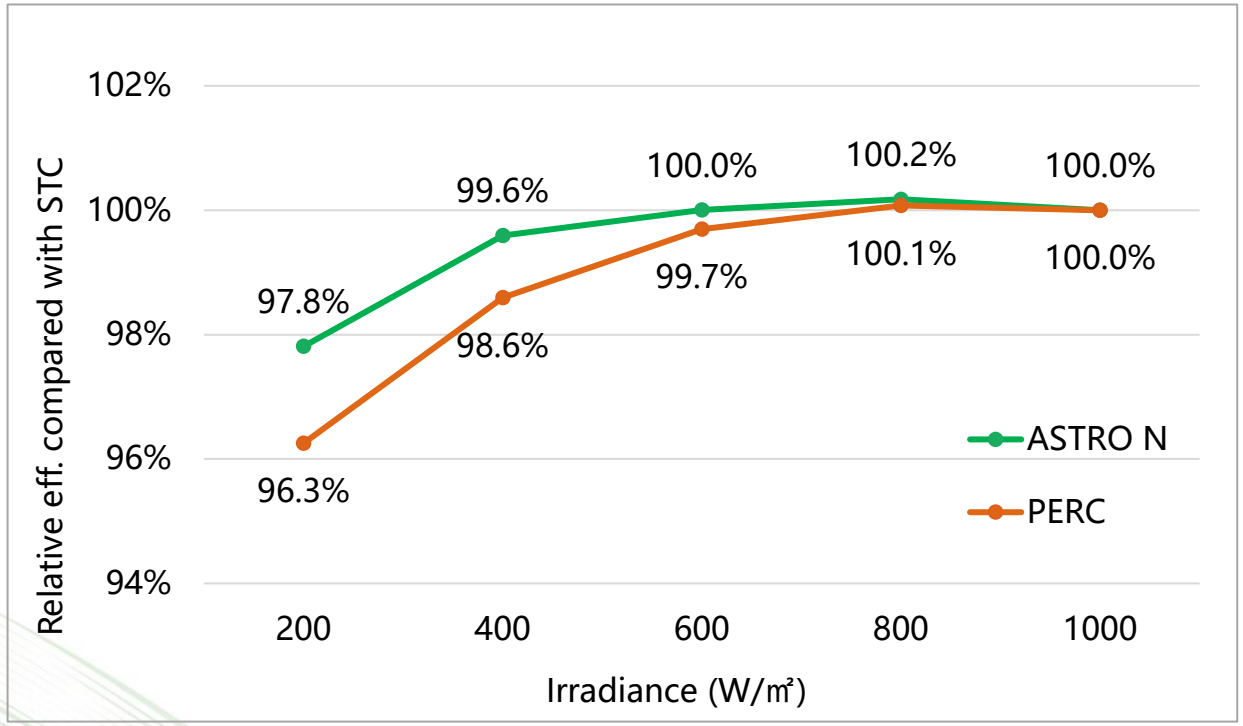
LID of ASTRO N is only 0.01% after light exposure of 90 kWh/m²

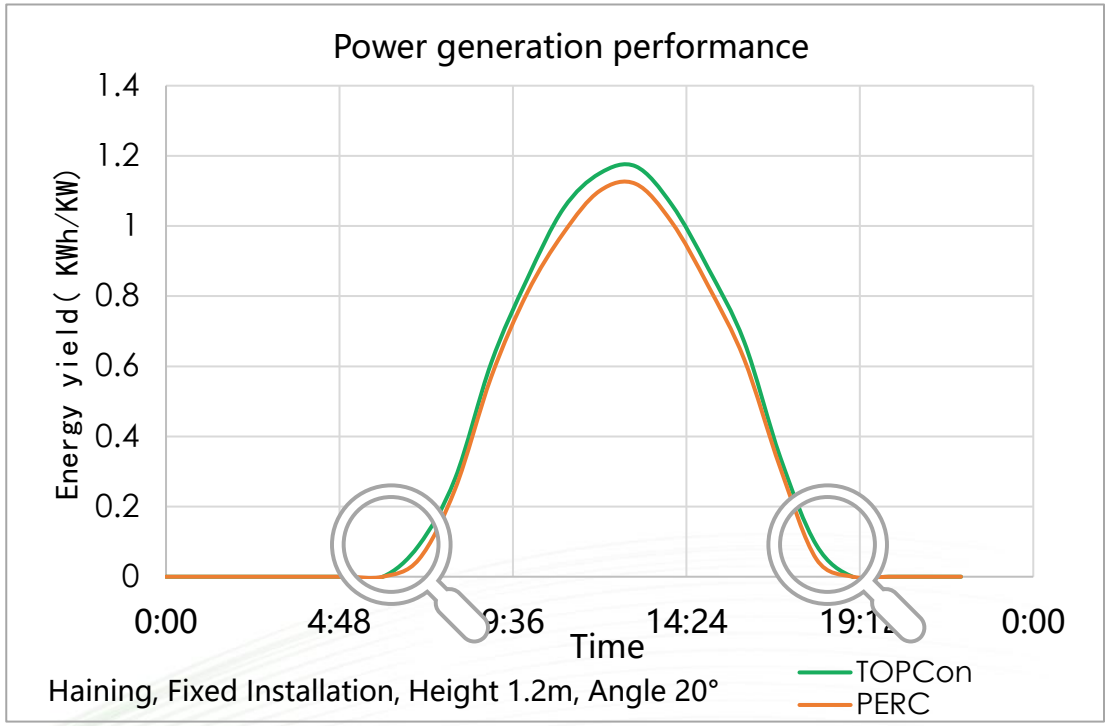


ASTRO N shows excellent performance in various IEC standard and multiple aging tests

- Due to the intrinsic features of N-type silicon wafer, the power attenuation of ASTRON are only **0.03%~0.71%** in IEC standard aging tests.
- Multiple strict tests of **TC,PID and DH** have been passed to fully verify the **high reliability**.

