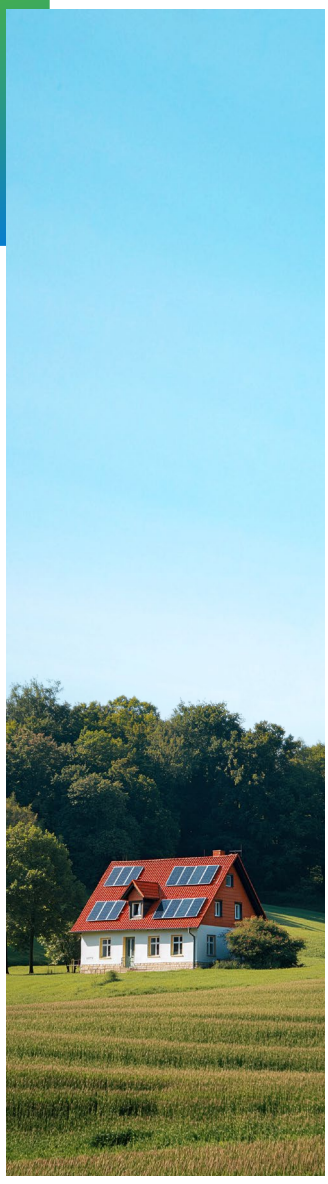
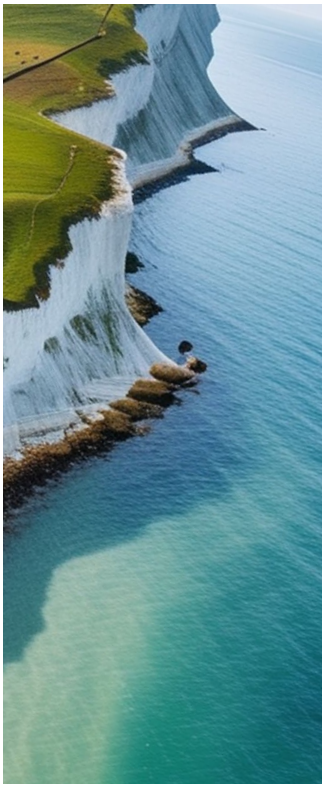
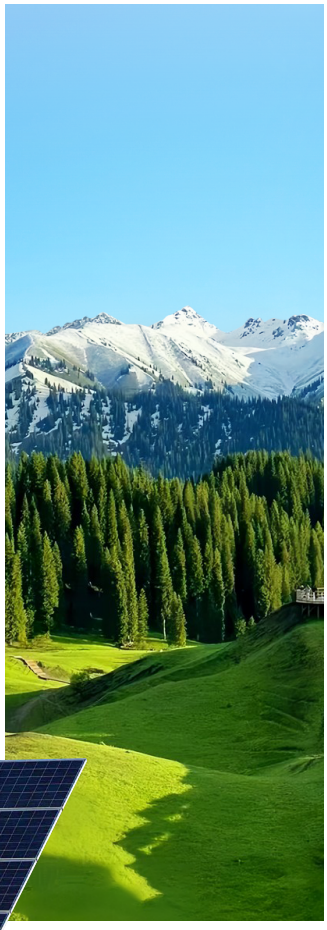
协鑫集成
GCL SI

2024

GCL SYSTEM INTEGRATION PRODUCT WHITE PAPER







Bringing **Green** Power To Life

Contents

01

Company Profile

GCL Group

Established in 1990, GCL (Group) Holdings Co., Ltd. ("GCL Group") is a green and low-carbon technology enterprise focusing on the new energies (wind power, PV power, energy storage, green hydrogen, green ammonia, and green methanol), clean energies and renewable energies, with the aim to achieve the goals set by carbon peak and carbon neutrality. Over the past 34 years, leveraging the cutting-edge technologies and digital empowerment, we have innovated in energy technologies centering on silicon materials, lithium materials, carbon materials and core materials applied in integrated circuits, in the hope of driving the manufacturing revolution and application revolution through material revolution. In response to the accelerated construction of the new power systems, GCL Group is developing electric power, energy storage and computing power as a whole, to enable the digital and intelligent development of energy and the coupling of industries covering source-grid-load-storage and charging-cell swamp-power sales-charging accounting-inspection-cloud. To that end, we have launched solutions for zero-carbon application scenarios and offered the comprehensive energy technology service, to contribute our part in the construction of the new energy system.

Global Top 500 New Energy Enterprises

Ranked **NO.4**

Listed affiliates

4

Experience in energy service

30+ years

Employees Worldwide

40000+

Production bases

60+

Assets

200+ billion RMB

Patents in force

3000+

GCL PV Integrated Industrial Chain

GCL Group made its debut in the PV field in 2006 and originated the GCL polysilicon technology, which has successfully broken the monopoly of foreign technologies and reshaped the landscape formed by external suppliers, logistics providers and clients. More than that, GCL is a pioneer in advocating that the on-grid price of PV power could be shifted from the stage of high price to the era of the fair price or even the low price.

Since 2011, we have been focusing on research and development of the FBR technology with independent intellectual property rights, which has been CCF and PCF certified in PV raw material fields in China and France, setting the record of the lowest carbon footprint in the world and accordingly ushering in a revolution in PV materials and a new era of low-carbon applications.

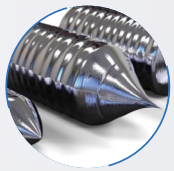
GCL Group boasts of a full-featured industrial chain in the PV field, encompassing silicon materials, silicon wafers, cells, modules, system integration, as well as the development, construction, operation, and maintenance of PV power plants. We have been devoted to upgrading the clean energy technologies from a global perspective and driving industrial innovation, with the aim to contribute our part for a greener and more sustainable future.

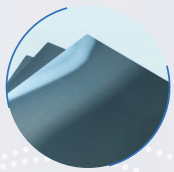
Six deeply collaborative business sectors, making GCL a leader in green technology

PV smart manufacturing

Upstream
(GCL Tech)


Silicon materials


Crystal growth


Silicon wafer

Mid-strem
(GCL SI)


System integration


Module


Cell

PV power station

Downstream
(GCL New Energy)


PV power station

Chairman of Global Green Energy Industry Council (GGEIC)

Co-chairman of Global Solar Council(GSC)

Chairman of Asian Photovoltaic Industry Association (APVIA)

Vice-chairman of China Electricity Council (CEC)

GCL PV integrated industrial chain


Effective capacity of granular silicon
420,000t


Annual capacity of silicon wafer
58.5GW


Capacity of N-type high-efficiency battery
14GW


Capacity of N-type PV modules
30GW


Installed capacity of operating PV power station
10GW

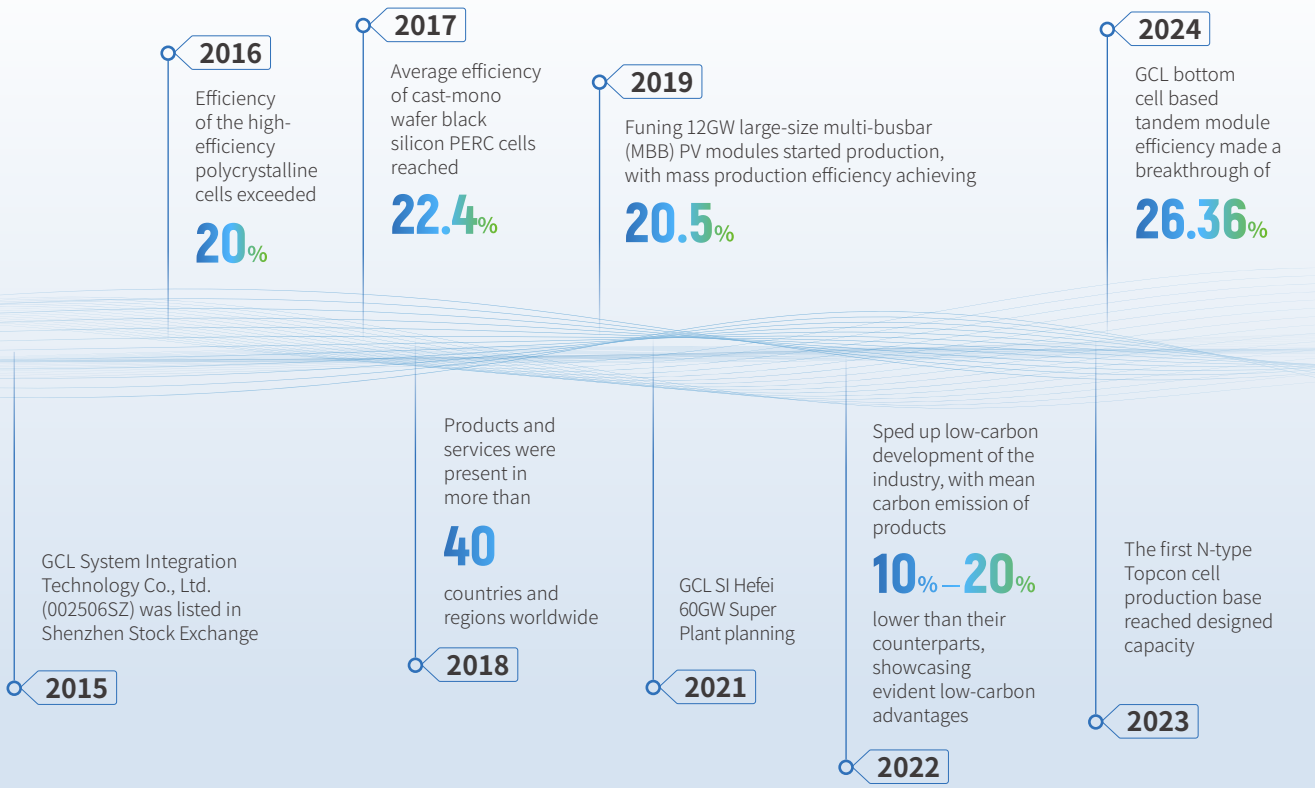
GCL System Integration

GCL System Integration Technology Co., Ltd. ("GCL SI") (002506.SZ), founded in 2003, has grown into a world-leading one-stop smart PV and storage system integrator. GCL SI has been highlighting the leading role of technologies and taking innovation as the driver, and firmly upholding the technical innovation route to present high-quality, efficient and differentiated products. Leveraging our powerful technical research and development strength and excellent system solution design capability, GCL SI has secured a leading position in intelligent PV and storage energy solutions after 20 years of unremitting efforts. As of today, our products have expanded to high efficient cells, PV modules and energy storage systems. More than that, we also offer diversified service modules including in-depth integration of financial services and intelligent operation and maintenance management. In this way, we are committed to providing global customers with efficient, intelligent and integrated energy solutions and supreme service experience.

Guided by the development concept of "Bringing Green Power To Life", GCL SI has quickened the pace of applying new materials and technologies such as high-efficiency TOPCon cells, large-size silicon wafer technology and sMBB technology to new products to elevate their performances and efficiency. Up to now, we are capable of producing 14 GW N-type high-efficiency cells and 30GW N-type PV modules. **By virtue of our powerful production capacity and delivery ability, GCL SI has ranked the fourth in terms of winning bids from the central enterprises and SOEs in the chinese market, while in the overseas market, we have consecutively won the GW-level large orders in India, maintained our position in the BNEF Tier1 rankings and been placed on TOP8 in terms of Infolink 2024H1 module shipments**. Meanwhile, taking the transparent green supply chain as an important engine for practicing new quality productive forces, we have launched the world's first management platform for the PV industry, enabling in-depth traceability from raw materials to products, so that the carbon footprints can be traced, searched, trusted and totally transparent. Our "SiRo" series low-carbon PV modules have achieved the advanced carbon footprint management level, with the carbon value of a single module under dynamic traceability hitting the lowest in the industry.

Development History

Taking scientific and technological innovation as the core driving force, GCL SI has rolled out a series of efficient and low-carbon PV products as a result of continuous R&D investment, technical iteration and capacity expansion. We aim to become a strong supporter for the popularization and application of green energies worldwide with our powerful capacity.



Global Layout

Our marketing channels have stretched to Japan, India, North America, Australia, Germany, Singapore, Republic of Korea and other countries and regions. We have set up representative offices in Thailand, South America, the Middle East, Europe, Africa and other countries and regions, to bring our products and solutions to more than 70 countries and regions globally.

