



2024 GCL – Advancing Solar Solutions

Embracing New Technologies

Ensuring Traceability

Reducing Carbon Emissions

Large Scale Lisbon
26 Mar, 2024



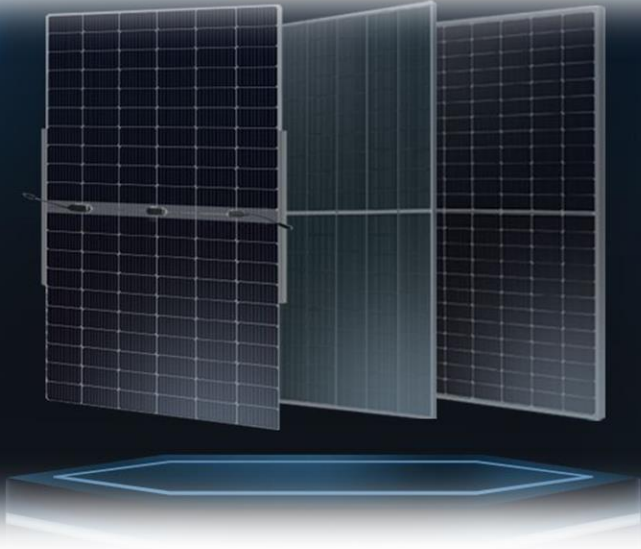
**Module
Technology, a
little bit of history**

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4

Photovoltaic technology route



Monocrystal technology

Polycrystalline technology

RCZ technology

Cast into square ingot

Thin film technology

Crystalline silicon technology

Photovoltaic technology

Photovoltaic technology route

Fotovoltaico

Monocristalino

Policristalino

a-Si

μ c-Si

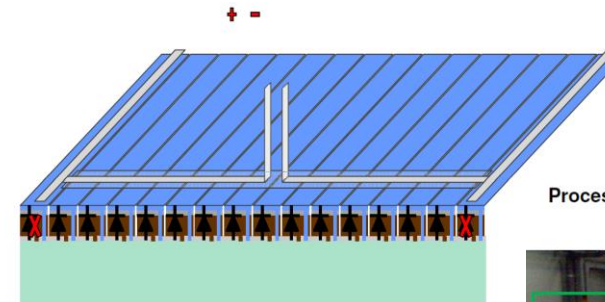
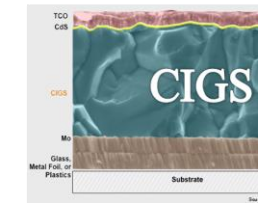
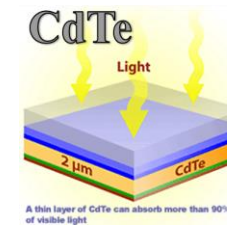
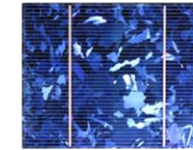
CI(G)S