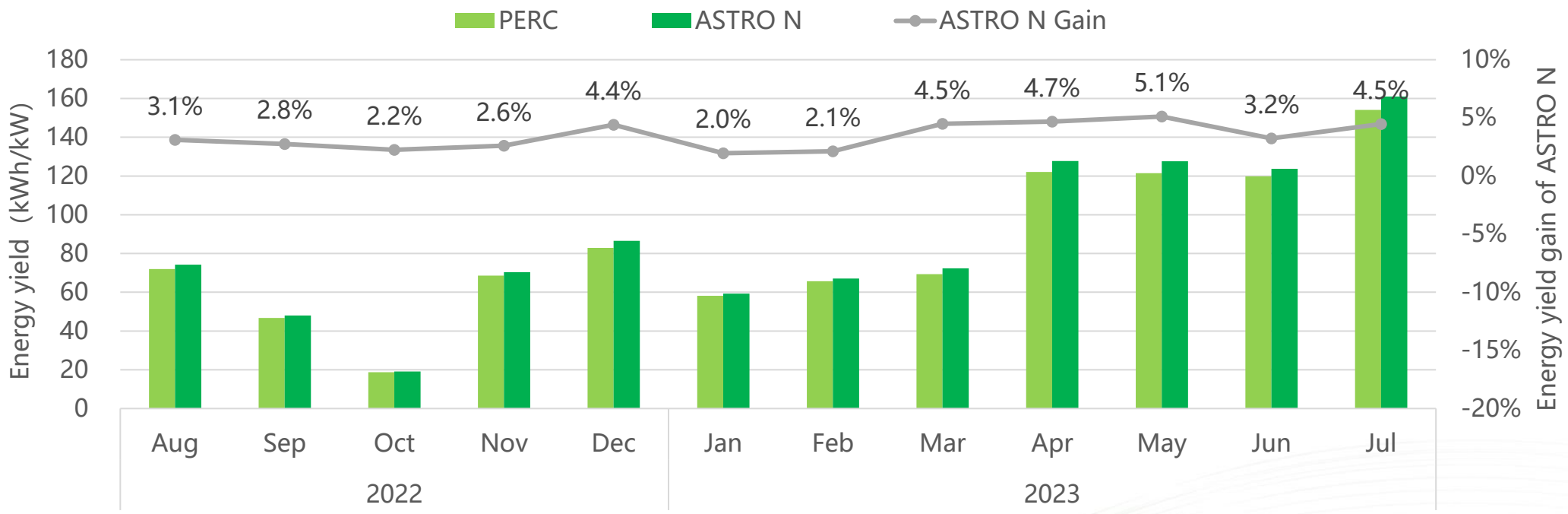
ASTRO N — Low-light Performance





- After being tested by the UL, the low-irradiation performance of ASTRO N **is 97.8%** at 200W/㎡, 1% higher than that of PERC. Moreover, ASTRO N also shows **better power generation** performance in **the low-light conditions**.

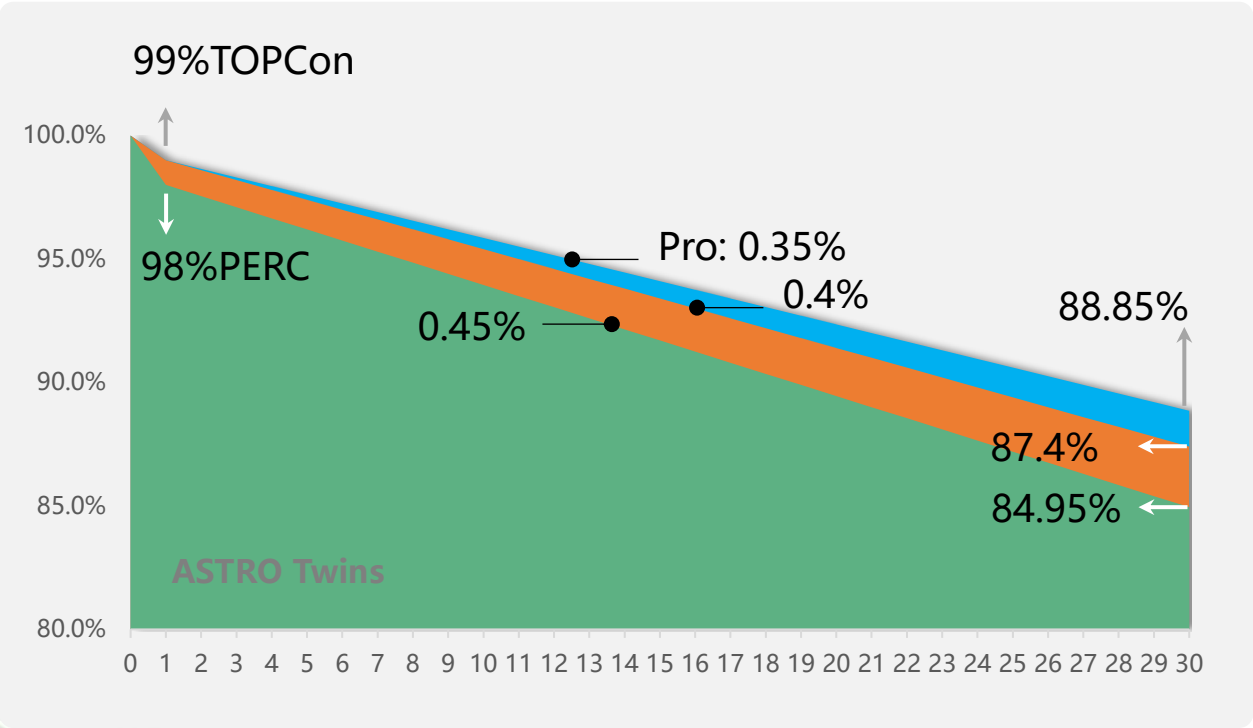
ASTRO N — Higher Energy Yield per Watt



Comparison of the energy yield per watt between ASTRO N and PERC modules at the outdoor demonstration base of Astronergy located in Haining

- Combined with the advantages **of higher bifaciality, better temperature coefficient, better low-light performance, and lower LID and LETID** than PERC module, the energy yield pre watt of ASTRO N is **3.8%** than that of PREC.

ASTRO N — Product Warranty



ASTRO N's excellent product quality ensures that after 30 years of steady output, the power will not be less than **87.4%**, Pro will not be less than **88.85%.**