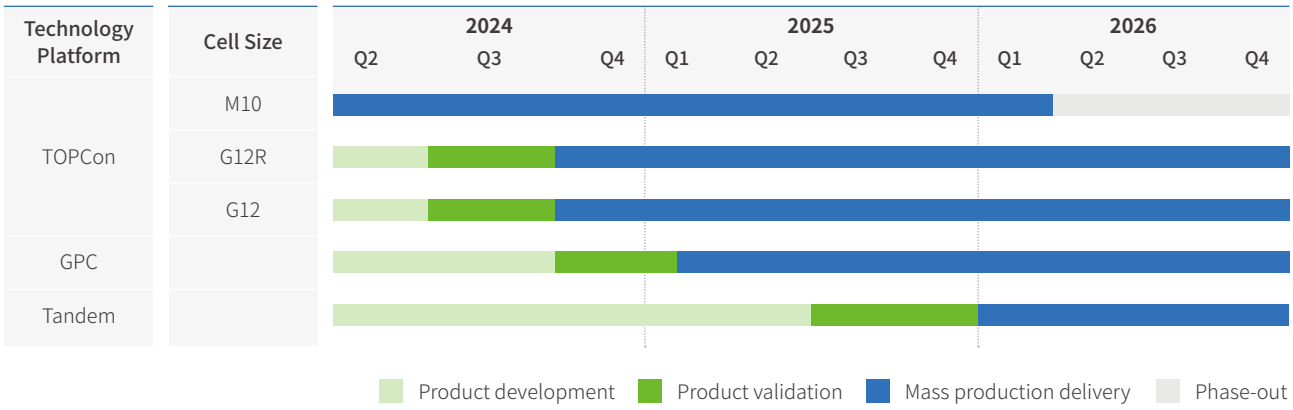
02

Product Roadmap and Production Capacity Distribution

Product Roadmap

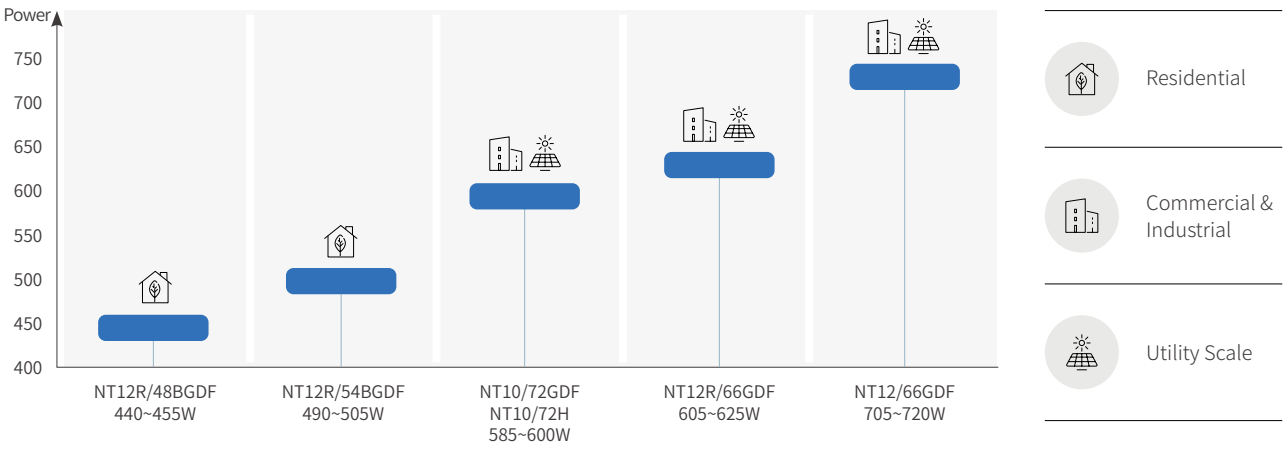
Solar Cells Roadmap

In response to the diversified market demand, uncertainties in technological advancement and fluctuations in raw material supply, GCL SI has implemented an all-round cell technology layout, dug into technological innovation, and consistently delivered industry-leading high-quality and efficient cells to global customers.



Solar Modules Roadmap

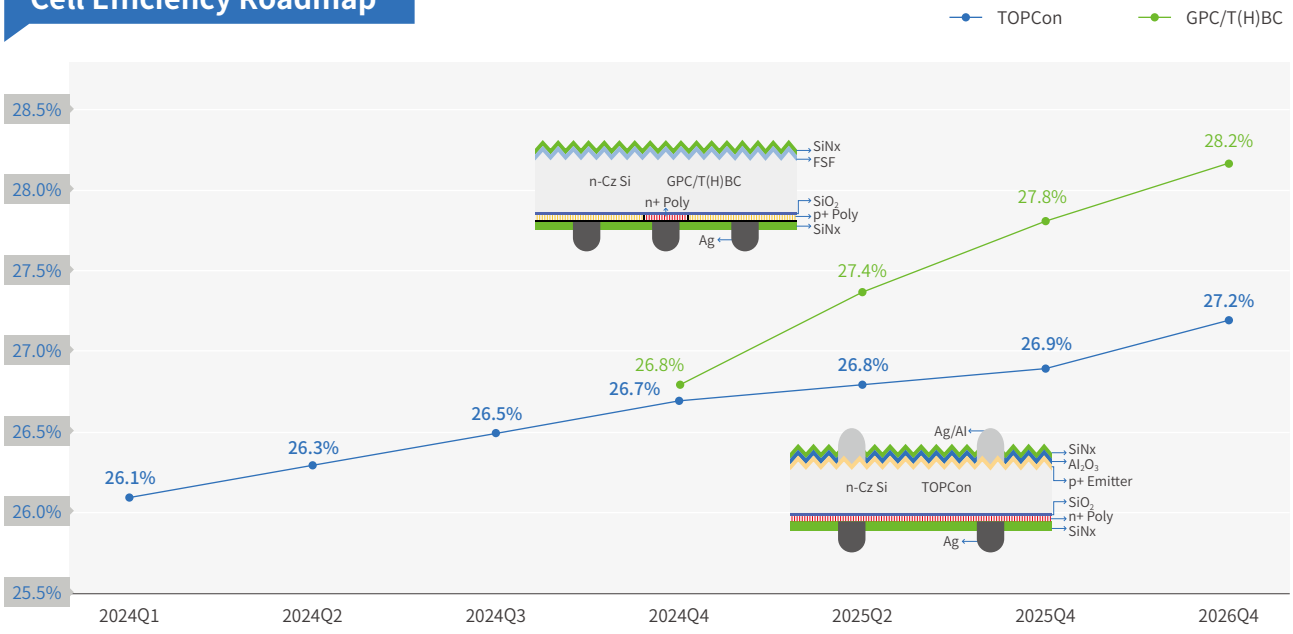
Upholding the concept of "customer first", GCL SI has meticulously designed and planned a diversified matrix of PV products to ensure that every single demand of the customers can be precisely satisfied with the most suitable products.



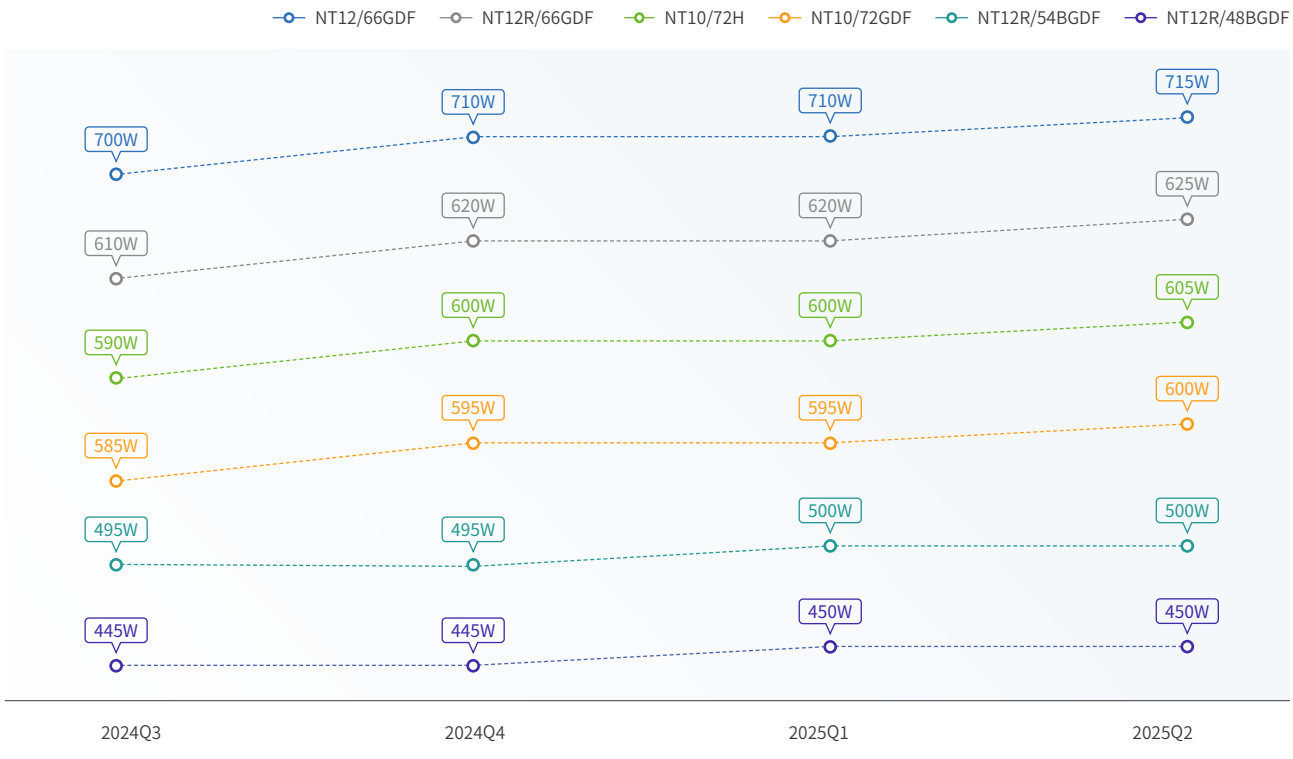
Product Power Roadmap

GCL SI continues to launch industry-leading, high-efficiency cells and high-power PV modules with outstanding performances to the global market.

Cell Efficiency Roadmap



Module Output Power Roadmap



*Mainstream delivery power

Production Capacity Map

GCL SI has been keeping track of the market demand and actively laying out advanced production capacity. The 12GW high-efficiency large-size modules in Funing Production Base have been in full swing and reached the designed capacity, while Hefei Production Base has realized 18GW efficient production capacity. So far, we are capable of producing 30GW high-efficiency modules and our 14GW N-type TOPCon cells in Wuhu Base have been put into full production and realized full capacity. Relying on the large-scale advanced production capacity and excellent immediate delivery system, GCL SI can quickly respond to the diversified needs from the market and customers through offering stable and efficient products.

Headquarters Production base

03

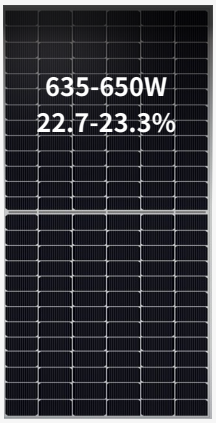
Introduction to Products

TOPCon Mainstream Products

GCL SI continues to launch 182mm and 210mm square and rectangular cells that can meet needs from a wide range of application scenarios in both the domestic and the foreign markets alike.

182mm Square Series

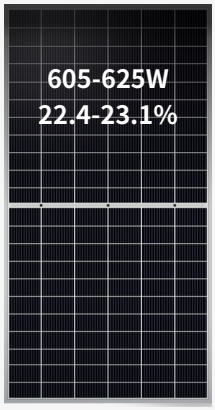
NT10/72GDF
2278*1134*30mm
31.2kg



NT10/78GDF
2465*1134*30mm
33.7kg

210mm Rectangular Series

NT12R/48BGDF
1762*1134*30mm
21.5kg



NT12R/66GDF
2382*1134*30mm
32.6kg

210mm Square Series

NT12/66GDF
2384*1303*33mm
38.5kg

Shorter degradation, long-term durability

- Free of LID and LeTID, with full life cycle gain of **3.4%*** and higher

* It is calculated according to the warranty terms and compared with that of PERC modules

Double-sided power generation, double effect

- Double-sided yield of N-type modules hits 80%, with gain of **1.2%*** and higher

* It is obtained from the internal empirical data and compared with the double-sided PERC modules

High temperature tested, stable output

- γ=-0.28%/℃
  Better temperature coefficient of power (TCP), outstanding performance in high temperature environments, with power gain of **1.19%*** at NMOT

* It is calculated in reference to TCP of PERC modules

Powerful performance even under the low light density, stable efficiency

- Better power generation performance under low irradiation, longer working time of modules, effective power generation even on cloudy days and at evenings

Analysis on Product Value in Application Scenarios

Residential Scenarios

Market Demand

Overseas residential projects mainly target owners, who prefer to maximize the installed capacity under a limited roof area and make modules beautifully integrated into the roof. Therefore, high-efficiency compact black modules will be their best choice. To facilitate installation and comply with relevant regulations, the installers will favor lighter and smaller modules.