CdTe

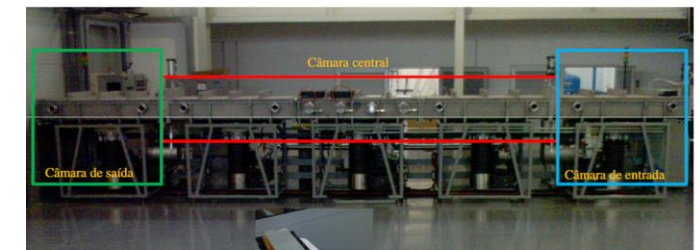
Mono c-Si



Multi c-Si

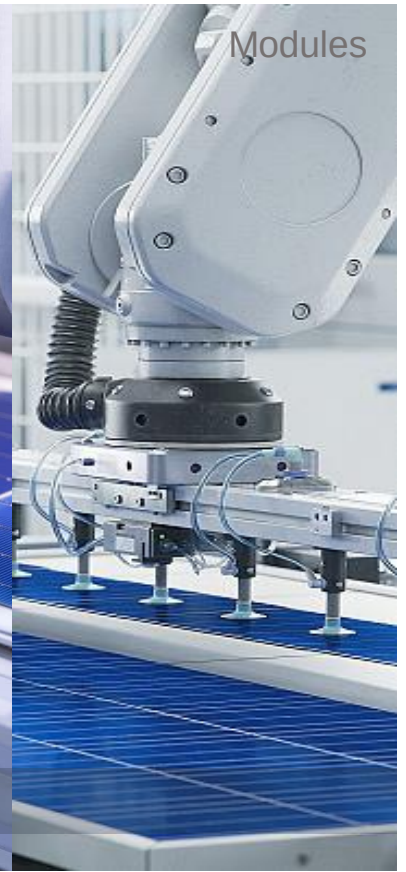


Processo Produtivo - Células Solares de Silício Amorfo- Sputtering



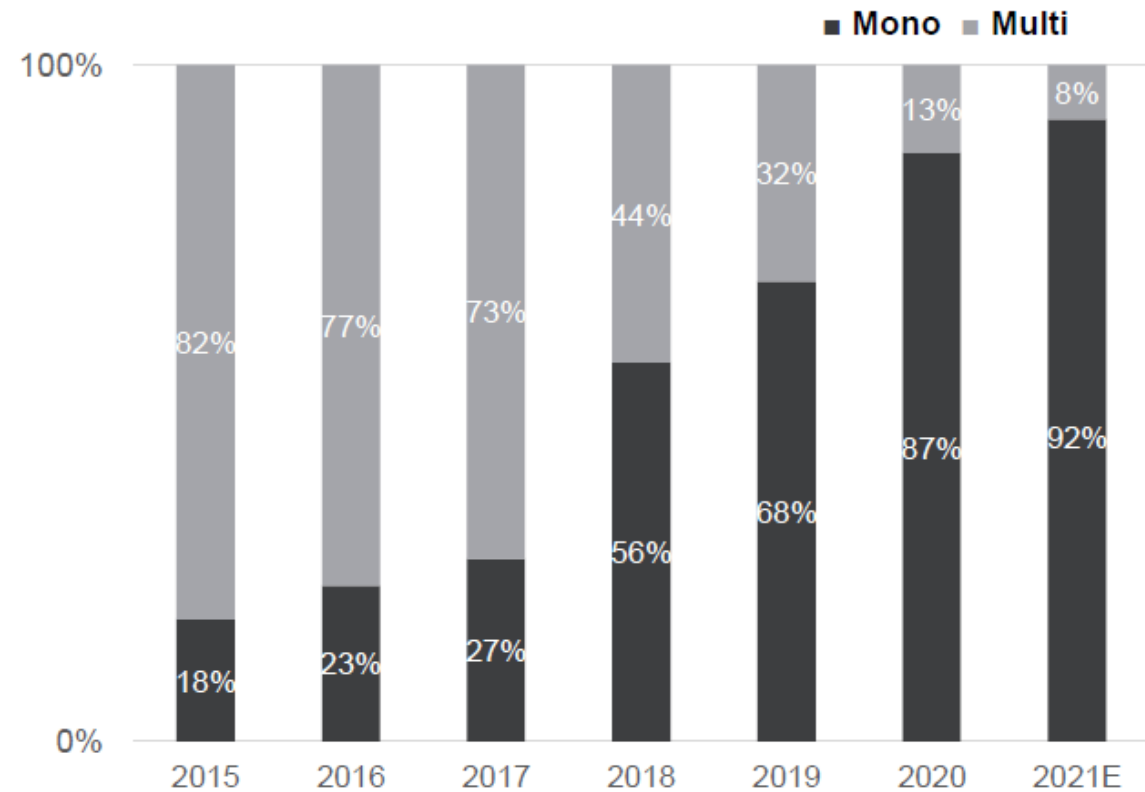
Target: Al/Zn

Photovoltaic technology route from Mono to Poli

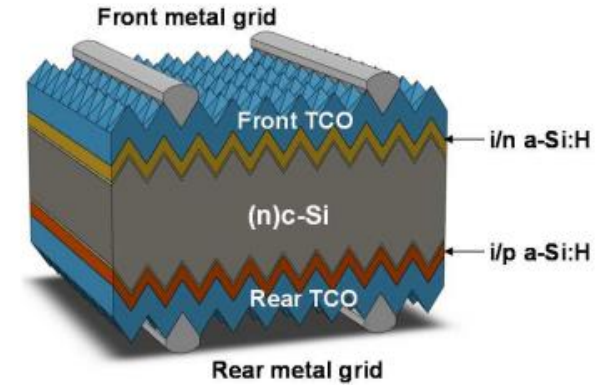
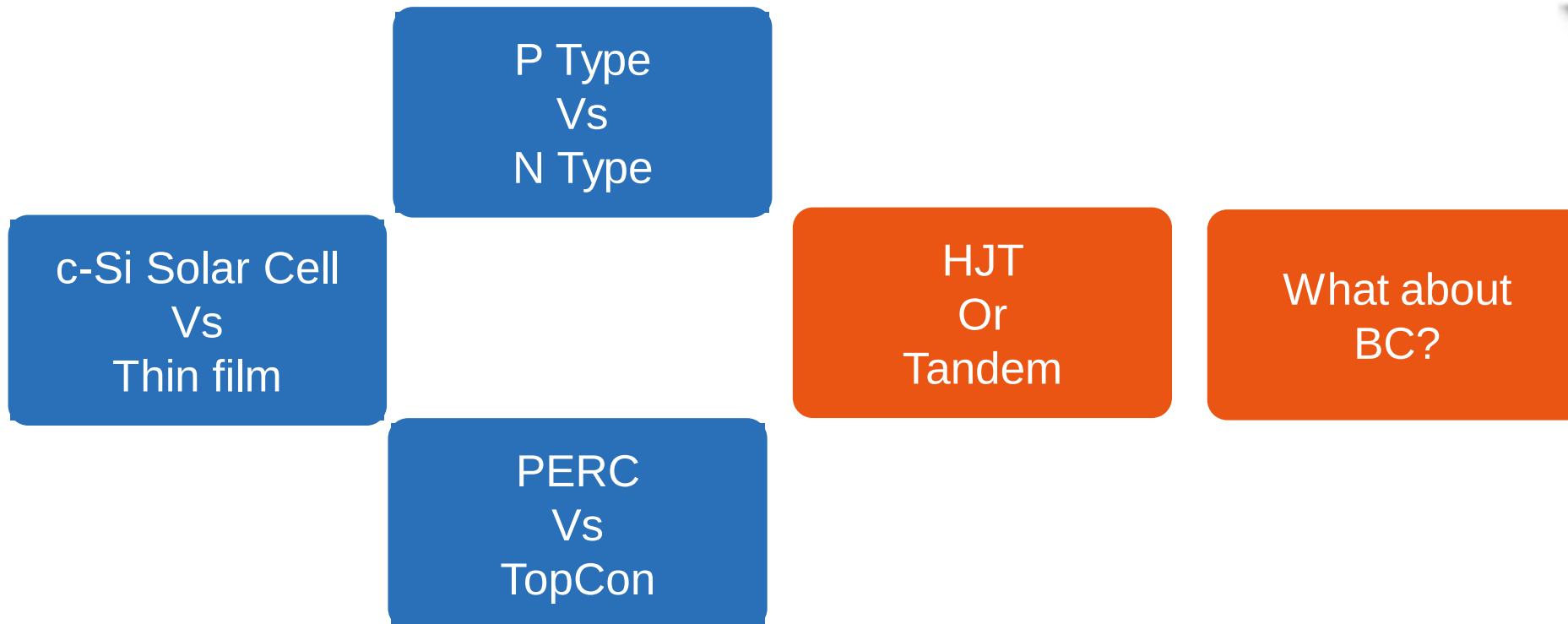


Photovoltaic technology route – Important Note

Global crystalline market is Monocrystalline

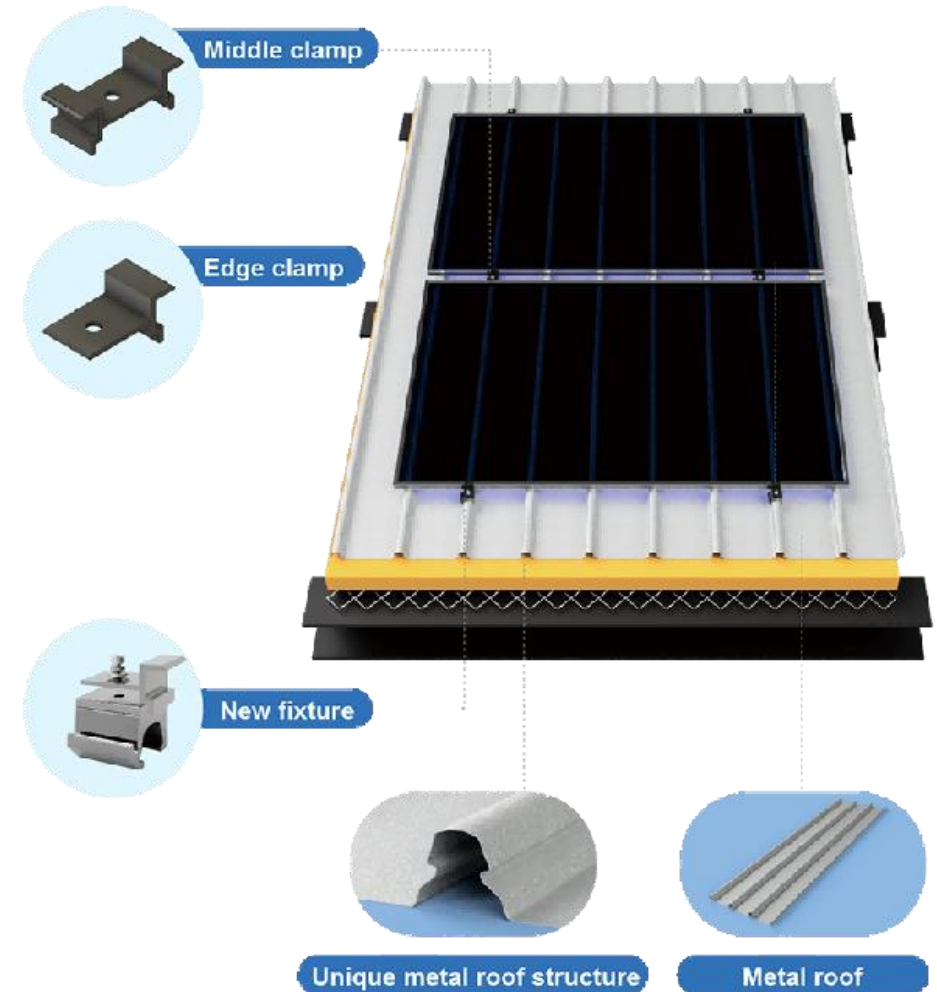


Global market share of crystalline solar product



Modules Design

- *M10 or M12??*
- *66; 72; 78 Cells??*
- *Bifacial or Monofacial??*
- *Frame or frameless??*
- *How I want to fix and install this modules ??*
- *Where will I Install this modules?*



R&D focus of large-size modules, solutions and test verification results



➤ Problems needing attention for large-size modules:

1. Load capacity of large-size modules?

2. Risk of overheating and damage to the junction box due to high current?

3. Risk of overheating of hot spots on large-size modules?

4. Operating temperature and outdoor power generation?

✓ Through a series of analysis and verification, the high reliability of large-size modules by GCLSI can still be guaranteed!

By optimizing the material and structural design and controlling the maximum shape variable of the load, the power degradation after the ML (5400/ 2400pa) test is less than 2%, which can fully ensure the reliability in the actual application scenario.

By optimizing the heat dissipation design of junction box and the process selection of bypass diode, the maximum working temperature of the junction box with high current is basically the same as that of 158/ 166 module.

The hot spot temperature of large-size modules (182-210) is slightly higher than that of 166 modules, but lower than that of 156 modules, indicating the risk is controllable.

The large-size modules adopt the MBB and Half-cut technologies; At the same time, the cell efficiency and bifaciality are both improved, and the series resistance is greatly reduced, resulting in lower power loss; The working temperature is equivalent to that of 156.75 modules, and no abnormal high temperature is observed. The outdoor experimental test is on-going.

