



# WHITE PAPER OF TONGWEI PV MODULES

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# Company Profile

Tongwei Co.,Ltd is a large-scale listed company of Tongwei Group, deeply involved in Green Agriculture and Renewable Energy. Tongwei now has more than 200 branches and subsidiaries worldwide, with more than 50,000 employees in total. Tongwei entered the PV industry in 2006 and experienced development for over 10 years rapidly. At present, its business scope covers highpurity crystalline silicon, high-efficiency solar cell, solar modules, and solar power plant construction & operation. It has formed a complete renewable energy industry chain with independent intellectual property rights and be industry-leading in scale, technology, cost and quality, which business covers the entire PV industry chain.

Tongwei started solar cells and modules business in 2013. Tongwei established the high-efficiency module R&D Department and started researching in relevant technical region in 2016. After more than 10 years of continuous investment in R&D, Tongwei has formed a matrix of product portfolios that covers differentiated market needs with Tongwei characteristics. Those have been widely used in residential rooftop, C&I projects, and utility-scale plants, meeting the ascending demands for clean energy of the global clients. Tongwei accelerated developing and expanding module business in the second half of 2022, with years of accumulated experience in technology and market, a competitive scaled half-cut module business system has been established by collaborating advantages of high-purity silicon and solar cell in the upstream. Clients are from state-owned power generation enterprises of China and those regions over 40 countries around the world. Tongwei achieved top 5 global ranking in module shipments in first half of 2023(PV InfoLink).The current total production capacity is 75GW in the respect of the Hefei, Jintang, Nantong and Yancheng (The largest, most automated, digitised and intelligent solar module workshop in the world) manufacturers, furthermore the Shuangliu Base is on running plan in 2025.