Considering key concerns in the overseas residential market such as high power, aesthetics, module weight and module area, the following analysis and recommendations are provided:

Module	Power (W)	Dimension (mm)	Area (m^2)	Weight ⩽ 25kg	Appearance	Installed Capacity for The Same Area	Recommendation Rate
NT12R/48BGDF	445	1762*1134*30	＜2	✓	Full black		★★★★★
NT12R/54BGDF	500	1962*1134*30	＞2	1.6+1.6mm glass: ✓ 2.0+2.0mm glass: ✗	Full black		★★★★★

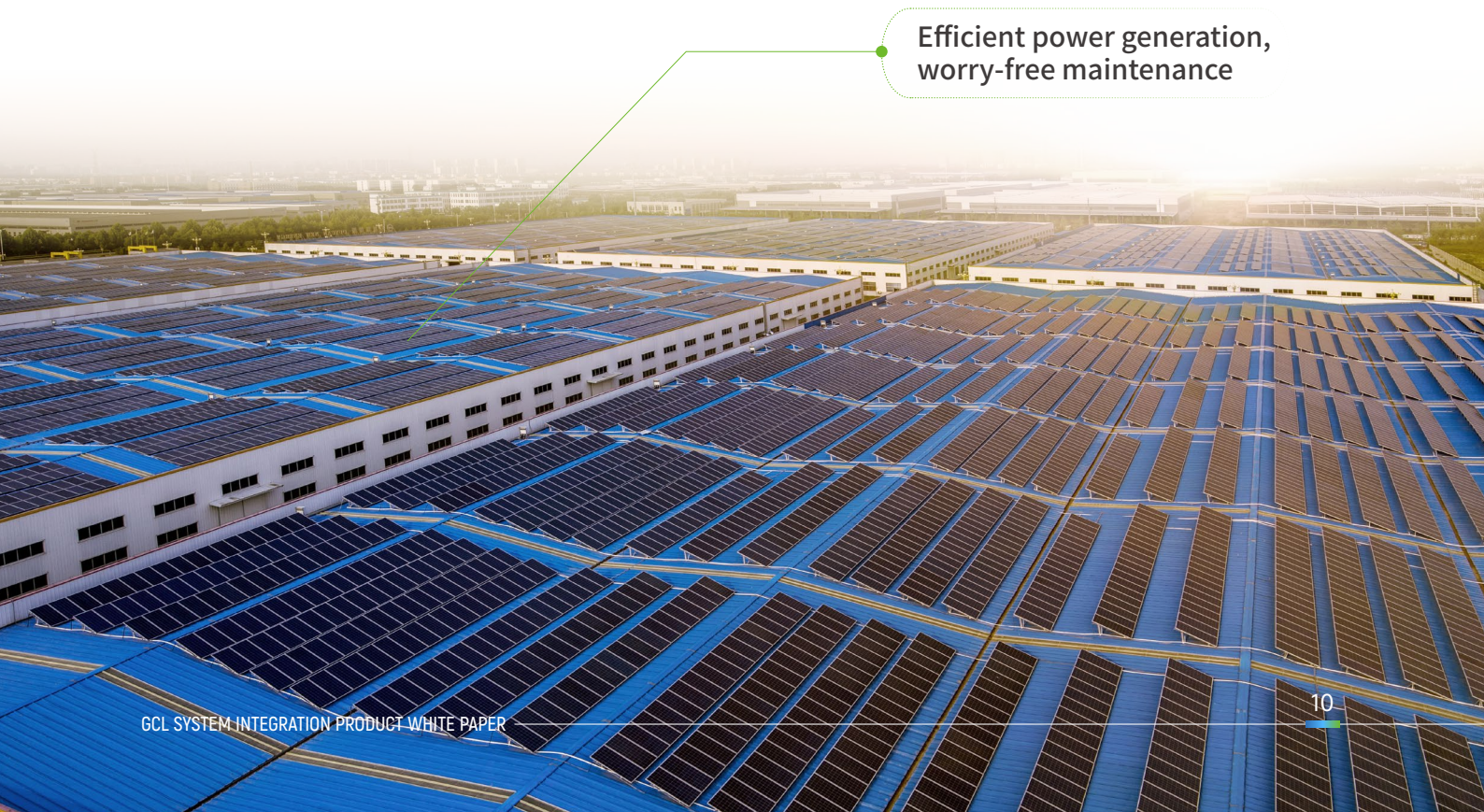
Commercial and Industrial Scenarios

Market Demand

In C&I segments, the surface of the modules applied on the low-angle color steel tile roofs is prone to dust accumulation, which will affect the power generation performance. Accordingly, PV modules with anti-dust performance and lightweight design will be a better choice to meet the specific needs of C&I roofs.

Considering key concerns in the commercial and industrial market such as anti-dust performance, light weight, stable supply and installed capacity, the following analysis and recommendations are provided:

Module	Power (W)	Dimension (mm)	Weight (kg)	Anti-dust Function	Market Maturity	Installed Capacity for The Same Area	Transport Cost	Recommendation Rate
NT10/72GDF	590	2278*1134*30	31.2	✓	👍		20 pallets/720 pieces 40-ft HQ container	★★★★
NT12R/66GDF	620	2382*1134*30	32.6	✓	👍		20 pallets/720 pieces 40-ft HQ container	★★★★★
NT12/66GDF	710	2384*1303*33	38.5	⊘	👍		18 pallets/594 pieces 40-ft HQ container	★★★★



Utility Scenario

Market Demand

Utility scale PV power stations usually have a large scale, long transmission distance, large investment and long construction period, so they look for lower LCOE but higher profitability. Besides, the power generation sites are usually located in mountains, deserts and water surfaces, where extreme weather happens frequently, so that module products have to operate for a long period in harsh outdoor environments, which means they should have higher safety and reliability.

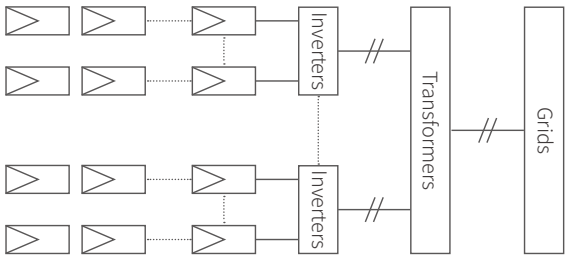
To sum up, utility scale mainly need double-glass modules featuring high power but low open circuit voltage, and are more concerned with BOS cost, LCOE and IRR. Hence, the following analysis and recommendations are provided:

Module	Power (W)	Dimension (mm)	Glass	Market Maturity	BOS Cost	LCOE	Recommendation Rate
NT10/72GDF	590	2278*1134*30	Double glass			Related to the actual design of the power stations, but high-current modules show poorer cost-effectiveness	★★★★
NT12R/66GDF	620	2382*1134*30	Double glass				★★★★★
NT12/66GDF	710	2384*1303*33	Double glass				★★★★

System Calculation

System Design Module and Conditions

- DC installed capacity 120MWp, fixed support.
- Power generation capacity is calculated based on the following conditions: monocrystalline double-sided modules, mainstream inverters, ground reflectivity 30%, module-to-ground distance 0.5m, and the meteorological data in the past 10 years as the actual representative radiation data.
- Other design conditions comply with the international or IEC standards.



Using the NT10/72 double glass as a benchmark, seven application scenarios with typical climatic characteristics are selected to compare the BOS cost and LCOE of the NT10/72, NT12R/66, and NT12/66.

Contrast of BOS cost

Contrast of LCOE

Data Analysis

- Under the same boundary conditions, the higher the module power is, the lower the BOS cost will be, i.e.: NT10/72> NT12R/66>NT12/66.
- The LCOE performance of each module varies irregularly due to factors such as the latitude, differences in monthly solar irradiation, construction conditions (temperature, terrain, elevation, etc.), financial modeling, and the number of guaranteed hours in the sites of the PV power generation project. Also, the empirical analysis has concluded that the high-current modules present slightly poorer cost-effectiveness, mainly due to losses and construction conditions of the system.
- Thus, NT12R/66 modules are recommended considering technology and cost-effectiveness.

04

Product Competitiveness

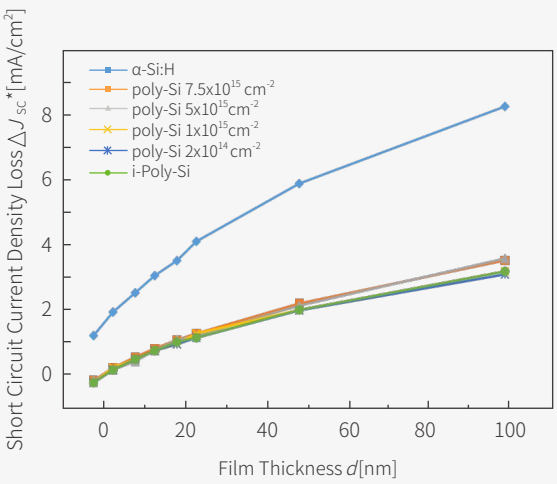
Cutting-edge Technologies

High Efficiency TOPCon Cell Technology

GCL cells have adopted our self-developed and industry-leading N-type G-TOPCon technology, and introduced the Ultra-thin Polysilicon (UTP) technology to improve parasitic absorption of light by polysilicon, thereby to boost the short-circuit current. The integration of Ultra-shallow Doping (USD) technology and Laser Induced Firing (LIF) technology enables good contact and passivation effects in the metal area. Multilayer deposition produces good appearance and optical performances of the cells. Also, the sMBB design has elevated the performance and reliability of cells. The combination of such technologies has brought the cell mass production efficiency exceeding 26.6%.

UTP Technology

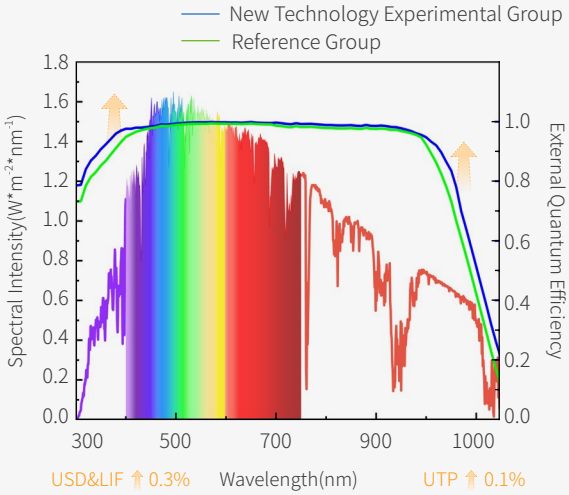
Polysilicon can cause parasitic absorption of light. The thinner the polysilicon is, the lower the current loss will be. Based on this theory, the UTP technology would raise the current density, increasing cell efficiency by **0.1%** and the double-sided yield by **1%**.



Cell short circuit current loss under different film thicknesses

USD Technology and LIF Technology

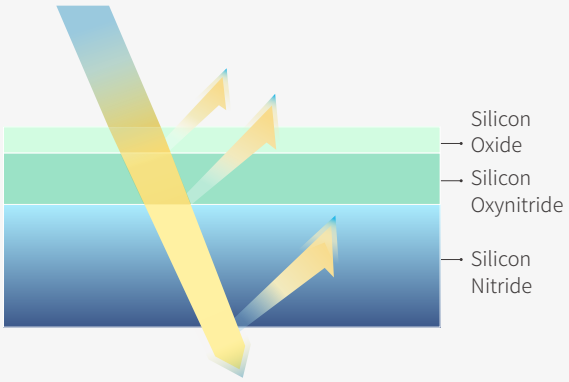
The combination of the USD technology and the LIF technology produces emitters with ultra-low junctions, which has greatly reduced surface recombination while effectively elevating the passivation level. The LIF technology provides precision control over the heat-affected area to form high-quality metal contacts, thus to raise efficiency by more than **0.3%**.



Impact of different technologies on cell QE at different wavelengths

Multilayer Deposition Technology

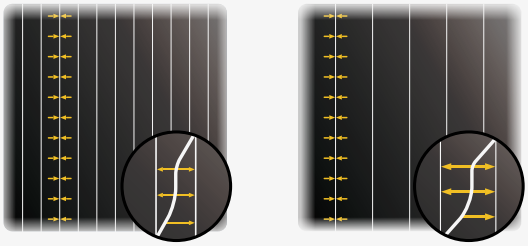
The front side of the cell adopts the multi-layer dielectric film technology, which can effectively balance the effects of passivation, antireflection and extinction while achieving an outstanding anti-PID function. In addition, the multi-layer films can significantly improve color changes of cells after lamination and make the modules more aesthetically appealing.



Schematic diagram of multilayer film reflection reduction

sMBB Metallization Technology

The sMBB technology improves light utilization and current collection capacity, achieving less shadow mask, shorter current conduction distance and more uniform force. It can elevate the tolerance for hidden cracks, broken grids, and rupture of the cells, hence improving reliability.



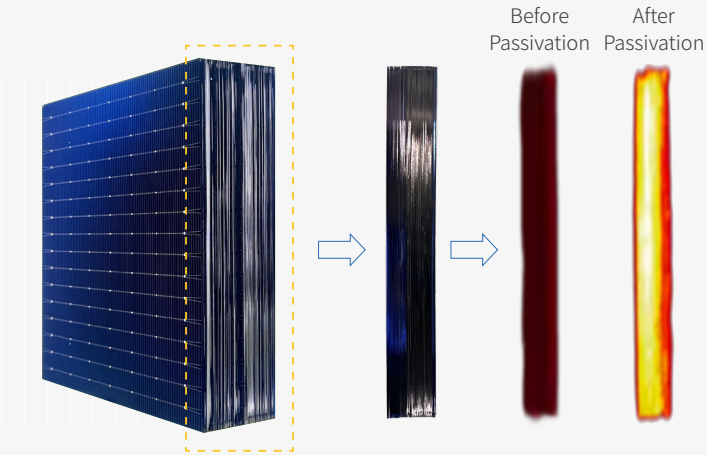
16 Busbars　　10 Busbars

sMBB

Power loss reduced by 1.5% at most

Precise Edge Passivation and Half-Cut Sorting Technology

The precise edge passivation technology has been adopted to repair damages on the cell cut surface and the half-cut sorting strictly exercised, to achieve module gain above **3.5W**.