-0.4%

Annual degradation

≤1%

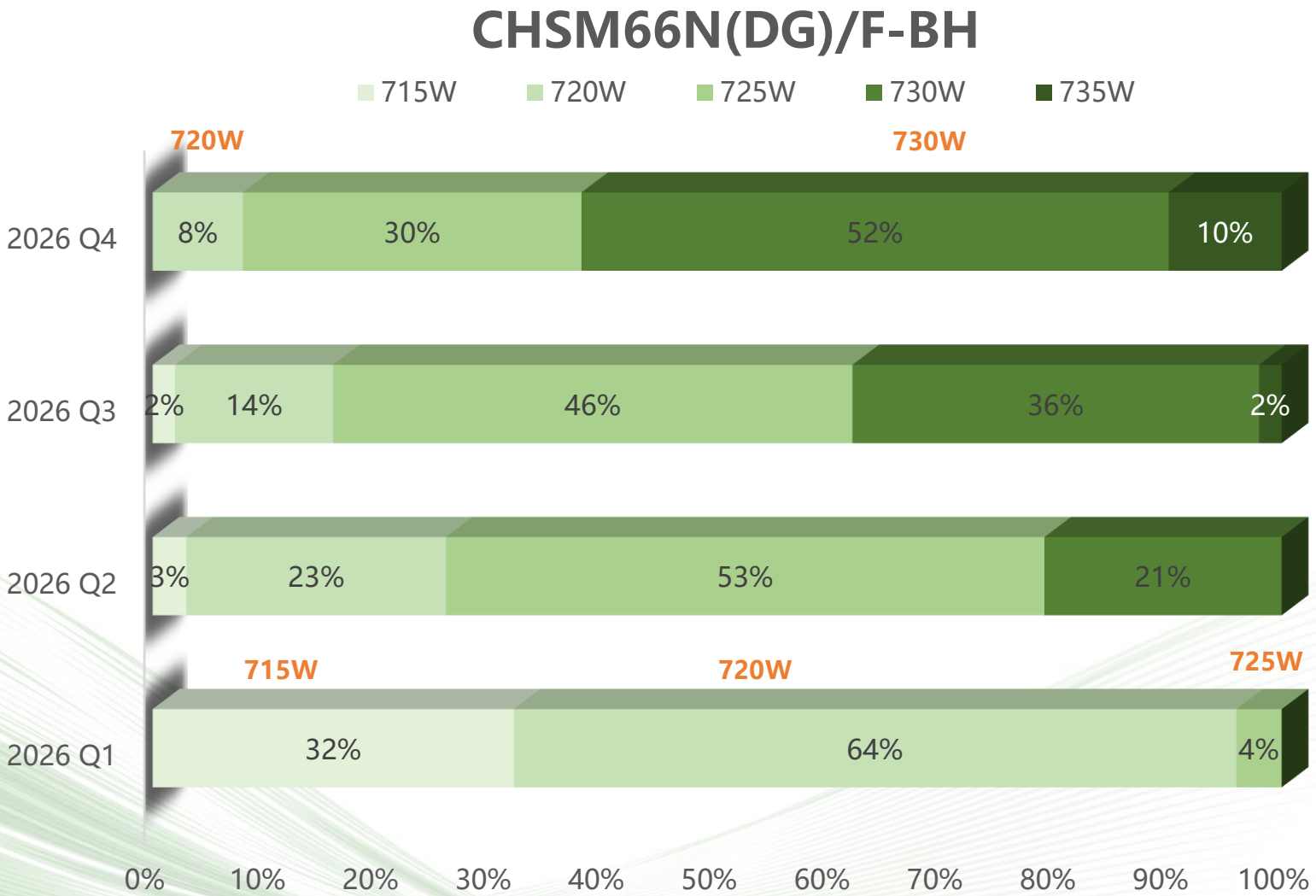
1st degradation

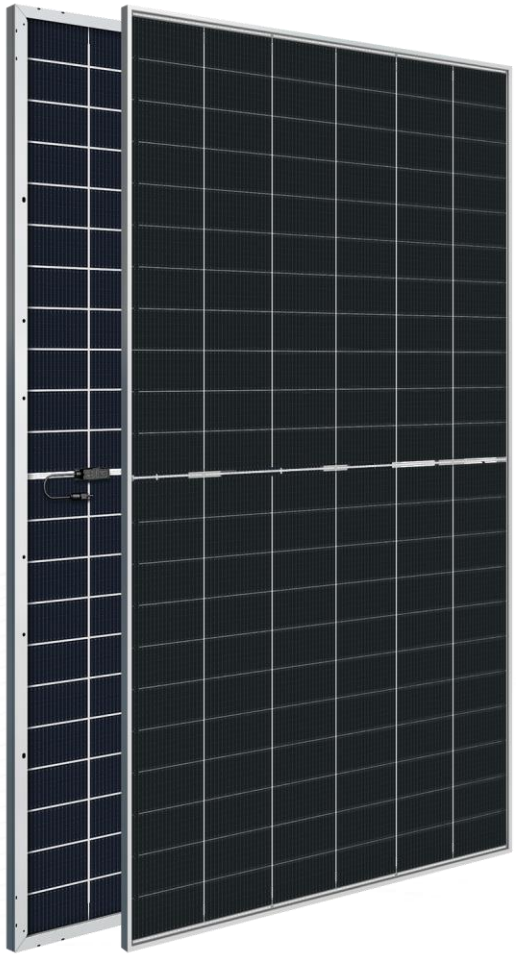
-0.35%

Annual degradation

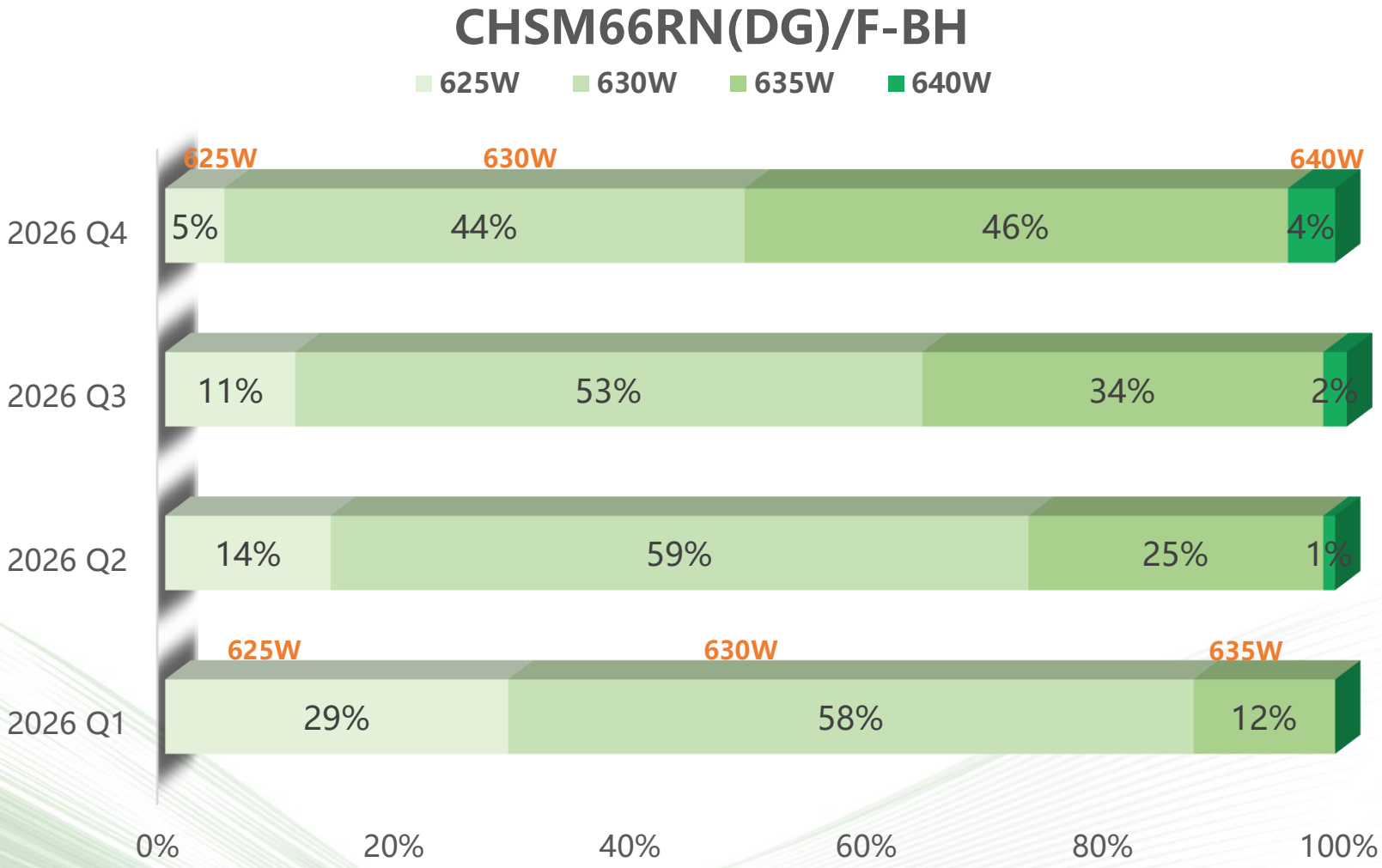
- Compared with PERC modules, ASTRO N exhibits **1% lower** first year degradation and **2.5%+ power attenuation** throughout the lifetime of the power station. Due to better **0.35%** annual degradation, ASTRO N7 Pro lifetime degradation will be **1.45%** lower than this.