**476th of Fortune  
Top 500**



**94th of Fortune  
Top 500 Listed  
Companies in China**



**494th of Forbes  
Top 2,000 Global  
Enterprises**

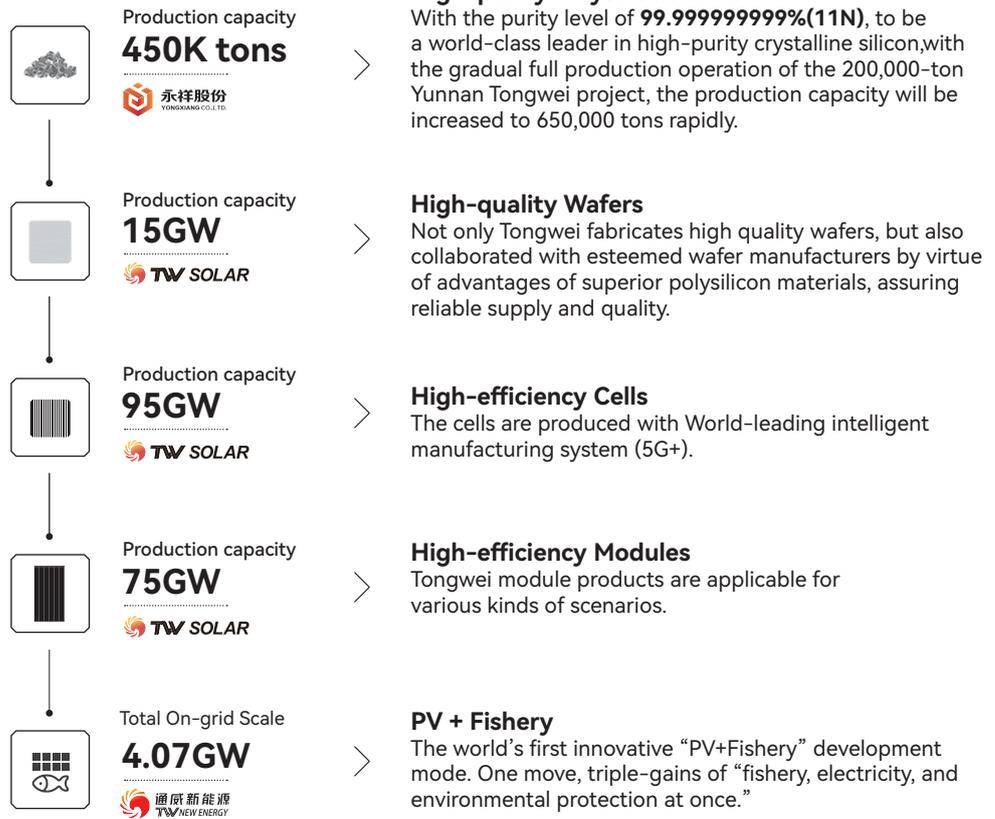
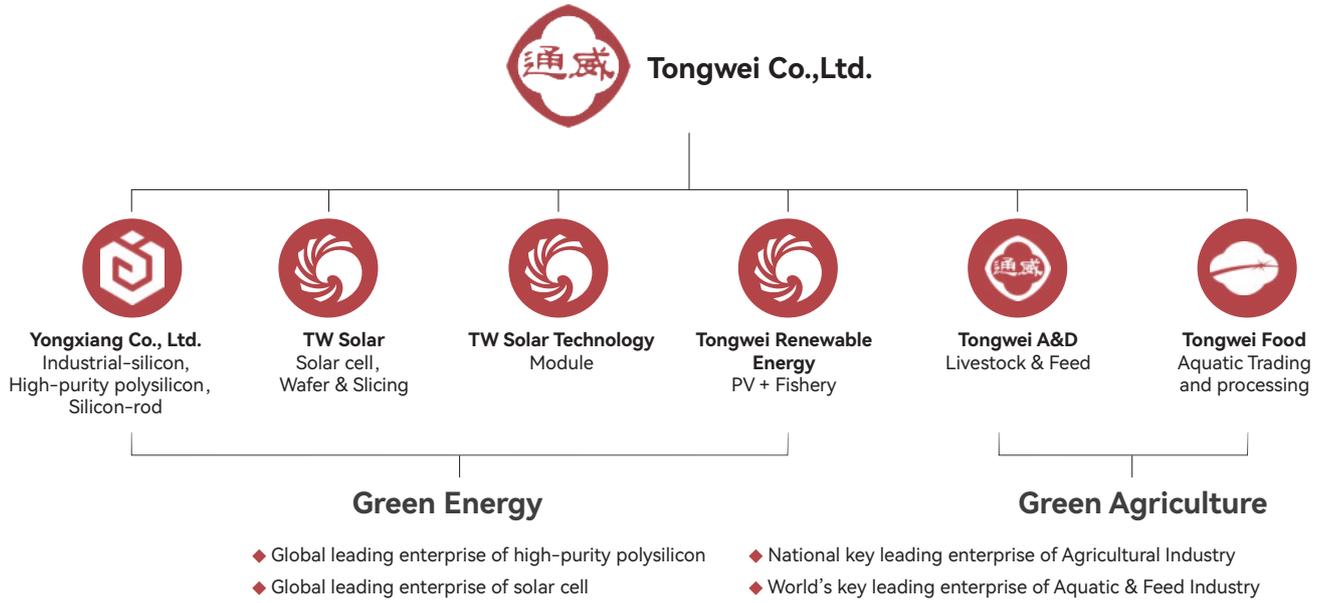


**State-level Green  
Factory**



**State-level Enterprise  
Technology Center**





High purity polysilicon planned  
**800K – 1000K tons**

Solar Cell planned  
**130-150GW**

Photovoltaic Modules planned  
**80-100GW**



TongWei —

# Bloomberg New Energy Finance (BNEF) Tier 1 Module Suppliers



40<sup>+</sup>

Tongwei cell and module reached 40 countries and regions around the world on the strength of excellent performance of products and full-dimension good quality service