Edge passivation schematic diagram and PL diagram

High-performance TOPCon Module Technology

Large-size Wafer Technology

Compared with M10 wafers, large-size wafers are generally inferior in process uniformity, but are superior in terms of improving module power, reducing project BOS costs, maximizing the utilization rate of containers, and lowering logistics costs, which are more in line with customer interests. Through process optimization and equipment modification, GCL SI has guaranteed that the large-size and small-size wafers have the same process uniformity and solve the possible yield and efficiency loss problems. As a result, end users can fully enjoy the advantages brought by large-size wafers.

BOS cost

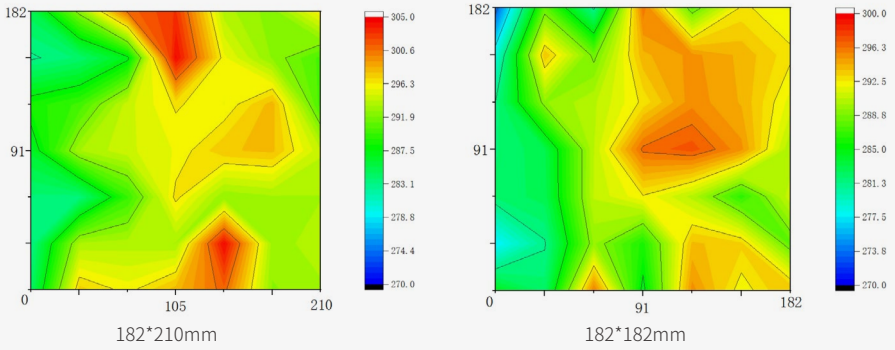
-2.5%

* Data source: a power station in a project site

40.5ft HQ container loading elevation

4%

* 2382*1134mm vs. 2278*1134mm



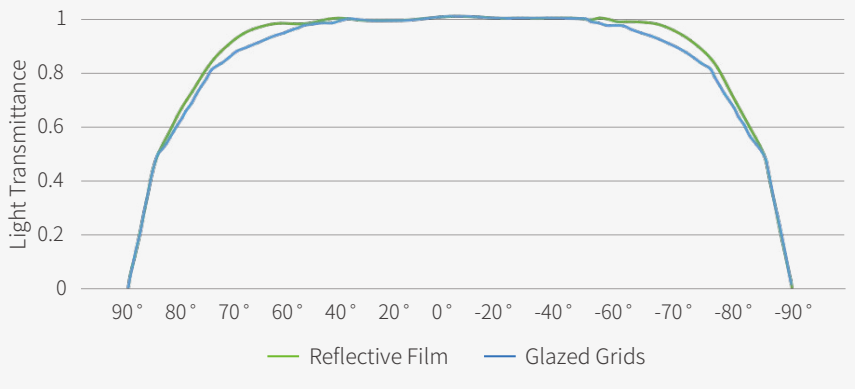
182*210mm 182*182mm

Thermogram of sheet resistance uniformity

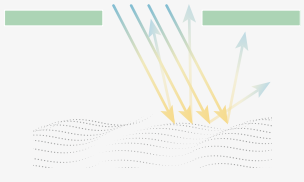
Same process uniformity of GCL cells of different sizes

Gap Reflection Film

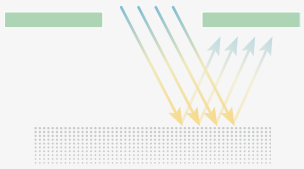
Gap reflection films adopt PET materials to reflect light from the cell gap back into the cell. Compared to white-glazed glass, they could increase light reflectivity by approximately **10%**. More than that, they are designed to reduce the shadow area of the backside cell, thereby increasing the module's double-sided yield by about **1%**.



PV module angular transmittance contrast (IAM)



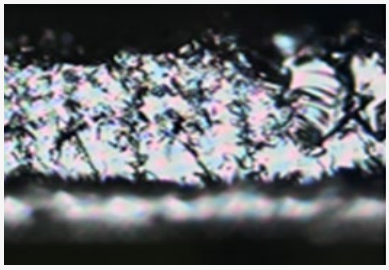
Glazed grid diffuse reflection



Gap reflection film specular reflection

Half-cut Non-destructive Cutting Technology

- Under the non-destructive cutting technology, the laser only performs minor localized cuts at the edge of the cell and utilizes the stress between heat and the cold to fracture the cell, so as to produce a smooth and flat cutting surface. This has reduced the risk of hidden microcracks by more than 50%, and accordingly elevated the reliability of the product. In addition, loss of cell efficiency is reduced by more than 0.15%, which can evidently improve CTM of the module encapsulation and increase the power of the module.

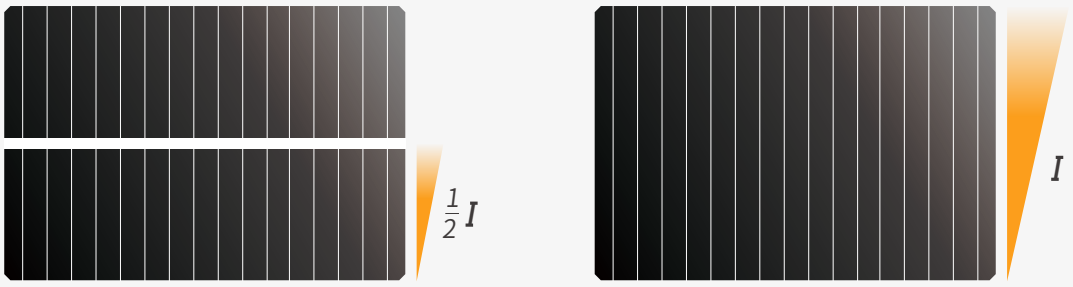


Destructive cutting section

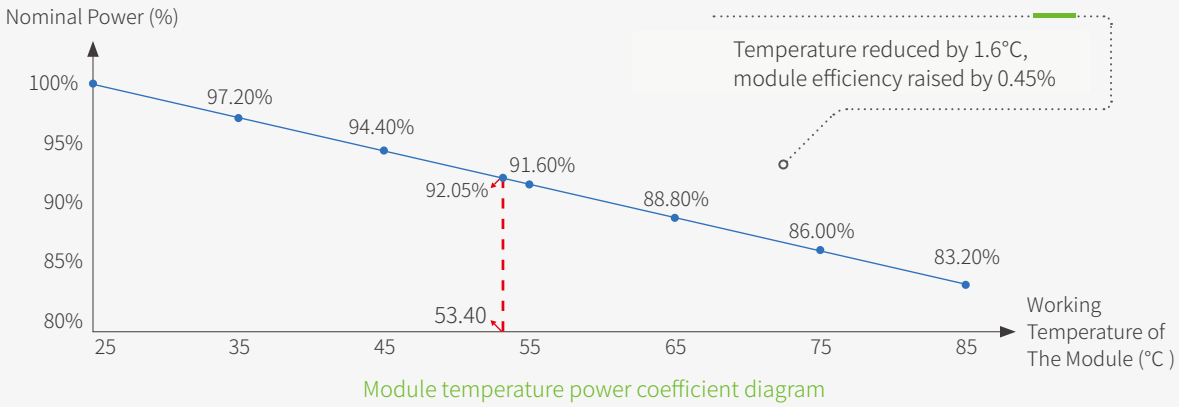
Non-destructive cutting section

- No mechanical loss
- Lower leak current
- Raise parallel resistance

- The half-cut design can decrease the original internal current by half, so that the working temperature of the module and the junction box can be reduced. If running outdoor, the half-cut module's own temperature is about 1.6°C lower than that of the traditional whole module, which improves the photoelectric conversion efficiency while lowering the hot spot temperature.



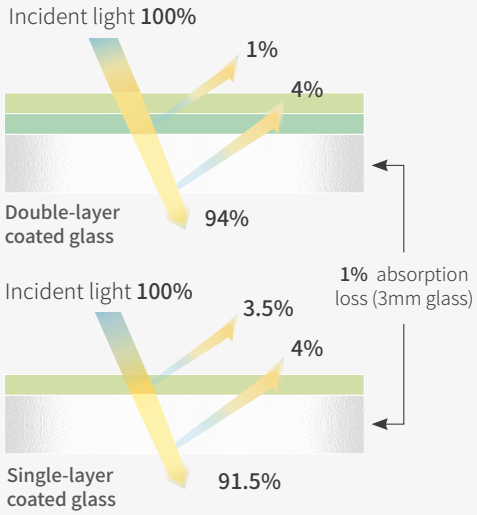
Current of half-cut cells vs. whole cells



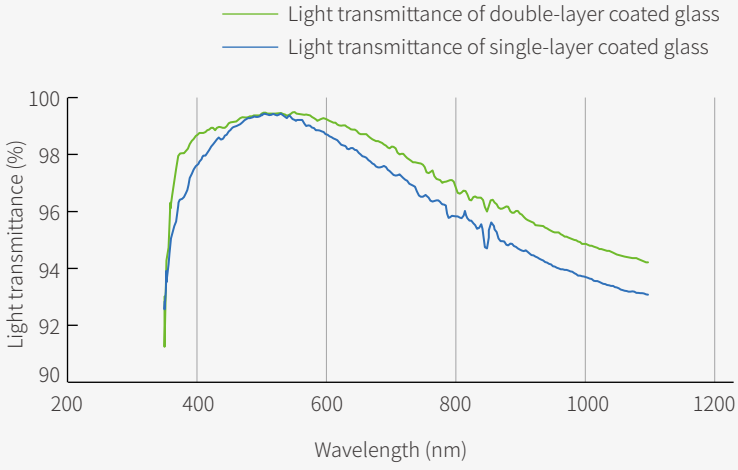
Module temperature power coefficient diagram

Double-Layer Coated Glass

Double-layer coated glass has a light transmission of over 94%, maximizing light absorption. Compared with single-layer coated PV glass, it has an extra dense SiO_2 underlying film, which better prevents moisture in the air from entering into the PV glass. More than that, it has better color uniformity than the single-layer coated glass and is, of course, more aesthetically appealing.



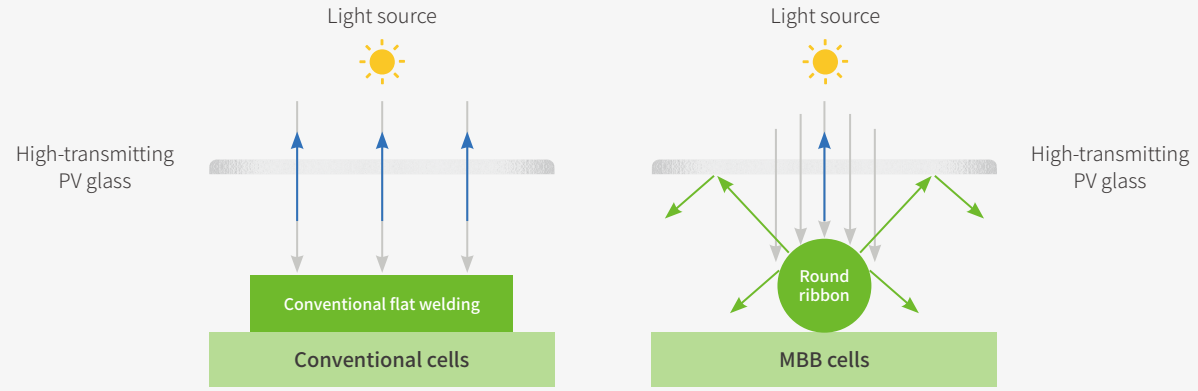
Schematic diagram of incidence path of light rays from double-layer vs. single-layer coated glass



Light transmittance and QE diagram of single-layer vs. double-layer coated glass

Flexible Encapsulation Technology

- Round ribbons can improve light utilization and, in combination with MBB technology, increase power by more than 1%.



Schematic diagram of the optical path of different types of ribbons

- Flexibility of welding

Spacing compatibility:
Compatible with the manufacture of modules with different sheet spacing such as negative spacing, zero spacing and fine spacing

Model compatibility:
Compatible with series welding of different numbers of cells and manufacturing of different models of PV modules

Ribbon compatibility:
Extended to be compatible with ribbons of different cross sections, such as round ribbons, triangular ribbons, flat ribbons and segmented ribbons

Minimize the complexity of specification switching and the impact on the production progress, allows for rapid response to customer needs and the delivery of diverse customer requirements.

Safety and Reliability

GCL SI strictly monitors materials from third parties, accurately implements lean manufacturing, relies on the quality management system for the whole life cycle of the modules, and ensures the high quality of each product with excellent processes. Moreover, strict testing and certification procedures from authoritative third parties have been satisfied to ensure the stability and safety of the modules. In addition, GCL SI provides professional one-stop solutions covering system design and construction, after-sales service, intelligent monitoring and operation and maintenance to ensure the stable output of green energy.