Power Roadmap- ASTRO N8 (G12)

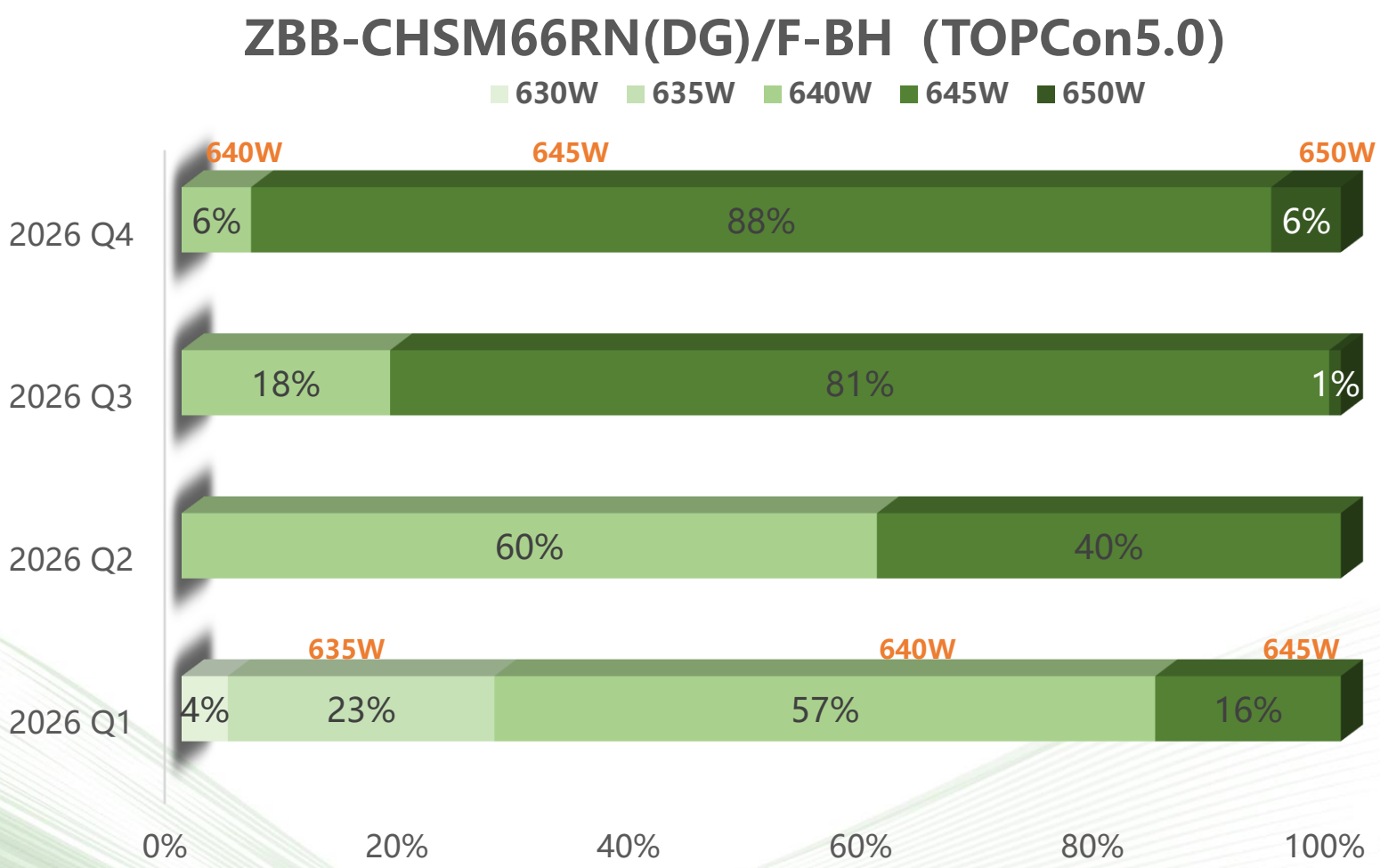




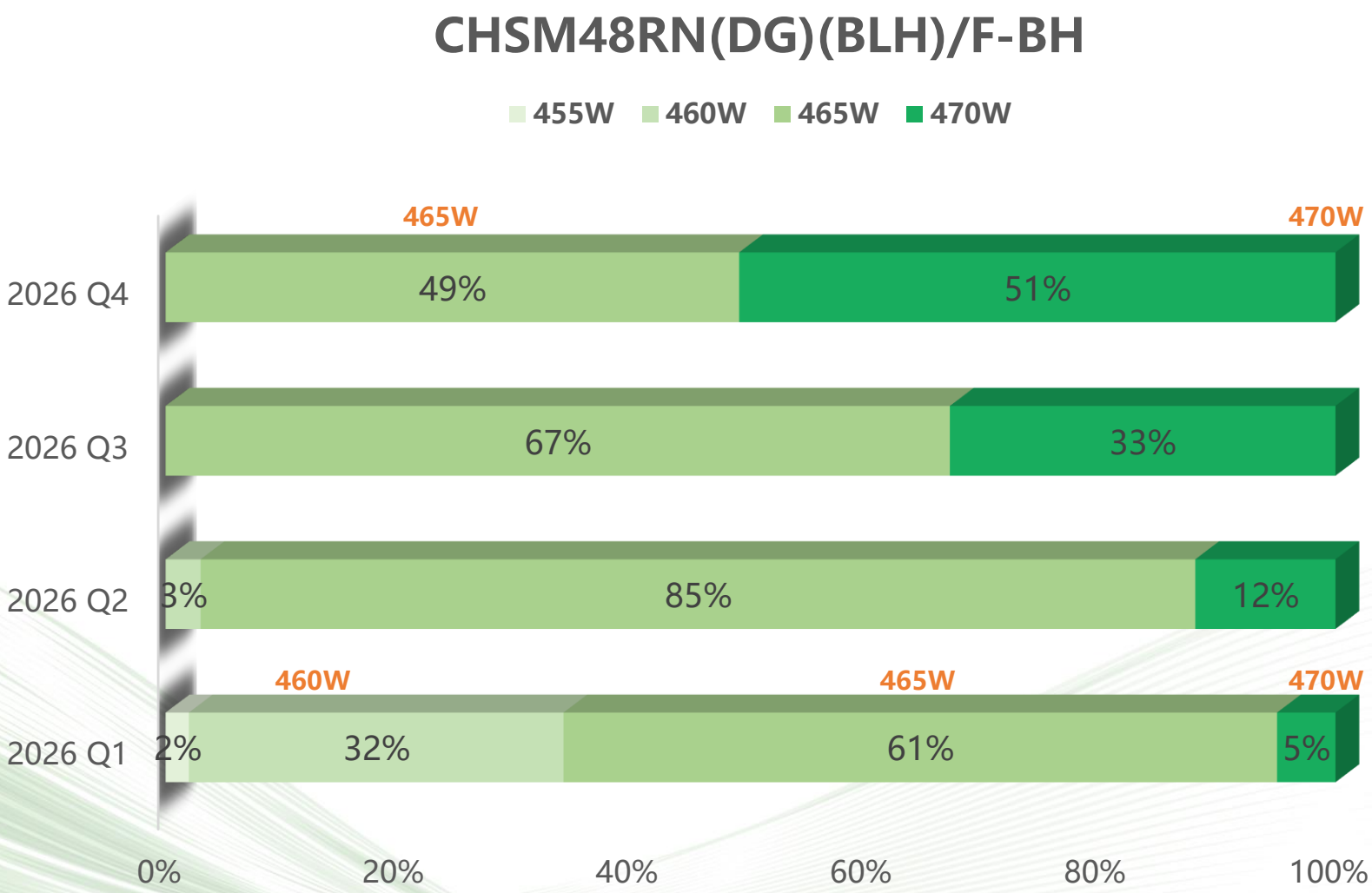
Power Roadmap- ASTRO N7 (G12R)