5

Tongwei formally entered the module industry in 2022  
Total shipment by the end of 2023 : **Top 5 in Global**

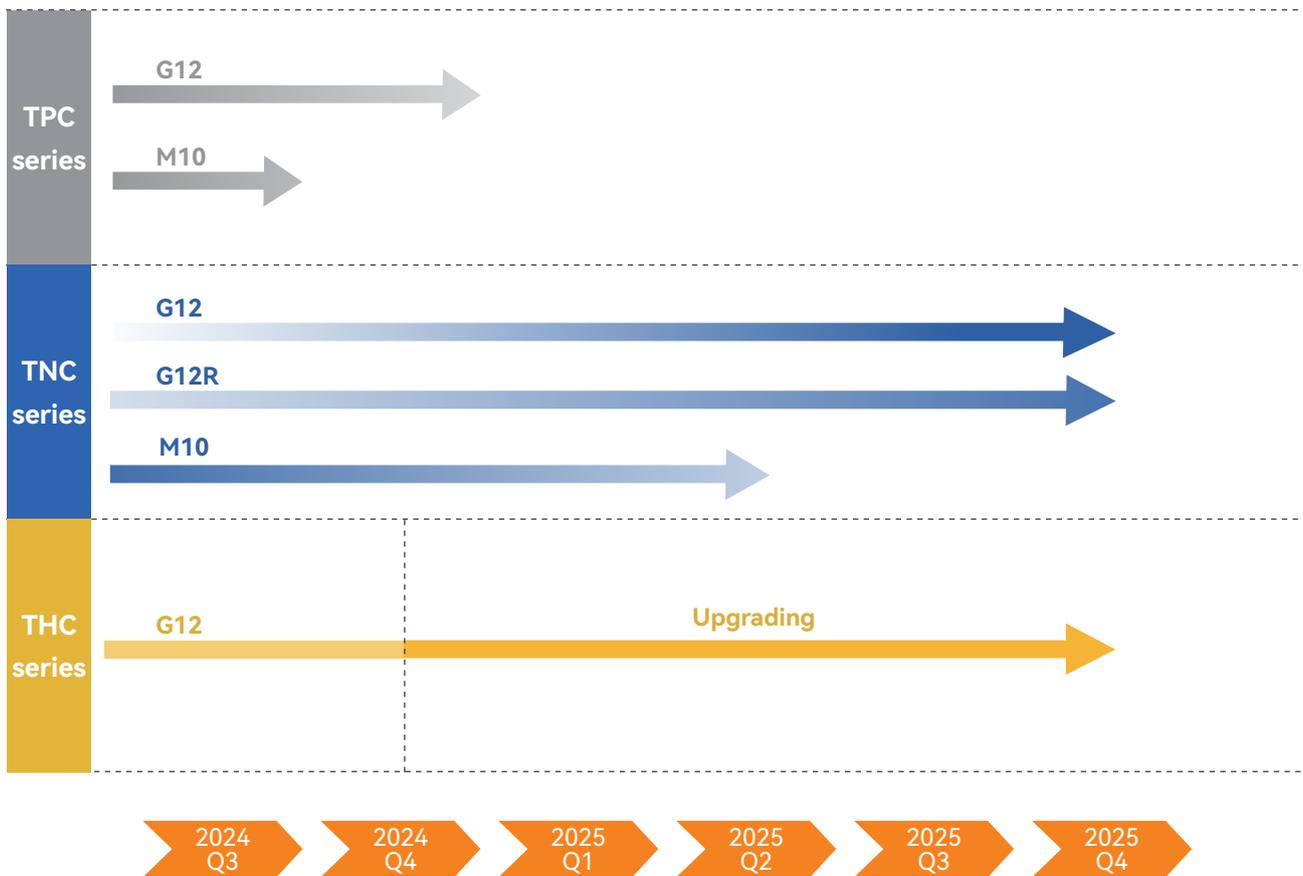


# Product Roadmap

Tongwei provides diversified product solutions based on the layout of multiple technology roadmaps and the demands of PV application market.