Incoming Inspection, Reliable Materials

- Supplier qualification review to screen qualified partners
- **300+** rigorous inspection standards, multi-dimensional assessment of quality of incoming materials
- Carbon chain empowers supply chain management, realizing all-round tracking of raw materials

Lean Manufacturing, Reliable Production

- Equipment automation rate of **90%+**, AI synergistic high-precision control in the whole process, effectively improving the yield rate of the process
- **500+** standardized workflow management norms, effectively improving production efficiency
- Long-term production safety with zero accident thanks to site management under strict safety standards

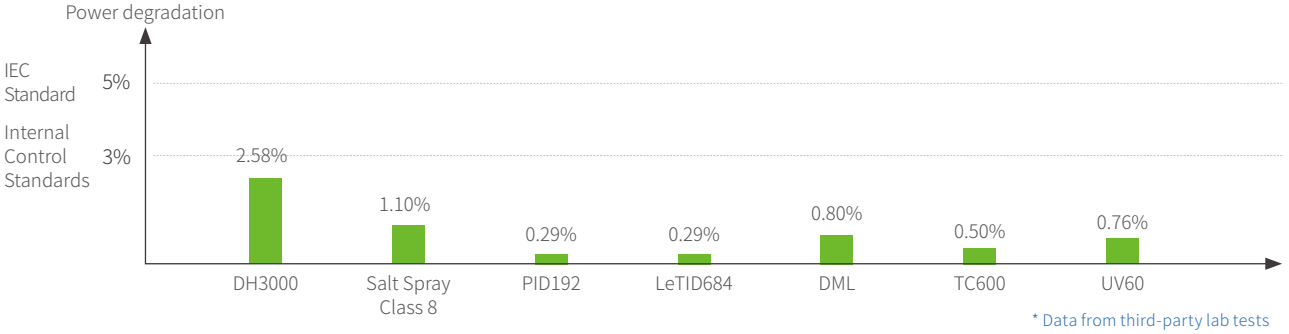
Quality Control, Reliable Quality

- Precise and intelligent AI visual QC coverage of 90%+, critical process defects identification accuracy of **98.5%+**
- **90** categories (**303** items) stringent quality controls and inspections to ensure that every detail is controlled
- **100%** inspection of shipments to protect the rights and interests of end-users

* Accredited PV laboratory under ISO 17205 by CNASAccredited PV laboratory under ISO 17205 by CNAS

Third-party Certifications, Guaranteed Performances

- GCL SI modules have passed stringent tests far exceeding IEC standards to ensure that they can operate reliably for a long period under diverse climatic conditions, providing industry-leading product quality assurance and meeting more harsh application scenarios.



* Data from third-party lab tests

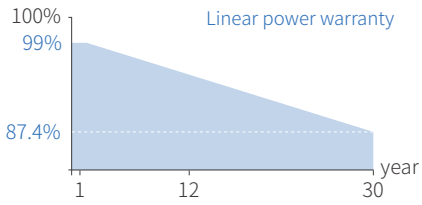
- GCL SI modules have passed the basic certification of IEC 61730 and IEC 61215, and have obtained certificates from internationally-authoritative third-party testing and certification organizations.

IEC61215 · IEC61730 · ISO9001:2015 质量管理体系 · ISO14001:2015 环境管理体系 · ISO45001:2018 职业健康安全管理体系 · IEC62941:2019 光伏组件制作质量体系

One-stop Services, Reliable Systems

Long warranty, no worries after the sale*

- **12**-year product warranty
- **30**-year power warranty
- Power degradation <1% in the first year
- Linear power degradation <0.4% during 2~30 years



* For details, please refer to the Limited Warranty Statement

System design, customized solutions

- Technical due diligence
- Investment estimation
- Project process supervision
- BOS selection
- Power plant testing
- Project site exploration
- ...
- ...


CNAS Certified


CMA Certified

Real-time monitoring, intelligent operation and maintenance

- Real-time data monitoring and analysis
- Carbon trade and trading of Green Electricity Certificate
- Drone monitoring inspection and testing
- Power plant due diligence and rating
- ...

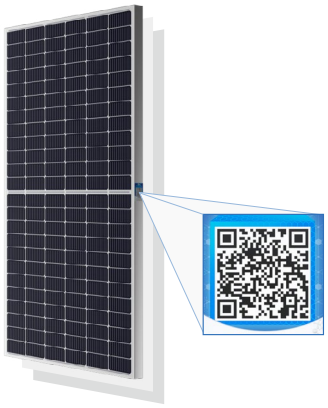
* GCL SI is committed to providing customers with efficient and professional after-sales services. The customer satisfaction survey in 2023 showed that the satisfaction rate of on-site services was 99.48 points and of after-sales service, 99 points.

Green and Low-carbon

Carbon Chain

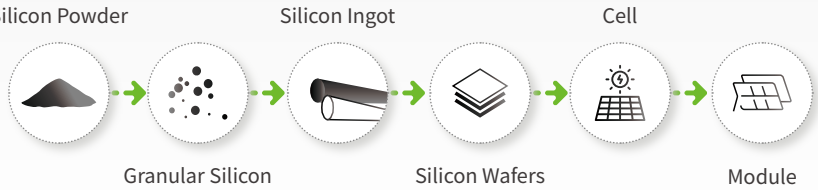
Carbon Chain Module

The world's first SiRo carbon chain PV module has innovatively integrated block chain technology + supply chain traceability + product carbon footprint management. It is managed through the GCL Carbon Chain Platform and introduces FBR granular silicon to significantly reduce carbon. As the end product, it ensures that the carbon footprint of the industrial chain is traceable, verifiable, credible but cannot be falsified. In this way, we could get the best carbon footprint score in the industry.



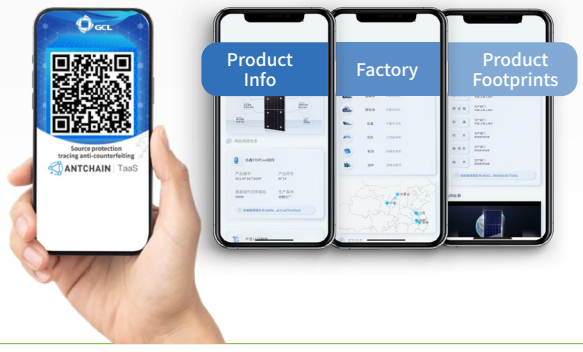
Traceable

Rigorous selection of the supply chain to achieve the lowest carbon value of materials in each section and the lowest carbon value of products in the industry



Verifiable

A unique code for each item enables precise carbon footprint tracking.



Credible

Certified carbon data, surpassing others in CO_2 emissions.

Carbon Chain Management Platform

Leveraging the blockchain technology, GCL Carbon Chain Platform becomes the world's first "Carbon Chain Management Platform" in the PV industry, which enables carbon footprint traceability of six core industrial sections from the raw material end to the product end and uploads the information to the platform in a real-time manner. Such information will be publicized after being certified by the third-party international authoritative organization, to ensure all information is traceable, verifiable, credible and transparent.

GCL Carbon Chain Platform

Green and transparent supply chain More guaranteed quality	Precise carbon footprint tracking Safer production	All-round carbon emission management Achievable green development
Supply chain traceability management	Product carbon footprint management	Enterprise carbon organization management
Monitor and record the origins of raw materials, processing, and production of products	Track greenhouse gas emissions from raw material extraction, manufacturing, and transportation of products	Manage carbon emissions from the production and operation of organizations or enterprises
Blockchain technology	Deep tracking	Authorized certification
Aided by ANTCHAIN	Deep tracking of six core sections of the whole industrial chain	TÜV+ ISO + Ecoinvent

Granular Silicon

GCL has successfully developed "FBR granular silicon" with independent intellectual property rights to reduce carbon emissions from the source. Its production capacity reaches 420,000 tons. So far, GCL has completely stopped producing polysilicon rods.

Strength in Technology

- **Better liquidity**
  Quicken intelligent upgrade of the application end (CCz)
- **More stable quality**
  Meet requirements from N-type single crystal in all aspects
- **Better carbon footprint**
  Carbon emission of the life cycle for the industrial chain reduced by 80%

Strength in Cost

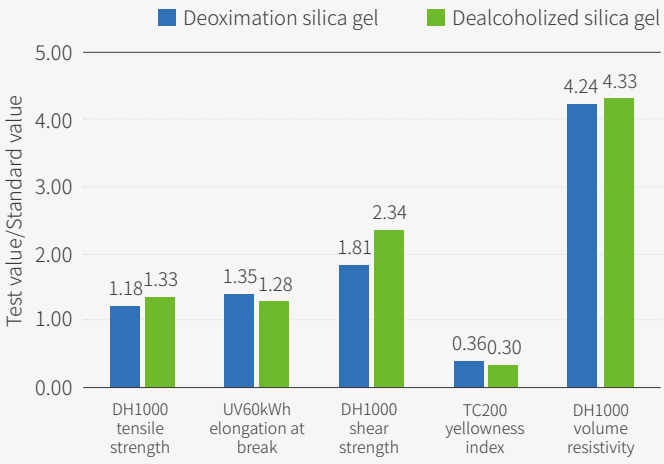
- Water resource consumption ↓ 18%
- Labor cost ↓ 61%
- Comprehensive power consumption ↓ 76%
- Hydrogen consumption ↓ 57%

Carbon Footprint Certification

* Compared with polysilicon rods with the improved Siemens method

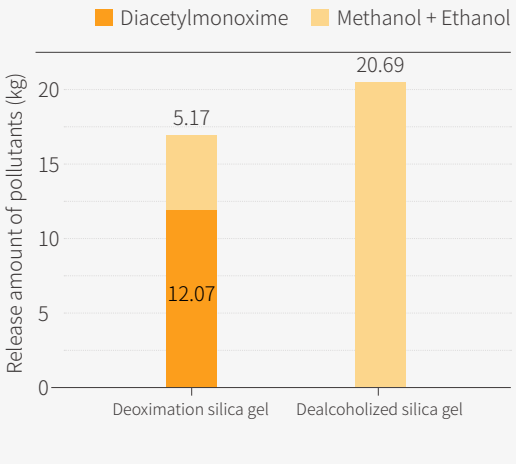
Dealcoholized Silica Gel

Deoximation silica gel releases diacetylmonoxime, which is considered to be carcinogenic, during the curing process. In contrast, the dealcoholized silica gel is more eco-friendly and safer. In addition, the two-component dealcoholized silica gel features fast curing, high shear and tensile strength, outstanding insulating properties, good adhesive properties, aging resistance, powerful compatibility, and a larger proportion adjustment space.



Normalized aging test of deoximation silica gel vs. dealcoholized silica gel

* Note: normalization processing is made with the ratio between the test value and the standard value; the test items with the strongest sensitivity to material properties are selected.

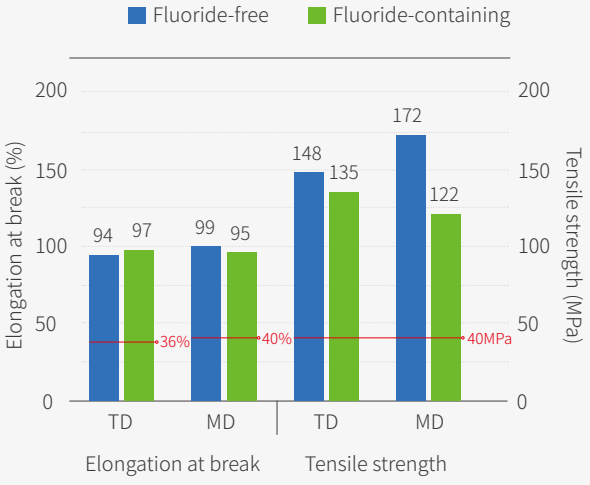


Pollutant release from deoximation silica gel vs. Dealcoholized silica gel at 1MW installed capacity

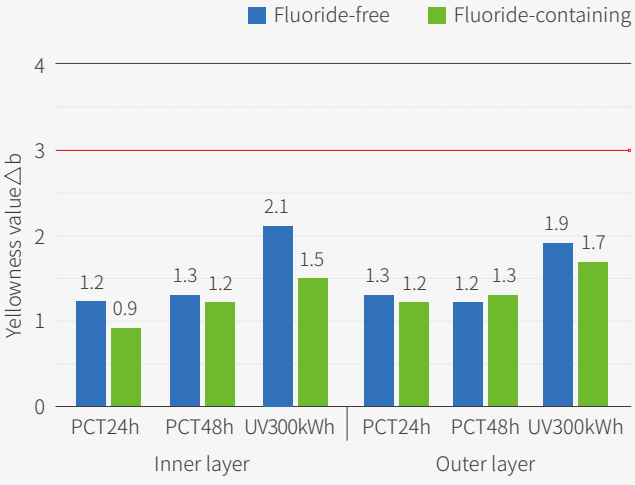
* Laboratory test data

Fluoride-free Backsheet

Slow degradation of fluorine compounds in the natural environment can lead to the accumulation of persistent organic pollutants (POPs), which will pose a threat to the environment and human health. By contrast, the fluoride-free backsheets apply weather-resistant PET instead of fluoride-containing materials, are designed with special formula and have received modification treatment, so that they boast of good weather resistance and aging resistance, thereby to effectively reduce the pollution to the environment.



Performances of DH380 & UV75 before and after aging



Contrast of yellowness of fluoride-containing/ fluoride-free backsheets after the aging test

*The red line is the standard line

Differentiated Functions

Anti-dust Functional Modules

Potential Failure Modes of Modules Due to Dust Accumulation

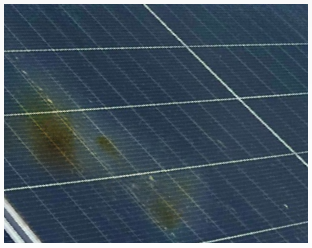
Data show that 80% of industrial and commercial scenarios are troubled with dust accumulation. In these places, due to the small installation inclination angle and the fact that the outer frame is slightly higher than the surface of the module, dust cannot be washed away by rainwater, thereby generating a mud belt and result in loss of power generation. In addition, the complex composition of dust may cause acid and alkali corrosion to the coating film and glass, which will thus affect the service life and safety of modules.