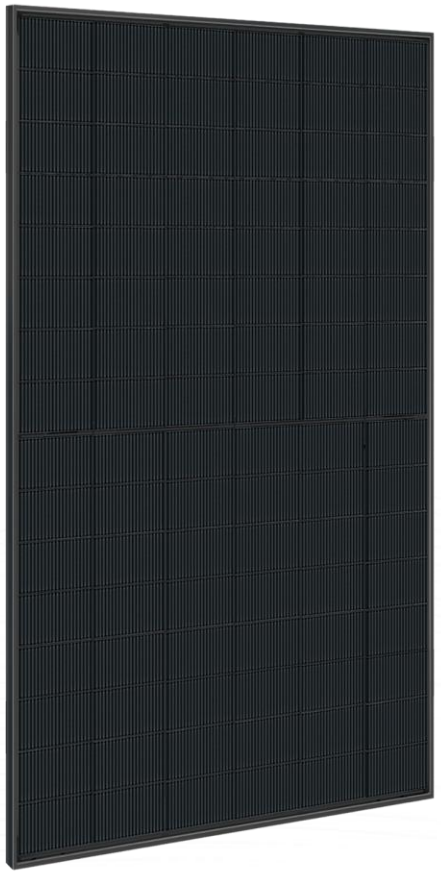


Power Roadmap- ASTRO N7 2.0 (G12R)-ZBB+TOPCon5.0

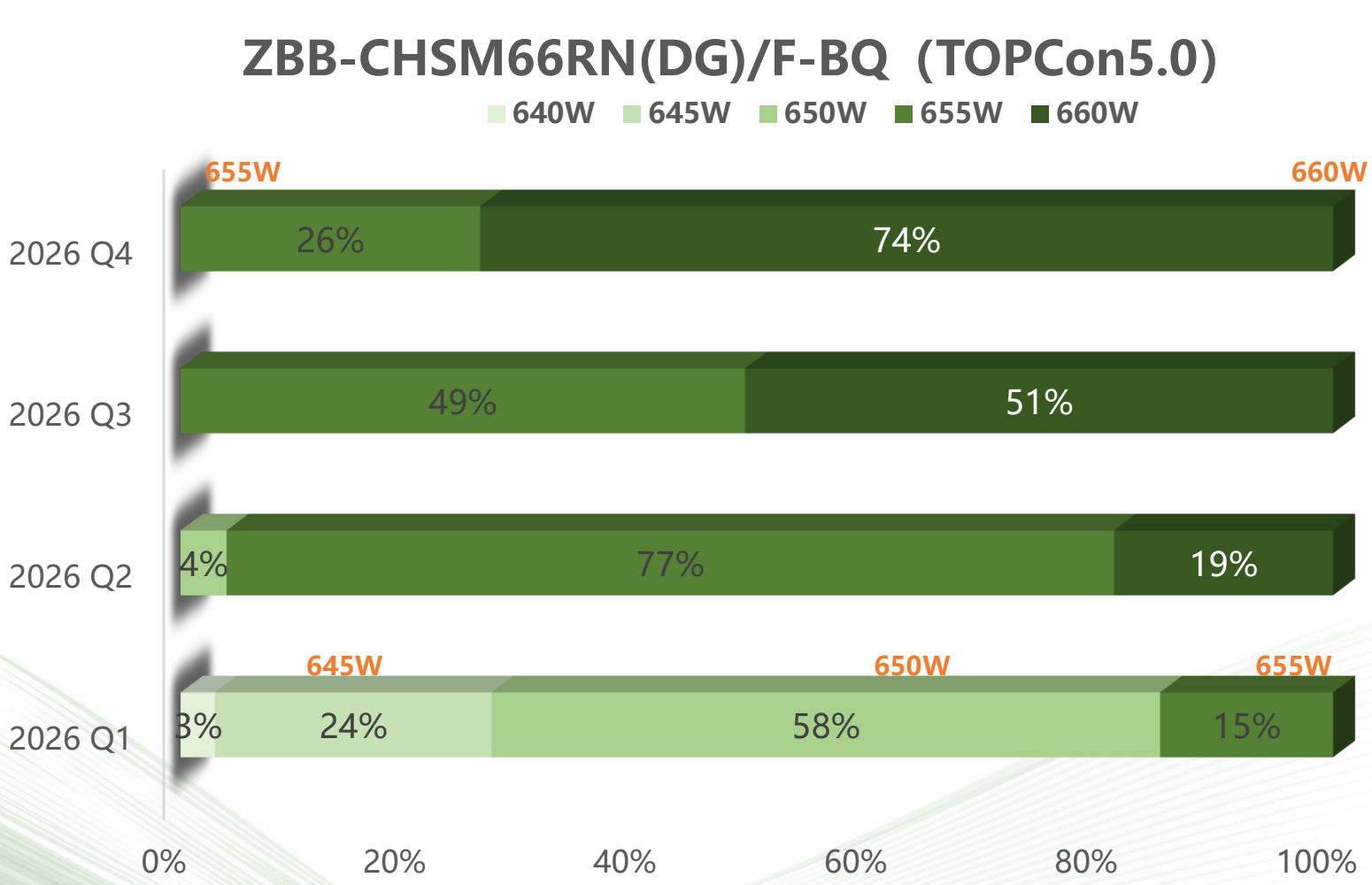


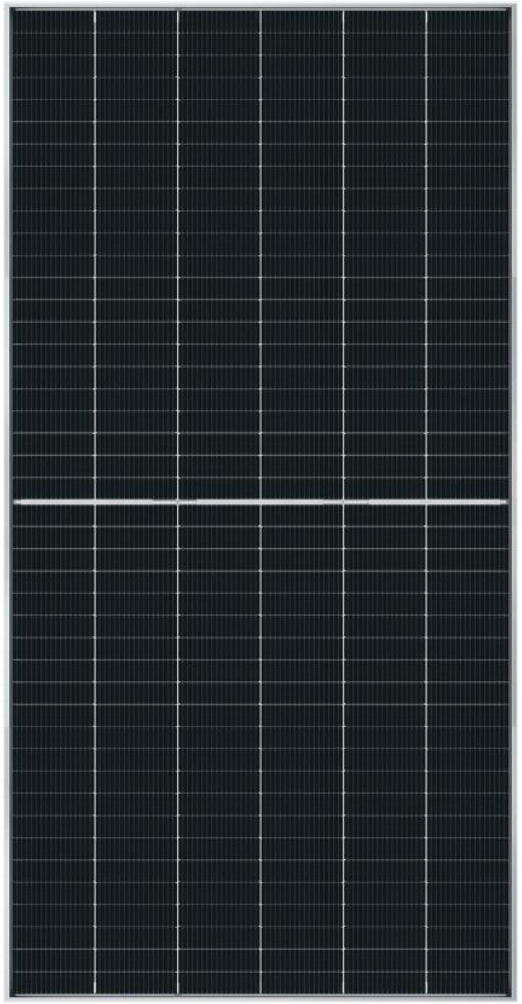
Power Roadmap- ASTRO N7s 2.0(G12R)-High-efficiency Plan





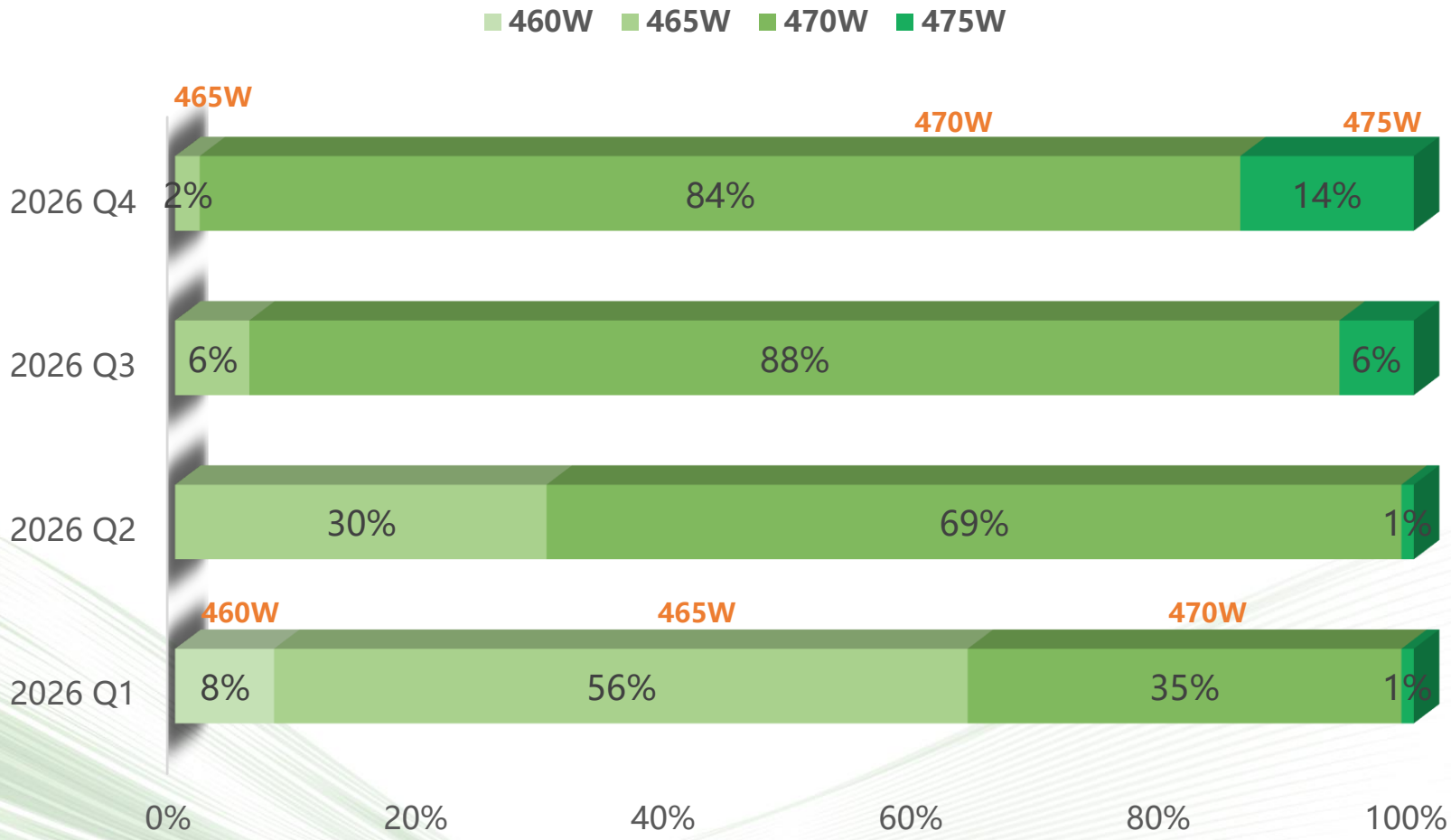
Power Roadmap- ASTRO N7 Pro (G12R)-ZBB+Multi-cut





Power Roadmap - ASTRO N7s 2.0(G12R)-High-efficiency Plan

CHSM48RN(DG)/F-BH



Business Value

Top 6 Module Shipments

- 2024 Modules Shipments among All Suppliers Worldwide

2025 PVEL "Top Performer" Award

- The ASTRO N Series has demonstrated outstanding performance in rigorous reliability testing, having been honored with this recognition nine times