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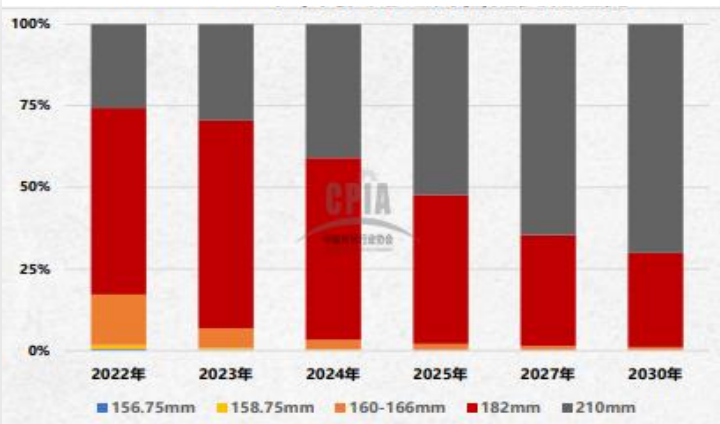
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Industry
Trends

Technology Trend: N Type + Thinner Wafer+ Rectangular Cell + Large Size Module + XBC

- Cost reduction advantage is obvious for thin slice, and its development is expected to speed up. According to the following calculation, for every 10μm of silicon wafer thinning, the cost of raw materials will decrease by 2.5%, and the trend of slicing is developing rapidly. At present, the average thickness of N-type TOPCon silicon wafer is 130μm.

Change trend of silicon wafers of different sizes in 2022-2030



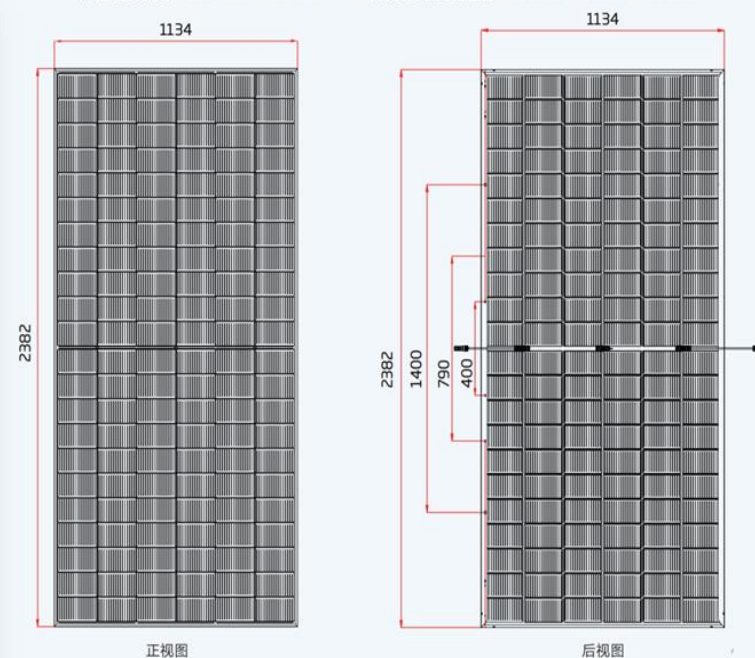
182mm+210mm Proportion:

2021: 45%
2022: 82.8%
2023: 93.2%

Data source: PV InfoLink

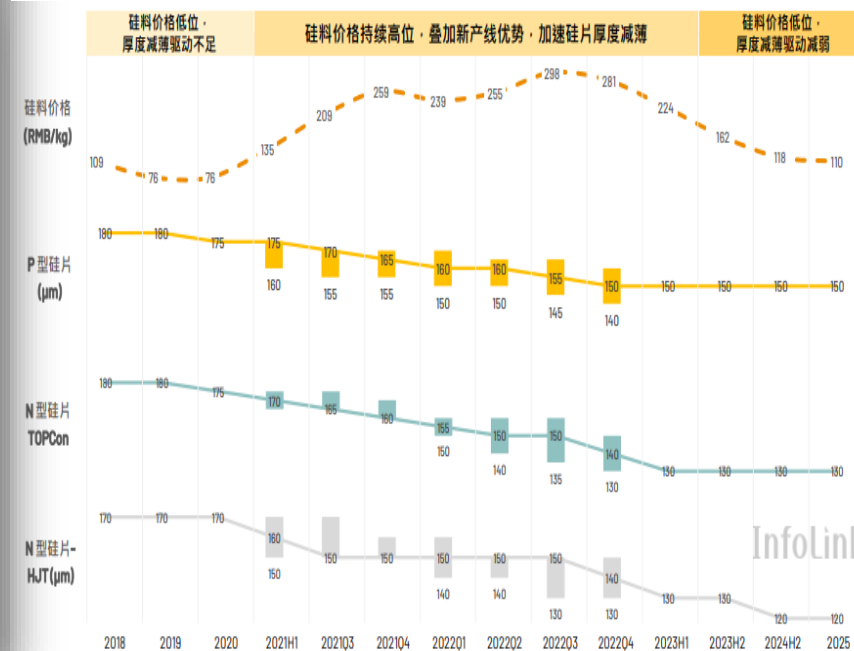
C9 company advocated standardized size

中版型组件尺寸: 2382mm*1134mm 组件长边纵向孔位距: 400mm/790mm/1400mm



Data source: CPIA 2023.02

The price of silicon material remains high, accelerating the thickness reduction of silicon wafer.

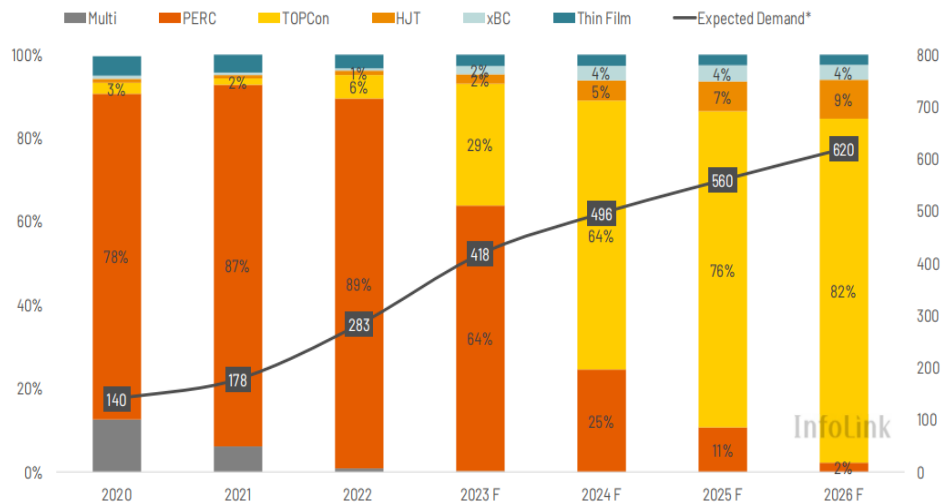


Data source: PV InfoLink

Technology Trend: N Type + Thinner Wafer+ Rectangular Cell + Large Size Module + XBC

- The TOPCon device investment has reduced to 0.15-0.2 billion RMB/GW, lower than HJT (0.35-0.4 billion RMB/GW), and it is the same high temperature process, compatible with the PERC line, many new PERC capacity can update to the TOPCon directly;
- N-type is developing rapidly, and the subsequent new capacity will be mainly selected in TOPCon and HJT
- Module shipments with TOPCon technology is expected to break the market share of 70% in 2024H1.
- OBB technology and XBC technology will lead the development of high-efficient and low-cost technology in the future.