Small installation inclination angle to cause dust accumulation

20% power generation loss at most as a result

Low cleaning frequency, long dust accumulation

Module service life affected by the hot spot risk



Difficult operation and maintenance due to accumulation of dust and limescale

High cleaning cost overlapped with operation/maintenance risks

Solutions

To solve the pain points of "reduced power generation, high cleaning cost, and less safety of modules" due to the accumulation of dust facing end-users, GCL SI launched the "LOTUS" Module and its frames are free of A side, which can prevent accumulation of dust and accordingly generate more economic value to the customers.

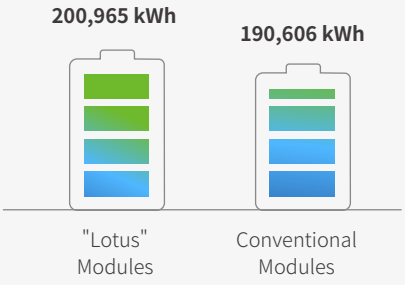
- **Frames Without A Side**
  The ingeniously designed frameworks ensure no dust accumulation and smooth penetration of the sunshine.
- **Upgraded Gluing Technology**
  The structure of the latex spout and anti-overflow glue tank achieves high-precision gluing, without missing or overflow of glue, thereby to improve the tightness of the encapsulation to block moisture.
- **Optimized Load Design**
  GCL SI's self-developed border adhesive and optimized stress structure of the frames guarantee a higher load capacity and weather resistance of the modules.

Value of The "Lotus" Module

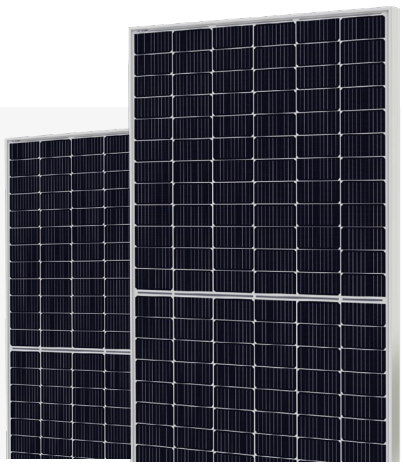
Higher efficiency

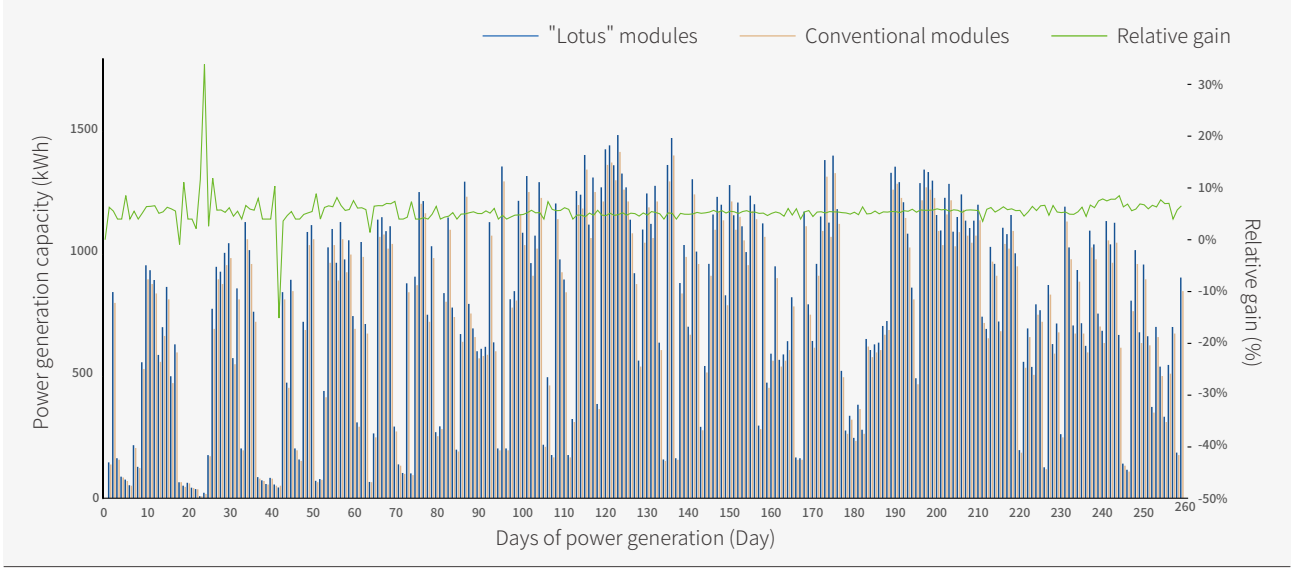
Total power generation gain

+5.44%



Contrast of 260-day cumulative power generation



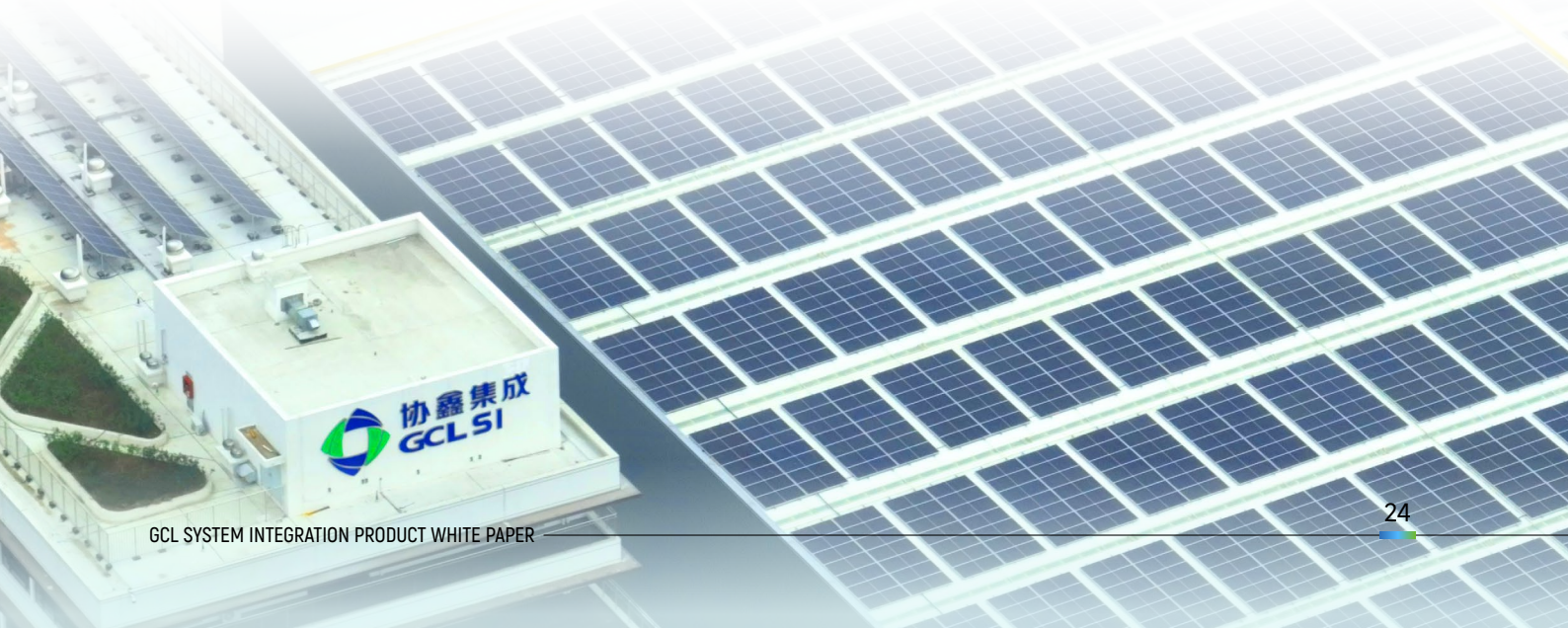


Hefei Plant

Contrast of 260-day power generation

3° low inclination scenario

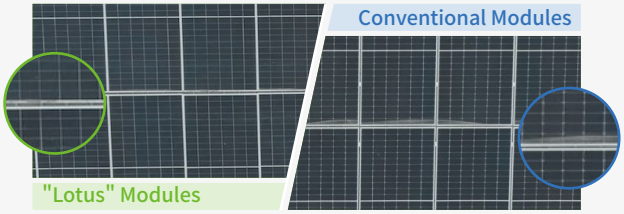
Installed capacity of 211.94kW for "Lotus" Module and conventional modules



Longer-lasting safety

More ingenious design, long-term safety

Innovatively designed frameworks are able to avoid dust accumulation, reduce risks of hot spots and prevent limescale.



Reliable products, easier maintenance

Have passed IEC61215, IEC61730 tests and full range of IEC environmental certification tests, certified by TÜV Rheinland and Swiss Re reinsurance services.

- Front-side snow cover thickness exceeding 2.2m (⩾ 5400 Pa)
- Back-side wind resistance 36m/s, equal to level 12~13 typhoon (⩾ 2400Pa)
- Certified by TÜV Rheinland Class 15 wind tunnel test

Stabler earnings

Take Shandong 1MWp power station as an example, on-grid price of 0.39RMB/kWh, 4° installation inclination

Gain of the first-year on-grid earnings of the 1MWp power station over the conventional modules

+46,198RMB

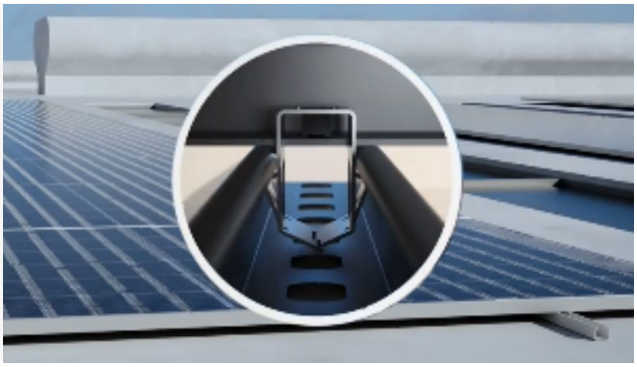
Gain of the 25-year on-grid earnings of the 1MWp power station over the conventional modules

+1,098,941RMB

* Compared with conventional modules

Easier installation

- Quick installation, compromising both the horizontal and the vertical installation, has reduced the labor time by 30%;
- Boltless installation better resists looseness and generates an outstanding performance in vibration reduction, which has lowered the risk of hidden cracks caused by wind-induced vibrations;
- The application of durable anticorrosion measures ensures reliable endurance. Also, no fastener is exposed, thus to present a aesthetically appealing appearance.



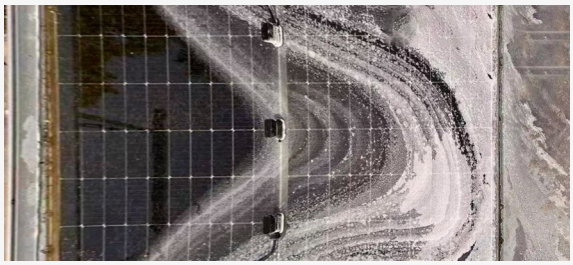
Offshore PV Modules

The global offshore PV market is promising since the sea is open and free of obstructions and has longer and fully utilized sunshine (reflected light from the water surface), which can significantly enhance power generation. Following the pace of technological progress and policy support, it is expected to become an important force in transformation of energy structure in the future. However, compared with the onshore market, the offshore PV modules are operating in the extreme environment of high temperature, high humidity, high UV, high salt spray, strong winds and waves, and strong precipitation, and thus they should have higher reliability and stability for that purpose.

Potential Failure Modes of Modules in Offshore Environments

Bird droppings and salt spray pose great challenges to corrosion resistance

Corrosion in offshore environments can be up to 550 times* that of the onshore. Strong corrosive environments can affect the PID resistance of modules, accelerating their aging and performance degradation. Bird droppings may cause hot spots.



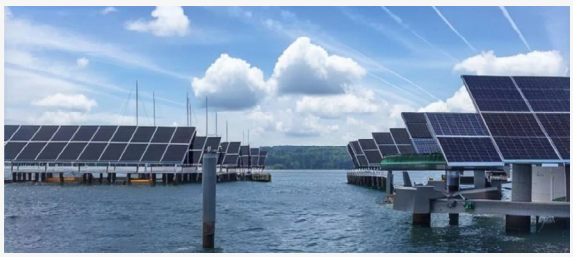
*Calculated in terms of the annual quality loss ratio of bare steel

Typhoons and waves cause risks to reliability

Waves caused by typhoons can rise more than ten meters, reaching or even exceeding level-12 typhoons, which can uproot large trees. This huge impact may lead to reliability problems such as damaged interconnection of cells, hidden cell cracks, broken glass or structural failure.

Humidity, heat and UV are enemies of a long service life

Offshore modules are exposed to high temperature, high humidity and high UV for a long time and are likely to be subjected to PID degradation. Such environments will accelerate the aging and delamination of the materials and reduce the performance of insulating materials, resulting in loss of power generation, and posing a threat to the service life of modules.



Value of Offshore PV Modules

With the aim to maximize the use of sea space and sunshine resources there and solve restraints on construction of onshore PV power stations, GCL SI has leveraged its rich experience in offshore projects to conduct full evaluation on the boundary conditions affecting the modules and ultimately provide customers with offshore PV module design solutions that are highly water-resistant, highly corrosion-resistant, and highly PID-resistant under different conditions. Such modules have already been certified by TÜV Rheinland, far higher than IEC standards.