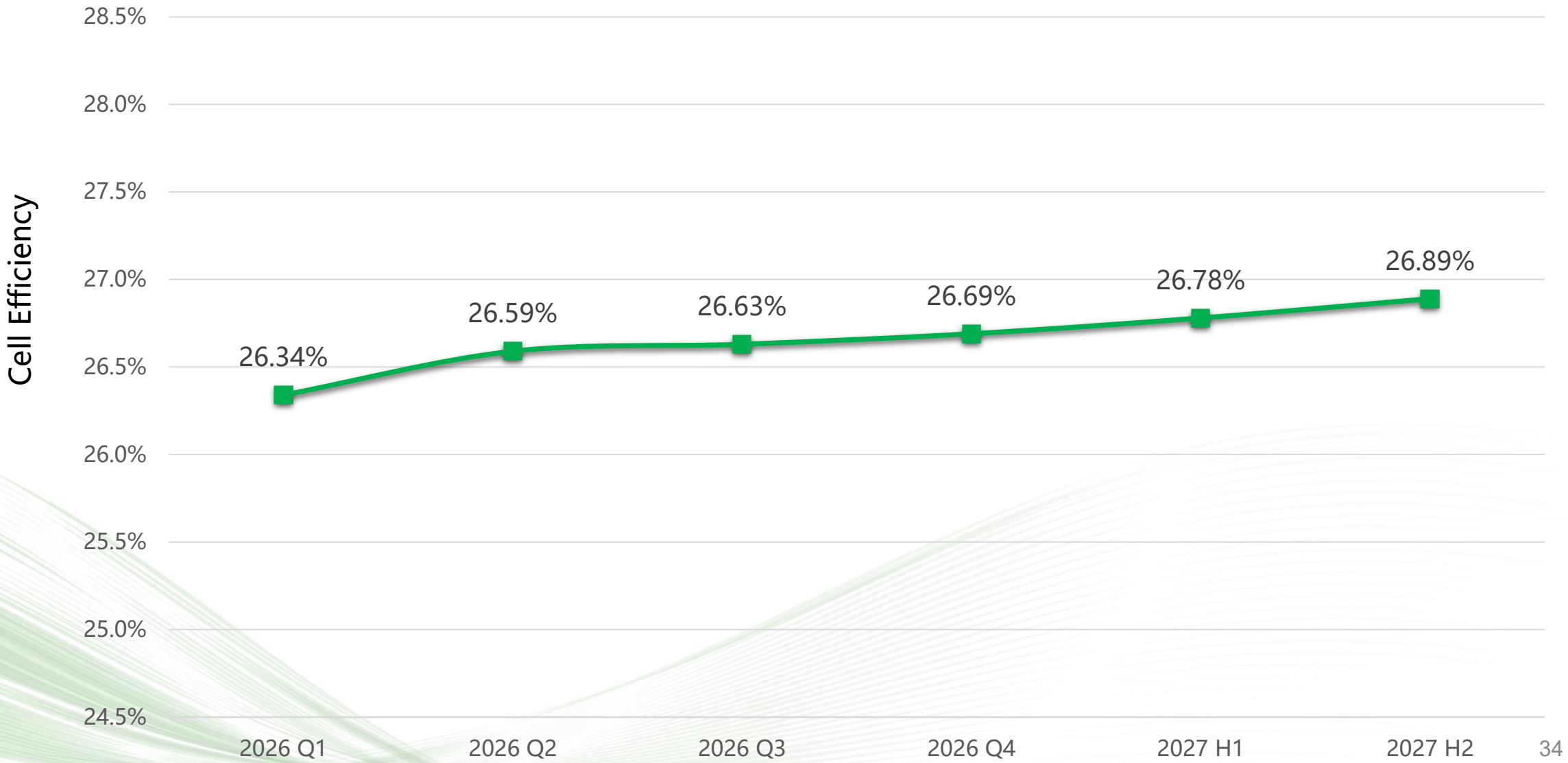
TÜV Rheinland "All Quality Matters" Award

- **Outdoor Energy Yield** Award (Bifacial Group)

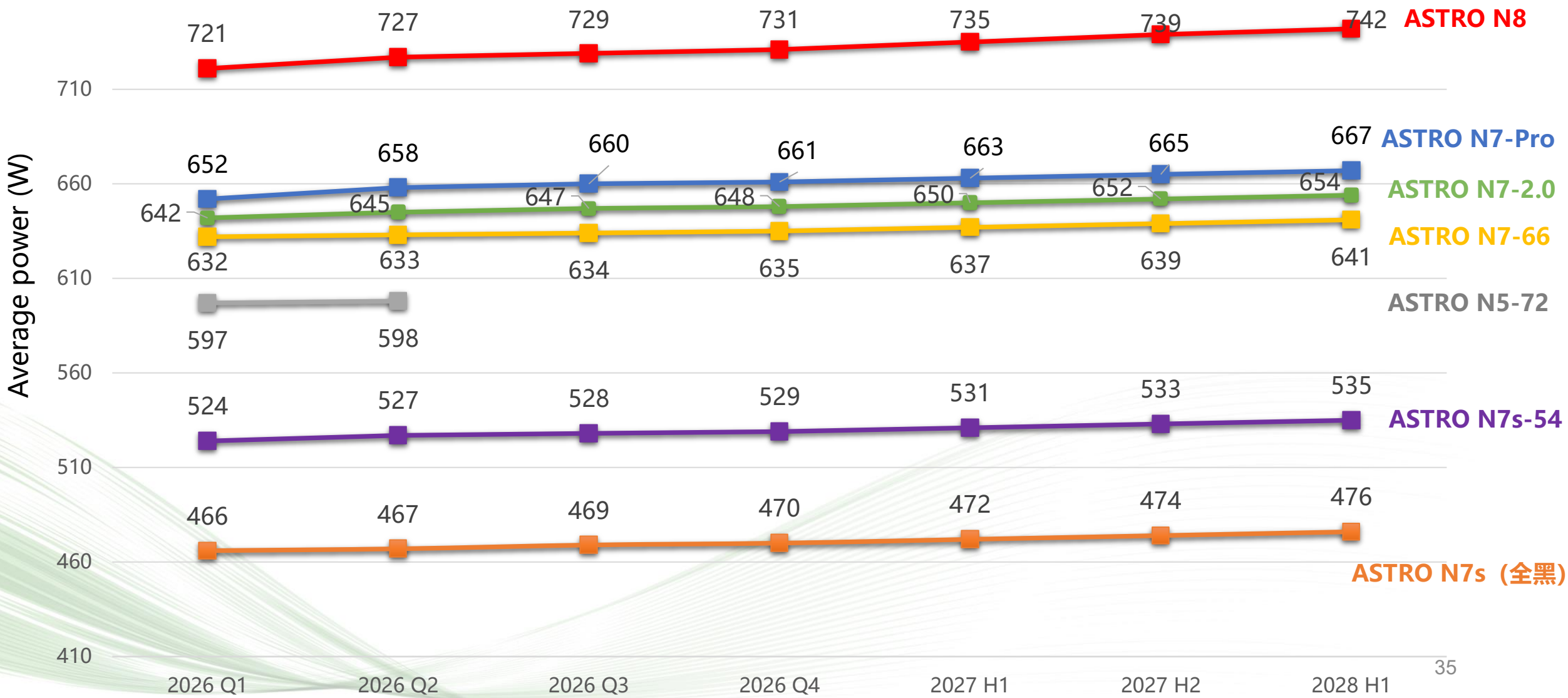
First Product Carbon Label Evaluation Certificate