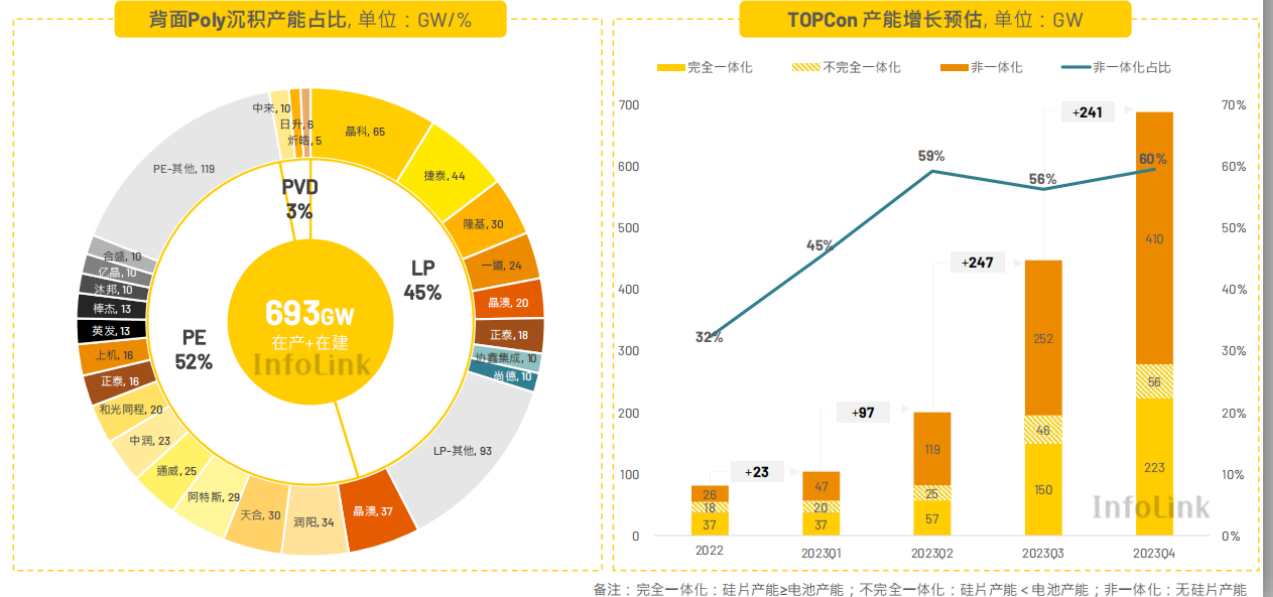
The trend of market share of different cell technology routes in 2021-2026



*Expected Demand 取乐观和保守情形的平均值

Updated: 2023/05/20

TOPCon capacity growth and technology



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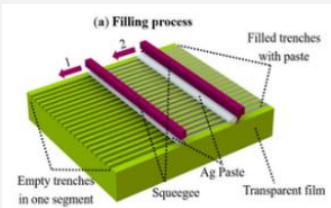
Module Technology Roadmap

Product Roadmap, GCL SI



- In 2024, GCLSI's products will cover high-efficiency cells, modules, photo-thermal and energy storage products;
- Continue to launch high-efficiency 182 and 210 module products. The maximum power of TOPCon 182R module will go to 610W, TOPCon 210 module will go to 695W and the HJT certified power is 710W;
- We attach great importance to differentiated products in the market segment, including new sea surface floating modules, BIPV products, intelligent modules, flexible modules, photothermal modules & systems, and household & industrial and commercial energy storage systems.

High-efficiency cells & modules



TOPCon cell (24.8~26%)

In 2024, cell efficiency will exceed 26%



High efficiency, large size module (540~710W)

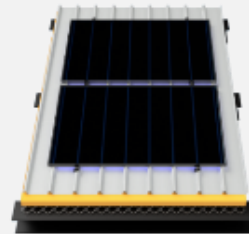
- Reduce cost and increase efficiency
- Vertical integrated industrial chain
- Lower BOS
- Lower LCOE

Differentiated products in the market segment



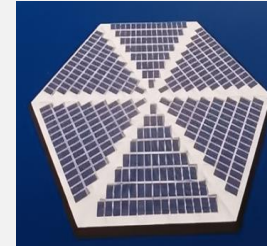
Smart module

It is a project cooperated with HUAWEI, sub-cascade power optimization, power generation increased by 5% - 10%.



BIPV product

Two series of products (JPV & SPV), which meet the building standard of photovoltaic modules.



New sea surface floating modules

Immersible, highly reliable floating photovoltaic system



PVT module

Power generation, heating, low energy consumption products and systems

Household energy storage products



Household storage products, high-voltage split machine, low-voltage split machine, low-voltage energy storage and inverter integrated machine have been listed in succession.

Standard Modules: PERC



M10/54H
410-420 W

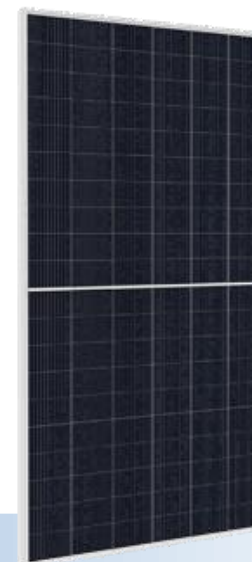
M10/72GDF
545-560 W

M10/72H
550-565 W

M10/72H-rooftop
550-565 W



182 Series



210 Series

M12/60GDF
595-615 W

M12/60H
600-620 W

M12/66GDF
655-675 W

M12/66H
660-680 W

TOPCon – Main Products Family



TOPCon Modules Applicable to all Scenarios.

NT12/66GDF

695Wp+

NT10/78GDF

625Wp+

NT10/72GDF

580Wp+

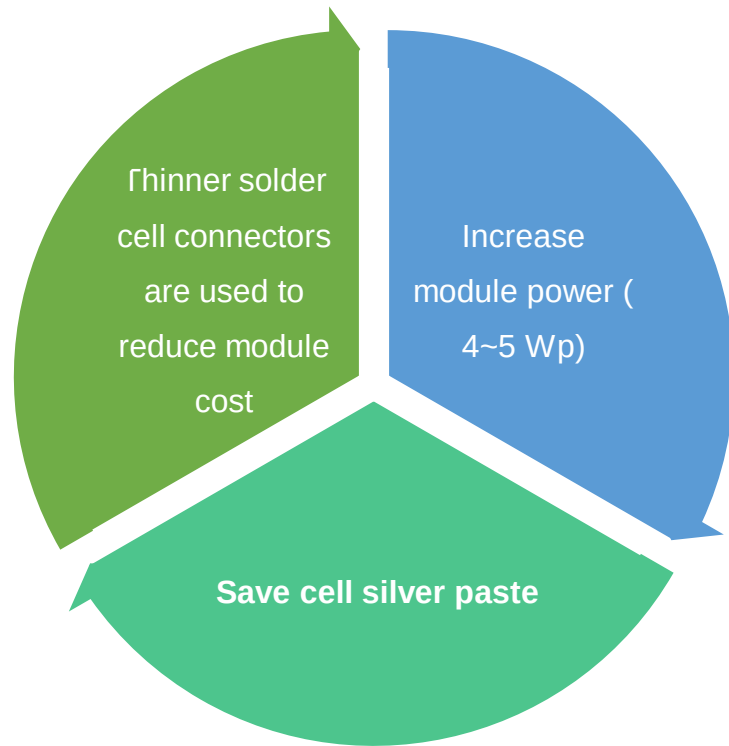
NT10R/54GDF

440Wp+



French Low Carbon Certification for TOPCon Modules.

TOPCon Cell Technology Combined with Module SMBB Technology Using High Dense and Fine Grid Technology



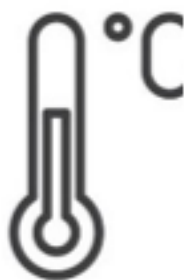
- SMBB technology reduces the consumption of cell silver paste, the number of multi-busbar is between 16BB~20BB.
- Topcon silver paste consumption is high, there is room for decrease with SMBB. At present, the consumption of Topcon silver paste is 20-30% higher than that of PERC (mainly the back of PERC is painted with aluminum, which has the effect of field effect passivation, and the back of PERC cell does not need to use too much silver paste), but with the application of SMBB, the consumption of silver paste can also be reduced; On the other hand, the silver content of the paste used by TOPCon can also be reduced considerably (about 60-70% silver content).
- SMBB technology can increase module power by 4~5Wp.
- SMBB technology enables the use of ultrafine cell connectors (0.23 ~ 0.26mm) and the thinning of EVA grams, which further reduces costs.

- SMBB = Super Multi-Busbar

Advantages of the N-TOPCon 182 Module



Power generation increased by more than 3%



The optimized temperature coefficient gain is more than 0.45%;



Higher bifacial factor, the gain is more than 1.1%;
N-type modules have higher bifaciality;
70% (P-type) to 85% (N-type), greatly optimizing power generation capacity.