Every risk under control for more reliable modules

Frame anti-corrosion technology

The coating layer of the aluminum frame is 5~10μm thicker to increase corrosion resistance of the module. The frames are designed with structures resisting anti-fatigue stress to better adapt to different offshore application scenarios.

Salt spray resistant glass

Double-glass and double-coating design can effectively fight against impact from wind and waves on the sea. High-transmitting double-layer coated PV glass enables "0" water permeability, to reduce the generation of crystal salt, and enhance salt spray resistance.

Upgraded weatherability of films

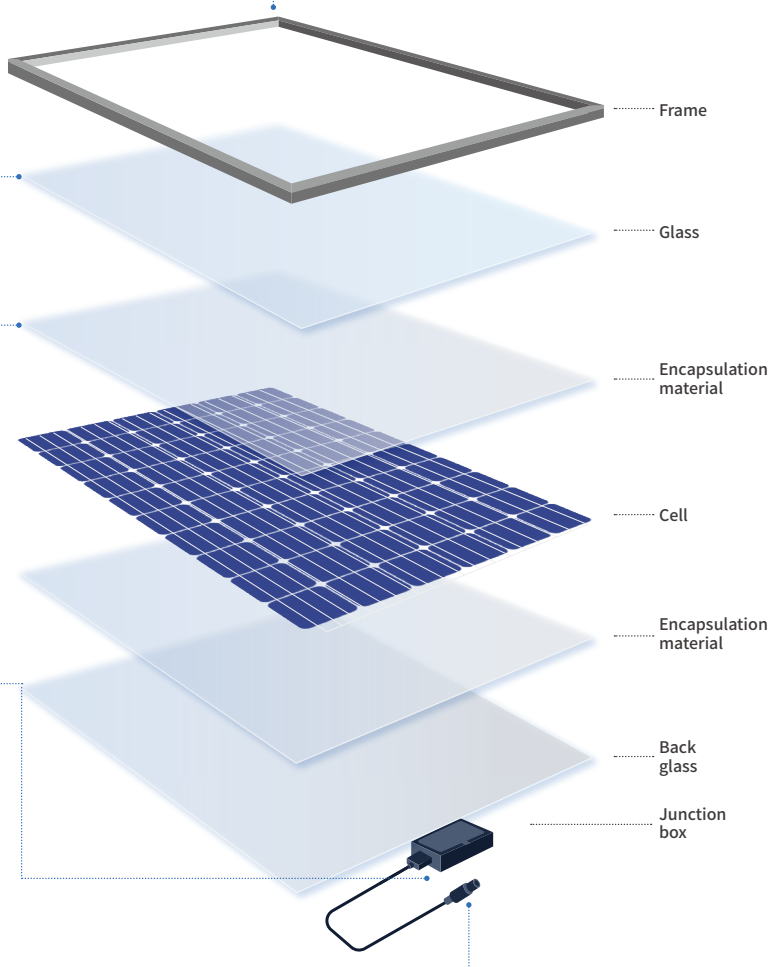
Double layers of high-weight POE films are adopted to increase moisture rejection rate and strengthen performances of PID resistance, yellowness resistance and UV resistance.

Highly waterproof design of the junction box

Four-layer waterproof structure design can prevent water and salt spray. The upgraded diode chips can balance heat dissipation brought by the strong airtightness of the water-blocking structure to avoid thermal breakdown. The waterproof junction box has been certified by TÜV Rheinland.

Upgraded connectors

The upgraded four-clip connectors elevate stability and reliability, so that they cannot be broken free in wind and waves. The double seal rings present more powerful water resistance to prevent arcing. When used together with cold shrink tubes and original dustproof plugs, they can prevent water entering during installation, which has lasted for 60h and thus passed the test.



Extended testing, more reliability

Offshore PV module power degradation Power degradation of conventional modules

High resistance to humidity and heat

DH2000

2.1%

2.4%

High corrosion resistance

Salt spray class 8

0.6%

1.1%

High weather resistance

TC400

0.30%

0.32%

UV60

0.70%

0.76%

High resistance to PID

PID576

1.5%

2.6%

High-temperature immersion PID300

1.8%

High water resistance

10 times IP68 test, the highest level of dust resistance and waterproofness, certified by CGC third-party test reports.

High resistance to wind and waves

Dynamic load testing @1440Pa & 5000 cycles

0.2%

0.8%


Prüfbericht - Produkte
Test Report - Products

TÜVRheinland®

Prüfbericht-Nr.: Test report no.:	50274576 047	Auftrags-Nr.: Order no.:	244517475 244540364
Kunden-Referenz-Nr.: Client reference no.:	2071098	Auftragsdatum: Order date:	23/05/2023 28/08/2023
Auftraggeber: Client:	GCL System Integration Technology Co., Ltd. Jianghai Economic Zone, Nanqiao Town, Fengxian District, Shanghai 201406, P. R. China		
Prüfgegenstand: Test item:	Photovoltaic (PV) module		
Bezeichnung / Typ-Nr.: Identification / Type no.:	See module type designation on page 3-4		
Auftrags-Inhalt: Order content:	Design qualification and type approval of photovoltaic (PV) modules		
Prüfgrundlage: Test specification:	Photovoltaic (PV) modules IEC 61215-1:2016; IEC 61215-1-1:2016; IEC 61215-2:2016; IEC 61730-1:2016; IEC 61730-2:2016; EN 61215-1:2016; EN 61215-1-1:2016; EN 61215-2:2017; EN IEC 61730-1:2018; EN IEC 61730-2:2018		
Wareneingangsdatum: Date of sample receipt:	03/07/2023 12/09/2023		
Prüfmuster-Nr.: Test sample no:	See clause 6		
Prüfzeitraum: Testing period:	10/07/2023 - 06/12/2023		
Ort der Prüfung: Place of testing:	Refer to page 6		
Prüflaboratorium: Testing laboratory:	TÜV Rheinland (Shanghai) Co., Ltd.		
Prüfergebnis*: Test result*:	Pass		
geprüft von: tested by:		genehmigt von: authorized by:	
Datum: Date:	07/12/2023	Ausstellungsdatum: Issue date:	07/12/2023
Stellung / Position:	Project Engineer	Stellung / Position:	Authorizer
Sonstiges / Other:	- Extension to alternative materials and combinations. - Refer to page 5-6 and Constructional Data Form (CDF) No. 50274576 047 for more details.		
Zustand des Prüfgegenstandes bei Anlieferung: Condition of the test item at delivery:	Prüfmuster vollständig und unbeschädigt / Test item complete and undamaged		

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

TÜV Rheinland (Shanghai) Co., Ltd. No.177, 178, Lane 777 West Guangzhong Road, Jing'an District,Shanghai, China
Mail: service@de.tuv.com · Web: www.tuv.com

* The third-party lab and internal test data show that the power degradation of GCL SI offshore PV modules is far lower than 5% as specified in the IEC standard and 3% stated in the internal control standard.

Anti-glare Functional Components

Risks of Glass

Glare is caused by strong sunlight reflected by the surface of the module, especially by those with high reflectivity. It can give rise to such problems as visual discomfort, light pollution, and driving hazards. When PV modules are used in special scenarios such as airports or highways, a comprehensive assessment on the impact of glare will be required.

Visual interference

Glare of modules interferes with visual judgment and in severe cases, may cause burns to the eyes.

Light pollution

Light pollution may affect behavioral patterns of wildlife, in a manner that birds and insects may be attracted to bright light and change their migration paths or breeding behaviors accordingly.

Hazards for pilots

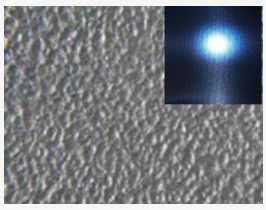
According to Federal Aviation Administration (FAA), approximately 1-5 visual interferences will happen to pilots, who are disturbed by glare and hence impair their flying.

Product Value of Anti-glare Modules

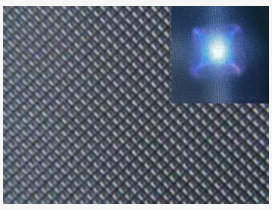
In order to avoid light pollution and visual hazards caused by glare, and to guarantee the safe use of modules in special scenarios such as civil airports and highways, GCL SI has offered anti-glare module solutions.

Anti-glare textured tech

The optimal texture structure of the glass surface has enabled the reflected light to be dispersed, to produce as small brightness as possible and reducing possibility to cause glare..



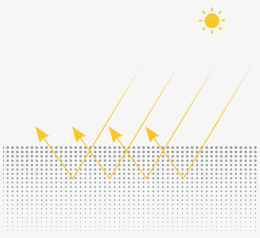
Glass surface of conventional modules



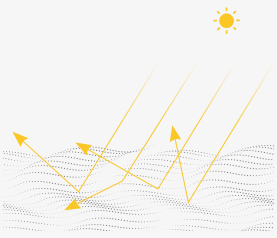
Glass surface of anti-glare modules

Multi-layer coating technology

Multi-layer coating has optimized the type of light reflection on the glass surface, dispersed its directions, which will convert the specular reflection into diffuse reflection to the maximum extent and thereby reduce the impact of glare.



Coating of conventional modules

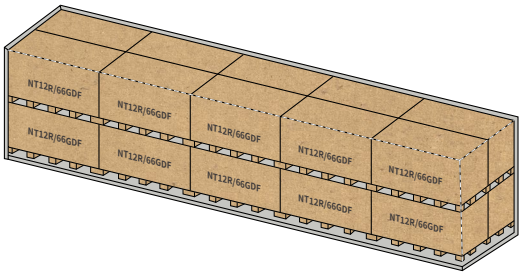


Coating of anti-glare modules

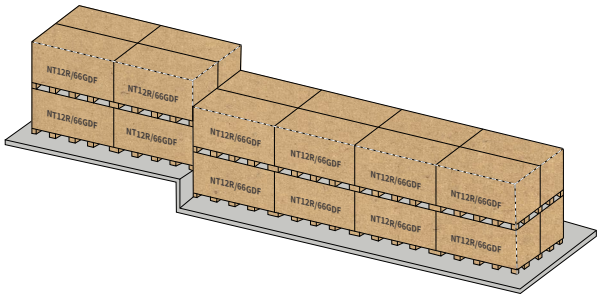
05

Packaging and Transportation

Module Type	Module Dimension (mm)	Packaging Method	40-ft HQ Container		17.5m Flatbed Trucks	
			Pieces	Watts	Pieces	Watts
NT12R/48GDF	1762*1134*30	Horizontal Package	26 pallets/ 936 pieces	416.52kW (445W/ pieces)	/	/
NT12R/54GDF	1962*1134*30	Horizontal Package	24 pallets/ 864 pieces	432kW (500W/pieces)	/	/
NT12R/66GDF	2382*1134*30	Horizontal Package	20 pallets/ 720 pieces	446.4kW (620W/pieces)	24 pallets/ 864 pieces	535.68kW (620W/pieces)
NT12/66GDF	2384*1303*33	Vertical Package/ Horizontal Package	18 pallets/ 594 pieces	432.74kW (710W/pieces)	22 pallets/ 726 pieces	515.46kW (710W/pieces)
NT10/72GDF	2278*1134*30	Horizontal Package	20 pallets/ 720 pieces	424.8kW (590W/pieces)	25 pallets/ 900 pieces	531kW (590W/pieces)
NT10/78GDF	2465*1134*30	Horizontal Package	/	/	23 pallets/ 828 pieces	529.92kW (640W/pieces)



NT12R/66GDF
schematic diagram of the 40-ft HQ container



NT12R/66GDF
schematic diagram of 17.5m flatbed trucks

* For details, please refer to *Product Packaging Manual of GCL SI*.

06

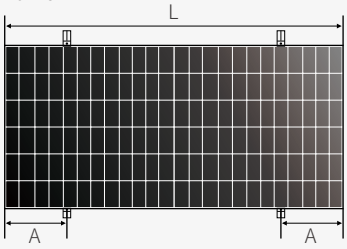
System Compatibility

Method of Installation

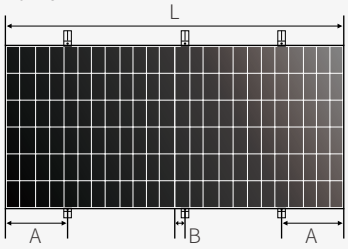
GCL SI modules are compatible with multiple installation methods in the industry.