- Firm green and low-carbon philosophy, strive to be the vanguard green production

Cell Efficiency Forecast

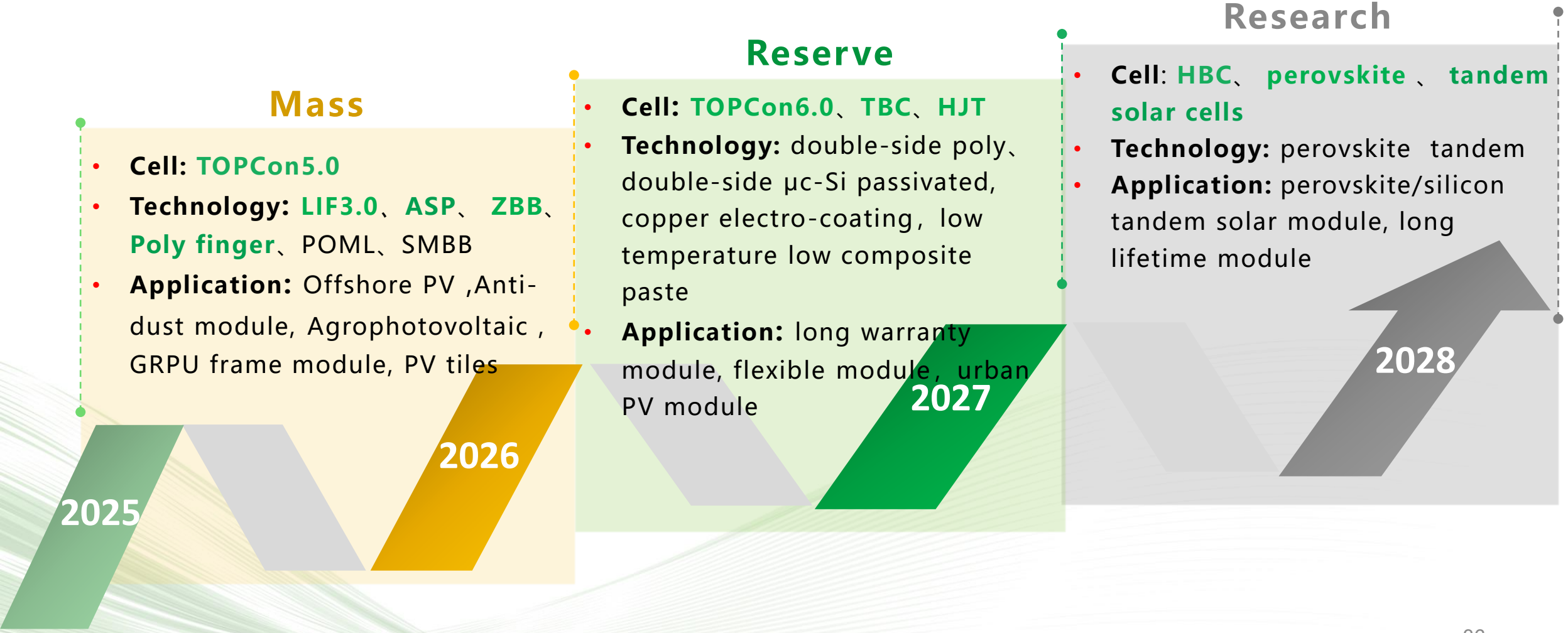


N-type Power Forecast



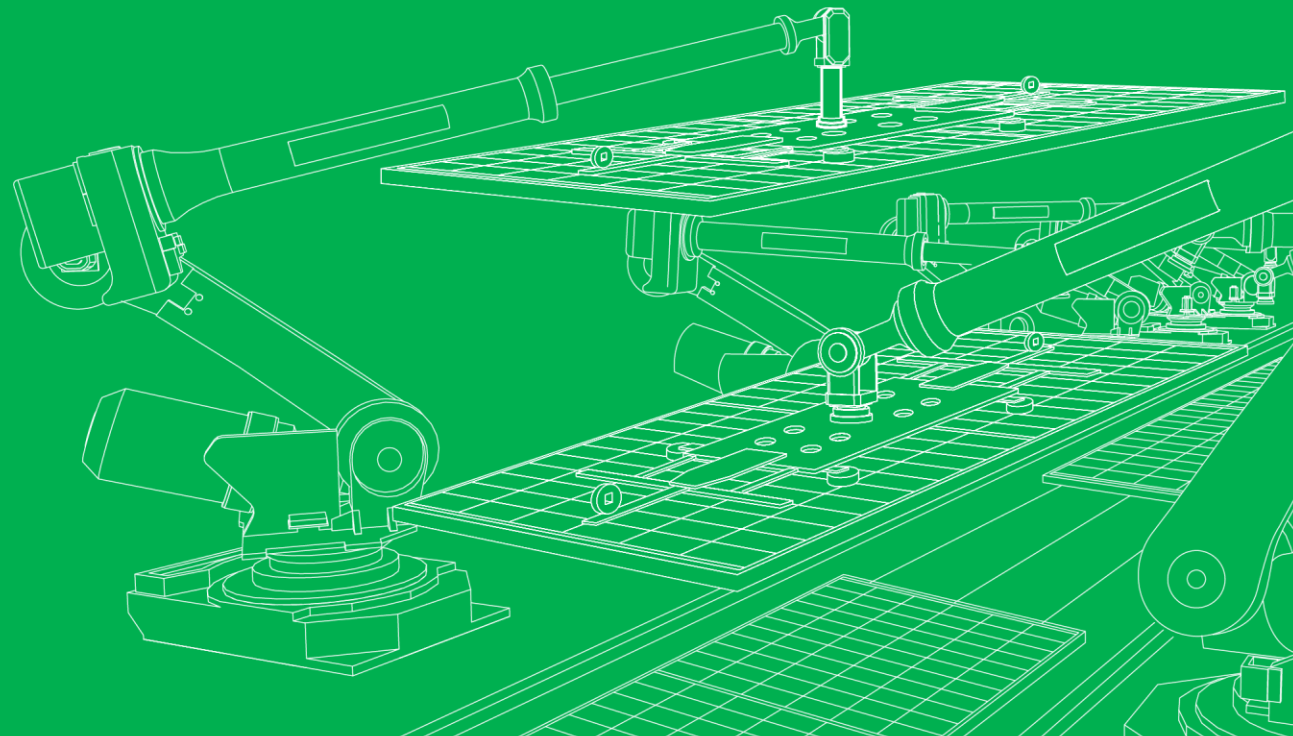
Product Plan

Product roadmap includes **TOPCon+、XBC、HJT and Perovskite/HJT** in 2024~2027.



ASTRONERGY

High Quality, High Performance, High Efficiency



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