Lower degradation rate, the power gain is more than 1.2%;
The boron content in phosphorus-doped N-type crystalline silicon is extremely low, significantly reducing the LETID (from 0.9~1.2% (P-type) to 0.4% (N-type) and optimizing the LID to <0.5%).



Better weak light performance, the power gain is more than 0.25% (N-type cell, higher internal resistance, longer minority carrier life, naturally has better weak light response).

Product Roadmap: N-Type



	580W	590W	615W	620W	625W	635W
EFFICIENCY	22.5%	22.6%	22.8%	23.0%	23.1%	23.5% *HJT
WAFER SIZE	182 mm	182 mm	182R/210R	182R/210R	182R/210R	182R/210R
MODULE SIZE	2278*1134 mm	2278*1134 mm	2382*1134 mm	2382*1134 mm	2382*1134 mm	2382*1134 mm
	2023 Q4	2024 H1	2024 H2	2025 H1	2025 H2	2026
	690W	700W	710W	715W	720W	730W
EFFICIENCY	22.2%	22.5%	22.9%	23.0%	23.2%	23.5% *HJT
WAFER SIZE	210 mm	210 mm	210 mm	210 mm	210 mm	210 mm
MODULE SIZE	2384*1303 mm	2384*1303 mm	2384*1303 mm	2384*1303 mm	2384*1303 mm	2384*1303 mm

* 182R: 182*191.6 mm
210R: 210*182 mm

Featured Product: TBC-182 Module



595-620W Monofacial

- N-TBC / half-cell technology
- Module efficiency 24%
- 3.2mm monofacial
- 2278*1134*35 mm / 2.58sqm
- -1% annual degradation for the 1st year, 0.35% for the years after



445-455W Monofacial

- N-TBC / half-cell technology
- Module efficiency 23.3%
- 3.2mm monofacial
- 1722*1134*30 mm / 1.96sqm
- -1% annual degradation for the 1st year, 0.35% for the years after



*Estimated mass production by end of 2024

LID Free

LID free, increased power generation

Excellent Anti-PID Performance

Due to the use of n-type TBC cell

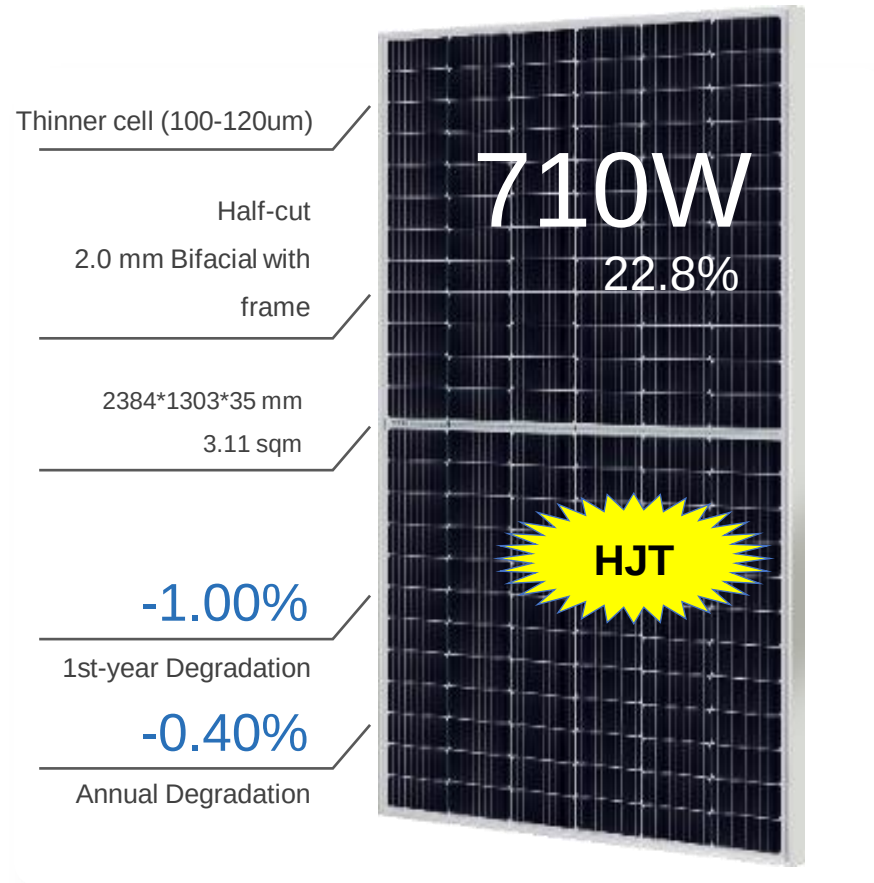
Ultimate 'Black'

No grid lines at front, all black modules demonstrating product aesthetics

Better Weak Light Performance

Lower temperature coefficient and wider spectrum to achieve higher power output under weak light

HJT N-type 210-66c Bifacial Dual Glass Module



GCL-NH12/66GDF 680-710 W

High Efficiency Front Side (up to 22.8%)

- HJT n-type cell

Up to 30% Additional Gain From Back

- Bifacial factor average 80%

LID Free

- LID free, More power generation

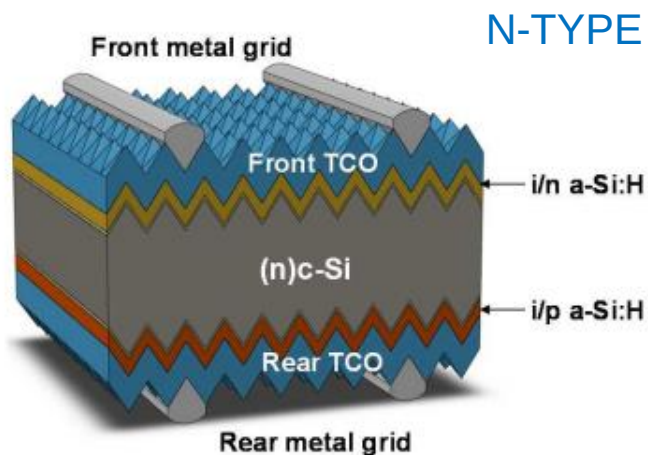
PID free

- PID free with HJT n-type cell

Better weak light power generation

- A lower temperature coefficient is associated with a wider spectrum, resulting in higher power output under weak light conditions

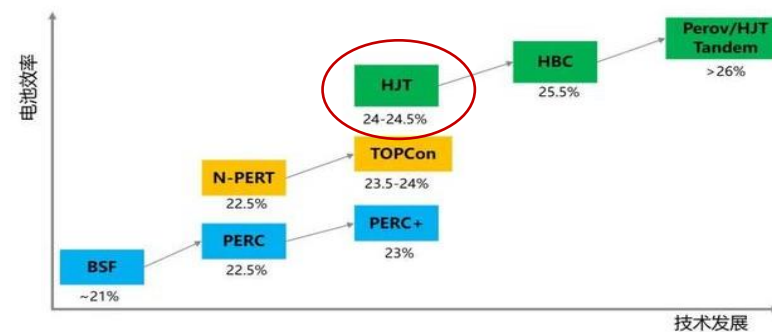
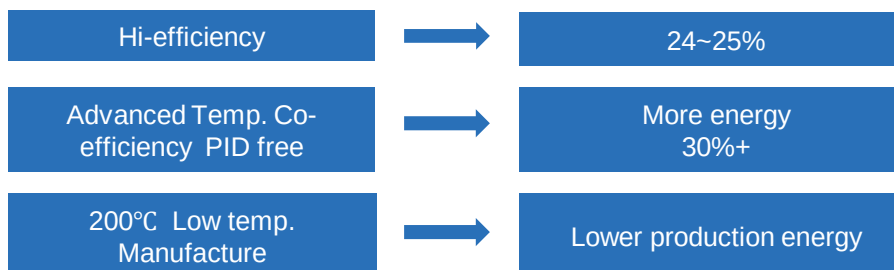
HJT Cell Technology



- Developed on n-type Cz Si
- Bifacial passivated structure by amorphous silicon film
- Heterostructure P-N junction
- Form conductive and antireflective layers by TCO