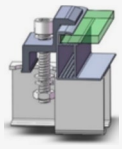
Fixture and lock block installation

Method one: fixed with four lock blocks, with the beam vertical to the longer frame

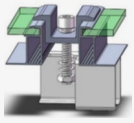


Method two: fixed with six lock blocks, with the beam vertical to the longer frame





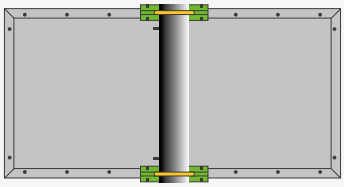
Edge lock block



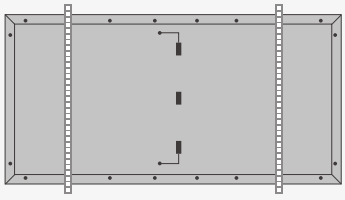
Middle lock block

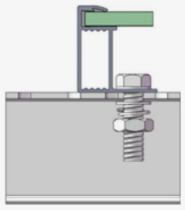
Bolt installation

Method three: single axis tracking system installation



Method four: beam vertical to the longer frame

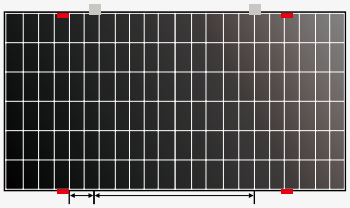




Bolt

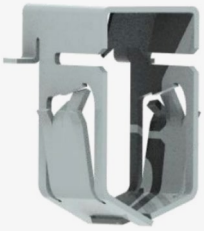
Clip installation

Method five: fixed by four clips, with the guide rail vertical to the longer frame



Distance between the mounting hole and the guide rail (D)

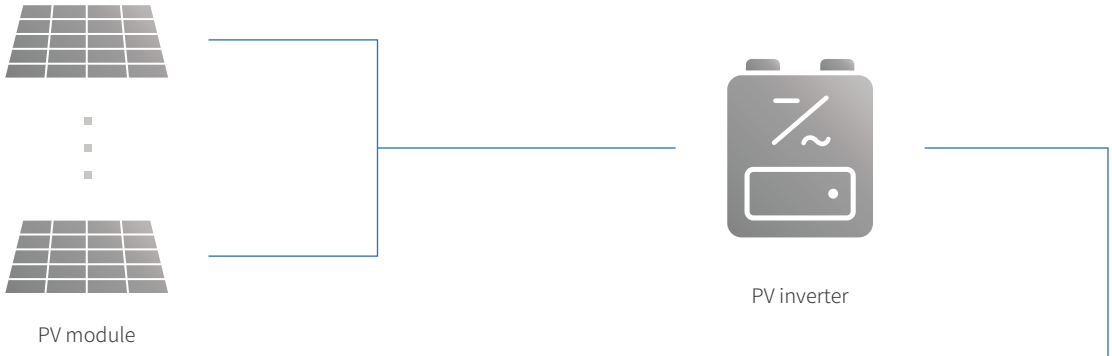
Guide rail outer contour spacing (L1)



Clip

* For details, please refer to *GCL SI Module Installation Modules*

Inverter



GCL SI compatible with PV inverters in all aspects

Electric specification

The electrical parameters of GCL modules, such as voltage and current, meet the requirements of the inverter.

Performances

The output characteristics of GCL modules satisfy the MPPT requirements of inverters, which effectively reduces series mismatch and improves system earnings.

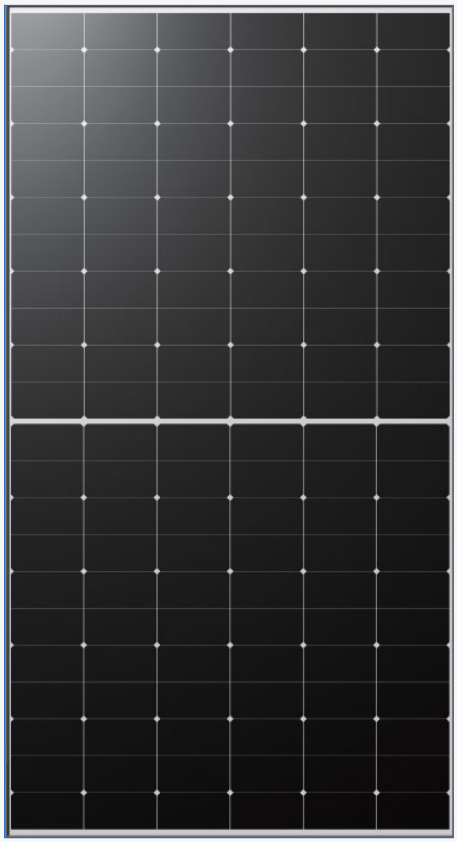
07

New-generation Products and Technologies

New-generation Product GPC

GCL SI will launch its New-generation product Graphical Precise-doping Contact (GPC) PV modules based on the BC (Back Contact) technology, to further enrich its product matrix and offer more choices for customers worldwide in their pursuit of efficient, reliable and innovative PV solutions.

New-generation product GPC



Product: GPC12R/66 double-glass product (N-type base)
Dimension: 2382*1134*30mm
Power: 660W

Lower Degradation

- Temperature coefficient -0.25%/°C
- First-year degradation <1%
- Linear power degradation <0.35%

Higher Gain

- Cell conversion efficiency >27.5%
- Outstanding shadow resistance
- Maximized light utilization

High Reliability

- Higher acid resistance of cells
- Lower risks of hidden cracks of cells
- Higher hot spot resistance

Clean Appearance

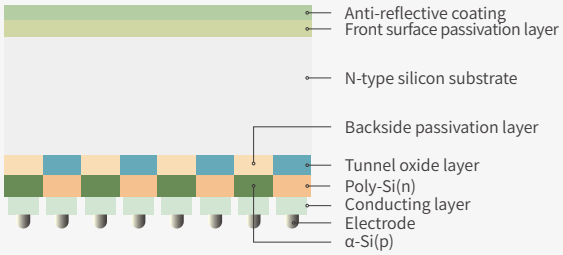
- No grid line in the front
- Handling complexity by simplicity

New-generation Technology

Third-generation GPC Technology

GCL SI's self-developed GPC3.0 technology is based on the BC cell structure platform after integrating the advantages of TOPCon and HJT technologies. Different passivation contact structures are adopted in the emitter area and the back surface field, namely, the Tunnel Oxide Passivating Contact (TOPCon) structure for the former and the Heterojunction Technology (HJT) structure for the latter. Combination of advantages of the two structures has increased the transverse electrical conductivity, reduced the thickness of the polysilicon layer, required fewer steps, cut the cost but offered higher reliability, thereby to further elevate the conversion efficiency of cell products.

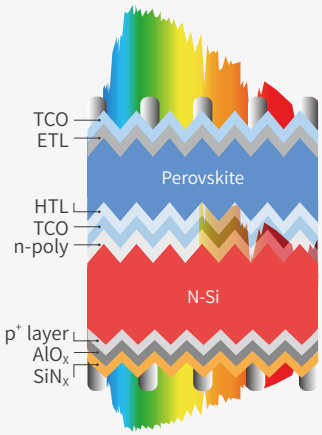
- Optimize P-zone passivation and contacting to improve cell efficiency by more than 0.6%
- Increase transverse conductivity and reduce parasitic light absorption in the passivation layer
- Generate more space for cost reduction through cell structure optimization
- Apply multiple technology to guarantee higher reliability



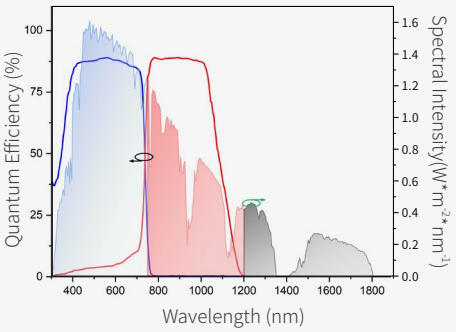
Hybrid BC cell structure

Tandem Technology

GCL SI's self-developed tandem cell technology is based on the TOPCon bottom cell technology and utilizes multi-film layer low-temperature deposition in the top layer superimposed on the wide-band gap perovskite top cells, enabling the segmented absorption of the spectrum by the top and bottom cells, reducing the relaxation loss, enhancing the utilization rate of photon energy, and breaking through the theoretical limit of the existing monocrystalline silicon cells, with the ultimate efficiency up to 43%.



Structural diagram of tandem cells



Schematic diagram of spectral distribution and current matching of tandem cells

- Maximize the absorption of light energy in each sub-band of the cell, the ultra-high efficiency limit of 43%
- High voltage and low current, lower heat loss
- Evident cost advantage of the top cell, reducing LCOE by 10-15%
- Compatible with existing commercial crystalline silicon module processes

08 Cases

Distributed - Residential Scenarios

Residential PV in Shaoxing, Zhejiang — Installed capacity: 0.74MW

Residential PV in Mondragon, France — Installed capacity: 0.30MW

Distributed - Industrial and Commercial Scenarios

PV Shed Project of Yangcheng eSports Hall — Installed capacity: 0.17MW

Wavrin PV Shed, France — Installed capacity: 4.6MW

Utility Scenario

"Fishery Farming and PV Power Generation" Power Station in Tianchang, Anhui Province — Installed capacity: 40MW

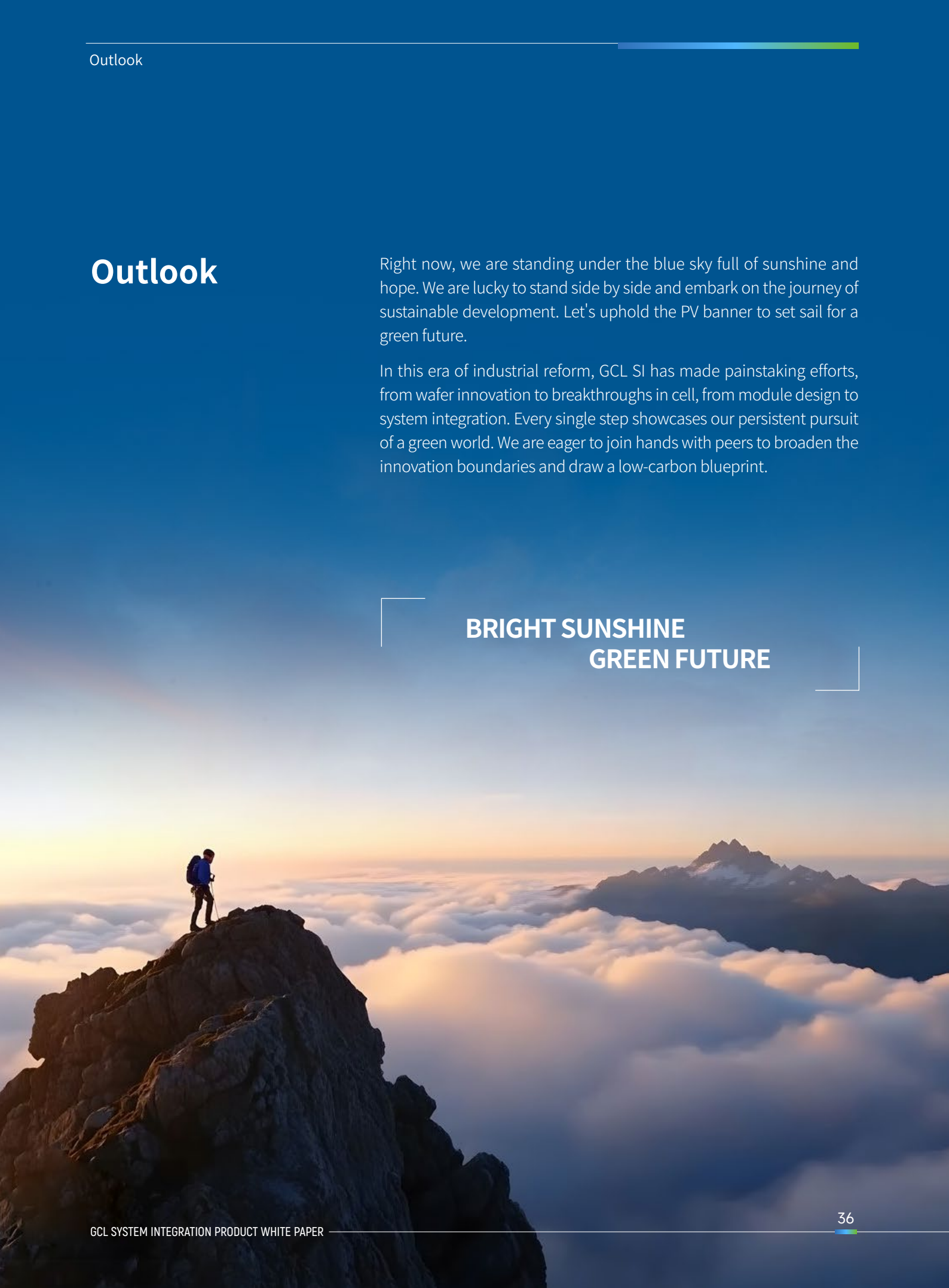
Utility Scale in LEVROUX, France — Installed capacity: 9.74MW

Outlook

Right now, we are standing under the blue sky full of sunshine and hope. We are lucky to stand side by side and embark on the journey of sustainable development. Let's uphold the PV banner to set sail for a green future.

In this era of industrial reform, GCL SI has made painstaking efforts, from wafer innovation to breakthroughs in cell, from module design to system integration. Every single step showcases our persistent pursuit of a green world. We are eager to join hands with peers to broaden the innovation boundaries and draw a low-carbon blueprint.

BRIGHT SUNSHINE
GREEN FUTURE



Bringing **Green** Power To Life

GCL SYSTEM INTEGRATION TECHNOLOGY CO., LTD.

Address: GCL Energy Center, No.28 Xinqing Road, Suzhou Industrial Park, Jiangsu Province, China
Tel: 86-512-6983 2999
Fax: 86-512-6983 2777
E-mail: gclsisales@gclsi.com

www.gclsi.com

GCL SI Website

GCL SI Facebook

GCL SI LinkedIn