Technical advantages of HJT: four high and two low

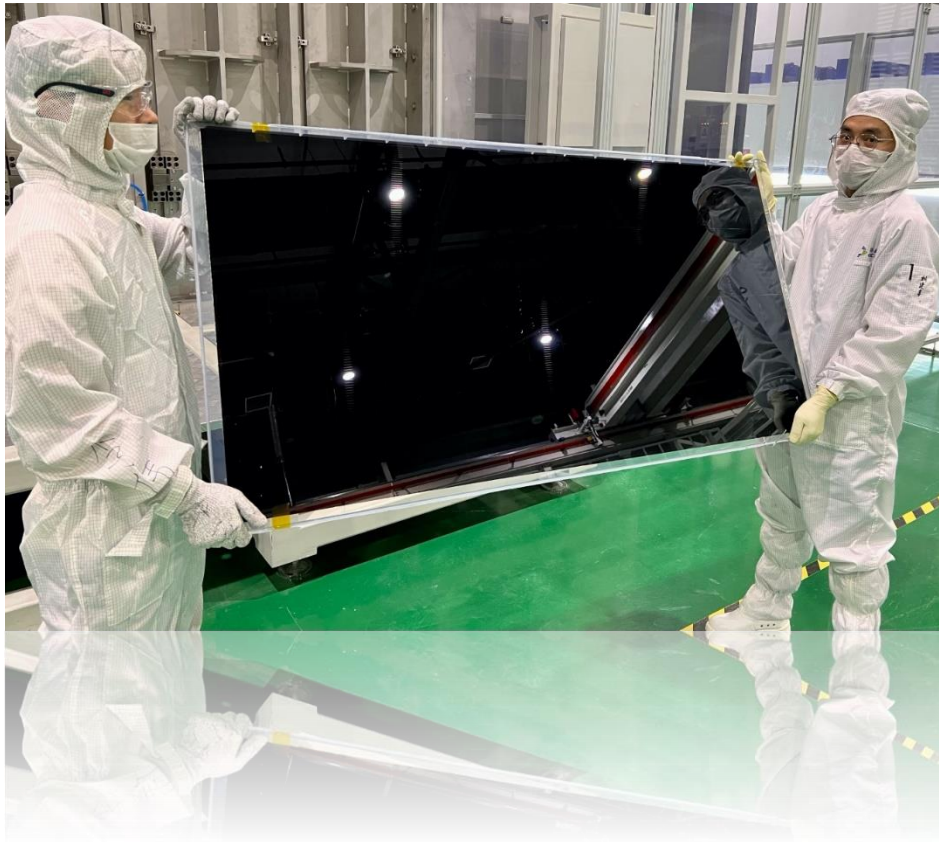
- The four highest are high efficiency, high yield, high bi-facial rate, and high LID.
- Two low is low power degradation, low temperature coefficient.
- Good technical expansibility: it can be upgraded to HBC, perovskite /HJT tandem cell, etc



Perovskite – A Revolution in Modules



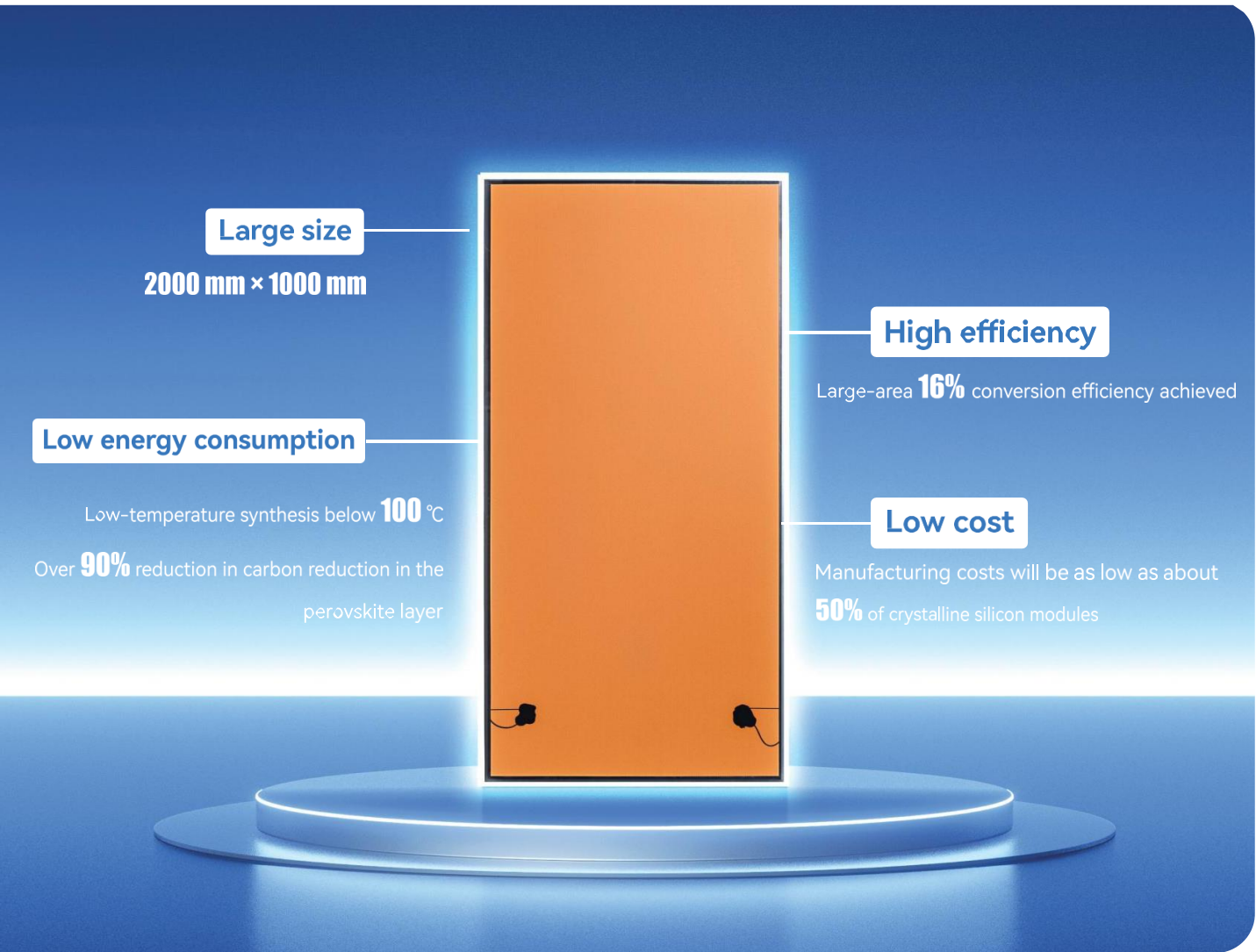
Global Leader in Mass Production of
Large Size Perovskite Modules



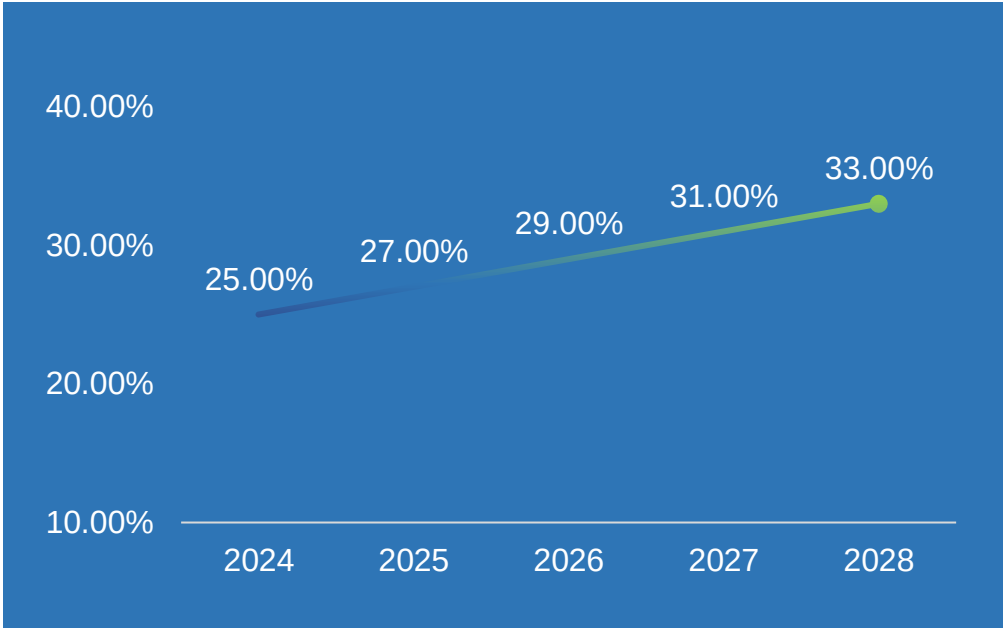
50% ↓ **Lower Production Cost:** the unit cost of modules is 50% lower

20% ↑ **Higher Power Generation:** 20% more power generated

Featured Product: Perovskite PV Module



Efficiency of Perovskite TANDEM



Perovskite silicon TANDEM Module
efficiency over 25% in 2024

25W higher power than TBC Module

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Industry
Trends

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Module
Technology
Roadmap

3

Innovative
design &
Reliability



**Traceability and
ESG**

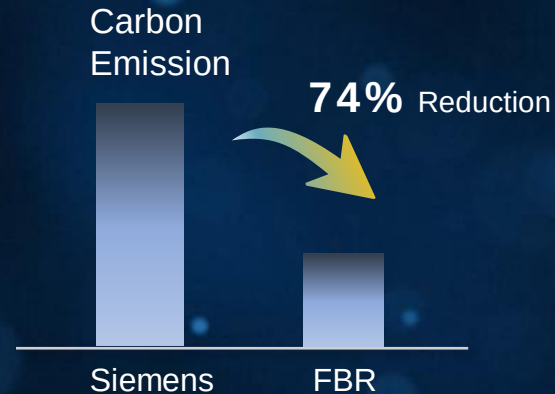
Decarbonization and Sustainability

FBR Granular Silicon – The Future of Silicon

GCL has the world's largest granular silicon (FBR) production capacity

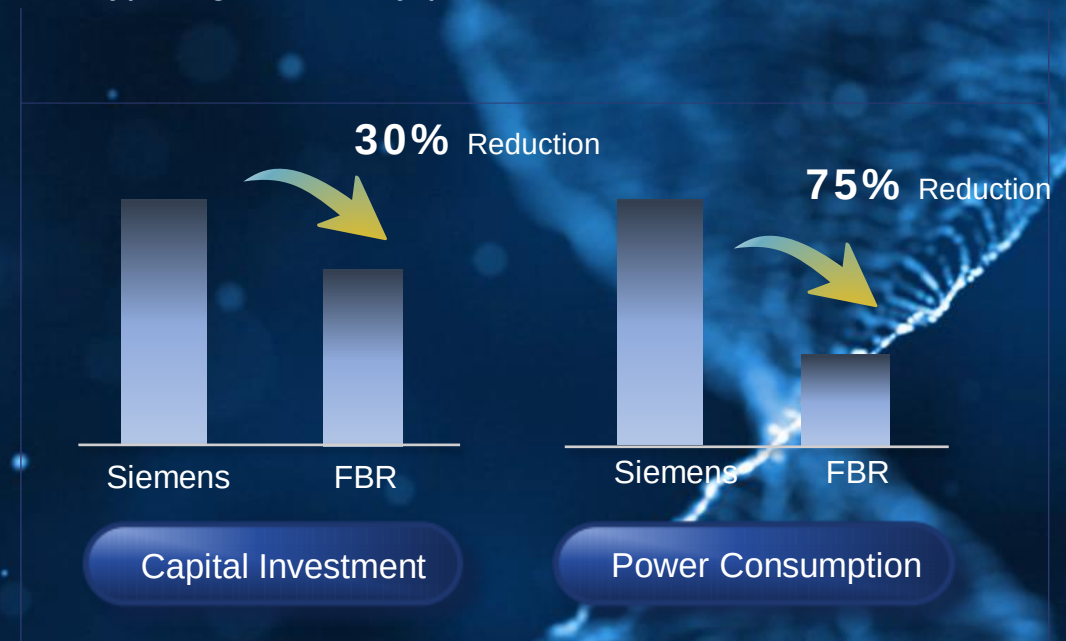


French Carbon Footprint Certificate



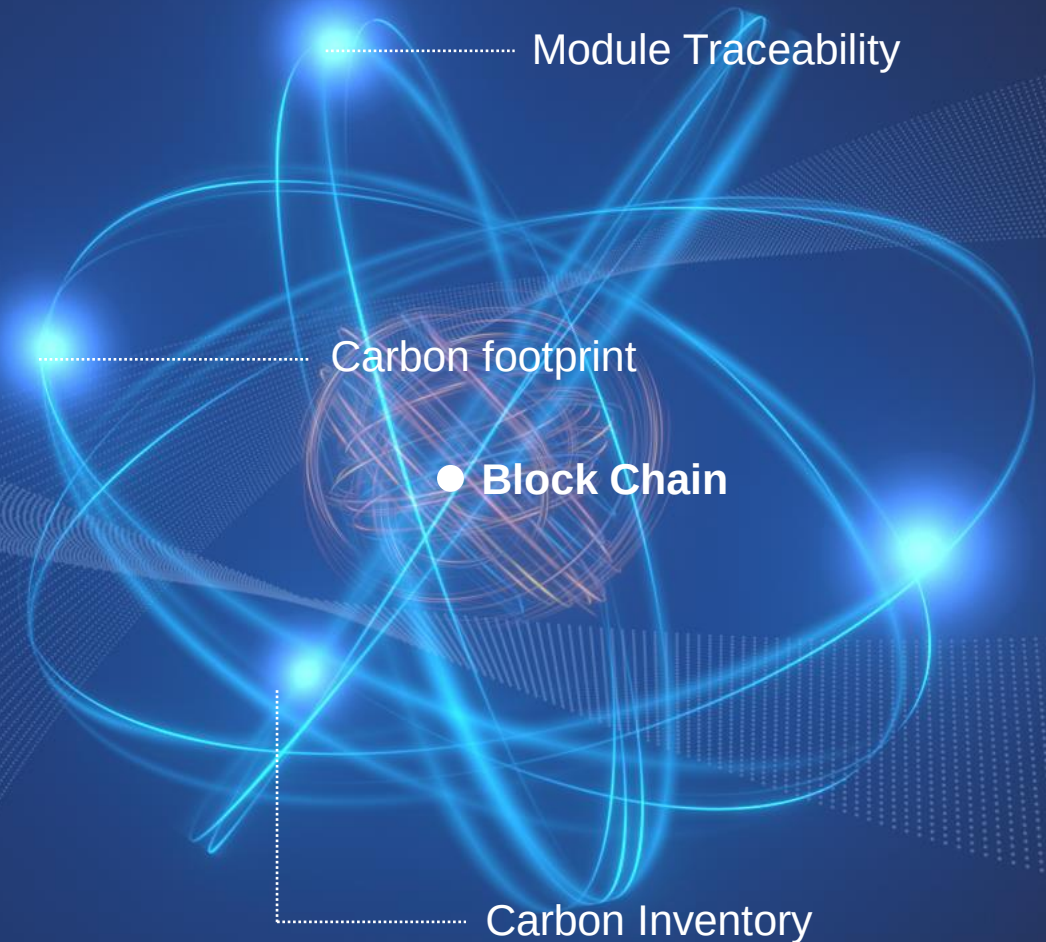
The carbon footprint value per kg of granular silicon is 20.74 kg of CO2 equivalent, and the carbon emission is the least in the world

GCL FBR Tech vs Siemens Method: Suitable for downstream production, effectively saving about **19%** of the cost, meeting the requirements of N-type high-efficiency products.



GCL Carbon Management

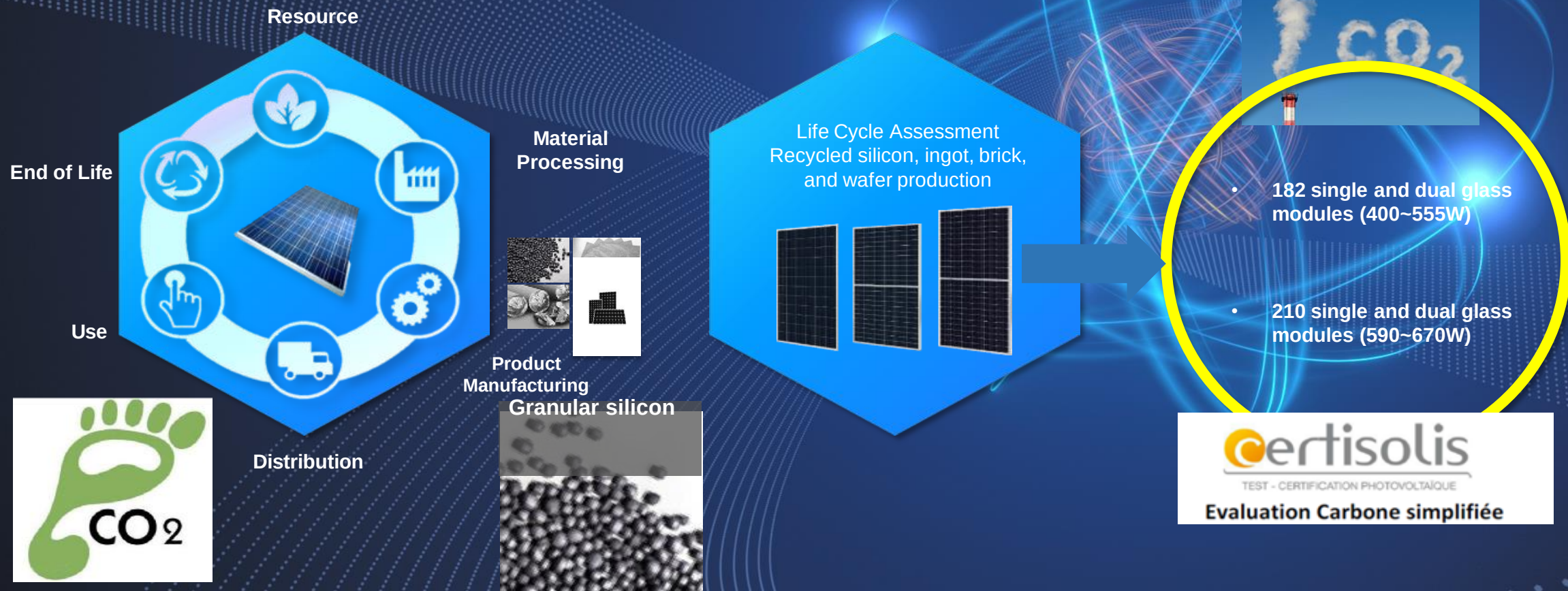
- Based on **Block Chain**, data security, privacy computing and other technologies, GCL digitally manages carbon-reduction data from upstream to downstream.
- Real-time product data and certification reports can be found on the Carbon Platform, where various certification bodies and suppliers are incorporated.



Differentiated Competitive Module: 182/ 210 Modules Meet the Needs of the French Carbon Footprint Market



- GCL vertical industrial chain further helps reduce the carbon footprint emissions of the single crystal, benefiting from the FBR granular silicon technology (GCL's black technology), the carbon footprint is about 10% to 20% lower than the average carbon emissions of the same model products of companies in the industry, with significant low-carbon advantages;
- Granular silicon + thinner silicon wafer (150~165 μm) will greatly reduce the carbon footprint of single crystal and make products more competitive.



Leading Manufacturing Decarbonisation. Offering transparency for all supply chain.



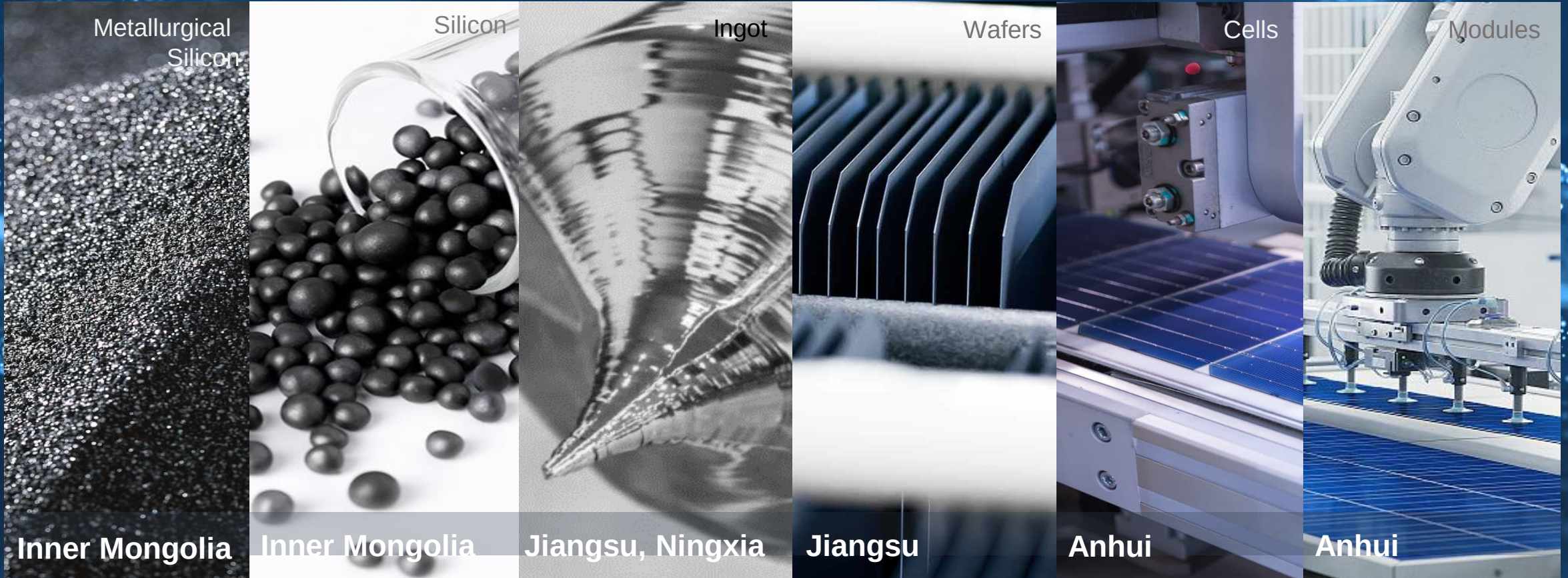
- Transparent manufacturing
- Innovative production methods
- Cutting edge sustainable products

GCL SI attains 14 out of 17 sustainable development goals defined by UN.



Vertically Integrated Value Chain Ownership.

Insure traceability Across Value Chain



GCL is the only solar manufacturer that can ensure total transparency and traceability from raw material transformation to end-product delivery

Real time Data Synchronization



One Module One Carbon Code



Block Chain and **QR Code Technology** can prevent supply chain data from being tampered hence, strengthening product transparency and carbon management.

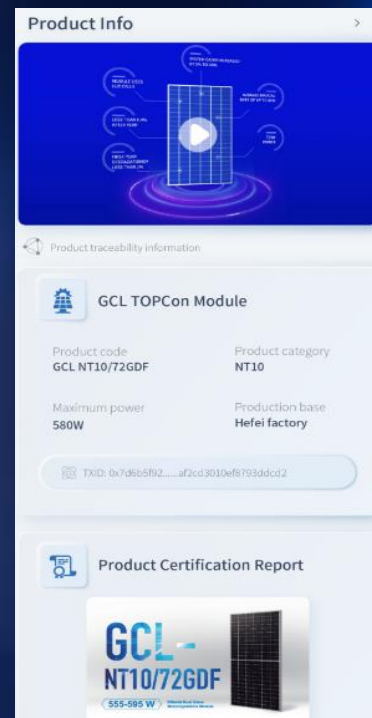
Carbon footprint & QR code



We adhere to and follow industry standards



Readily Available Data Upon Scanning



Product Info



Low Carbon Info



Component Visibility

**GCL pledges to help its clients towards a
bright and sustainable future.**





Bright Sunny Future!!

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