Tongwei is promoting TNC as mainstay products, meanwhile making TPC stepping into phase out and increasing supply of THC series according to market feedback.

TNC M10 series will be upgraded to G12R gradually, TNC G12 series are now available. The THC G12 series are on the progress of upgrading, with completion expected in Q3 2024.



# Module Capacity

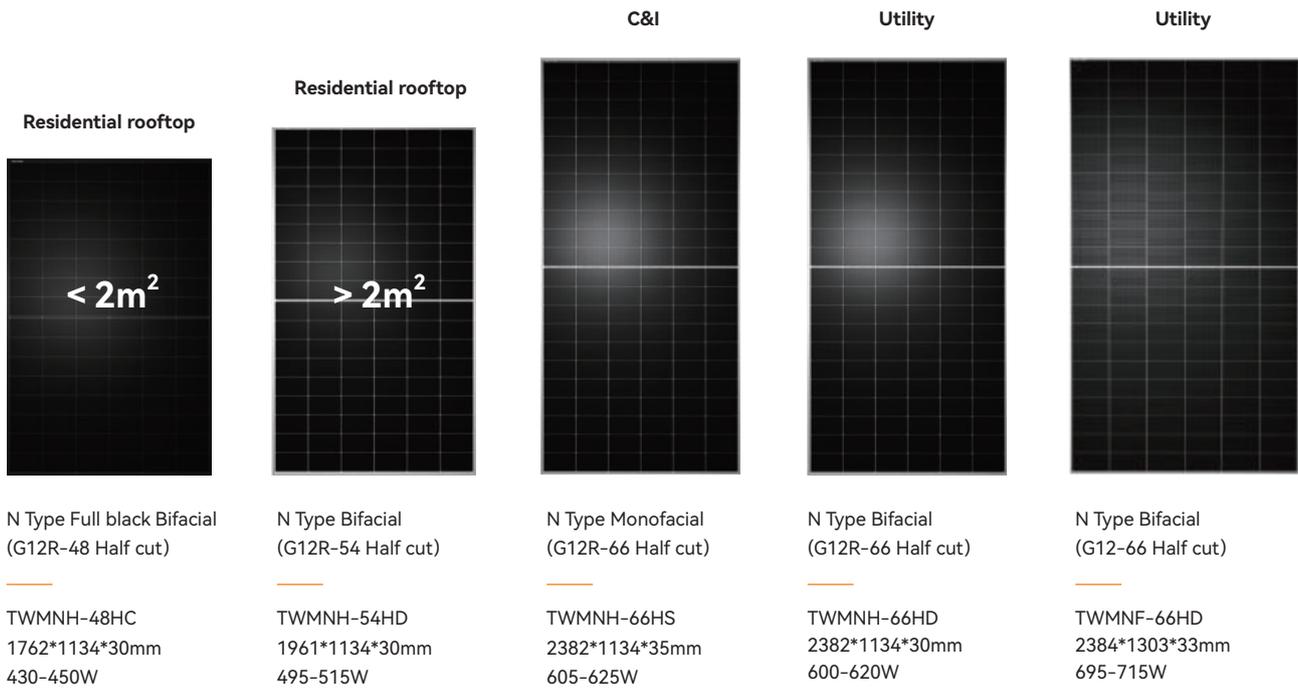


Total capacity **75GW**

The Nantong base is under construction, and the total production capacity shall be updated based on the each progress.  
Due to Modules' flexible manufacturing system, production capacity planning formulated by supplying of solar cells and costumers demands.

# Primary Recommends

Tongwei recommends 5 standard products of TNC Series, with wattage up to 450W, 515W, 620W, 625W, 715W respectively, which are widely used in residential , C&I and Utility Plants.



# Application Value

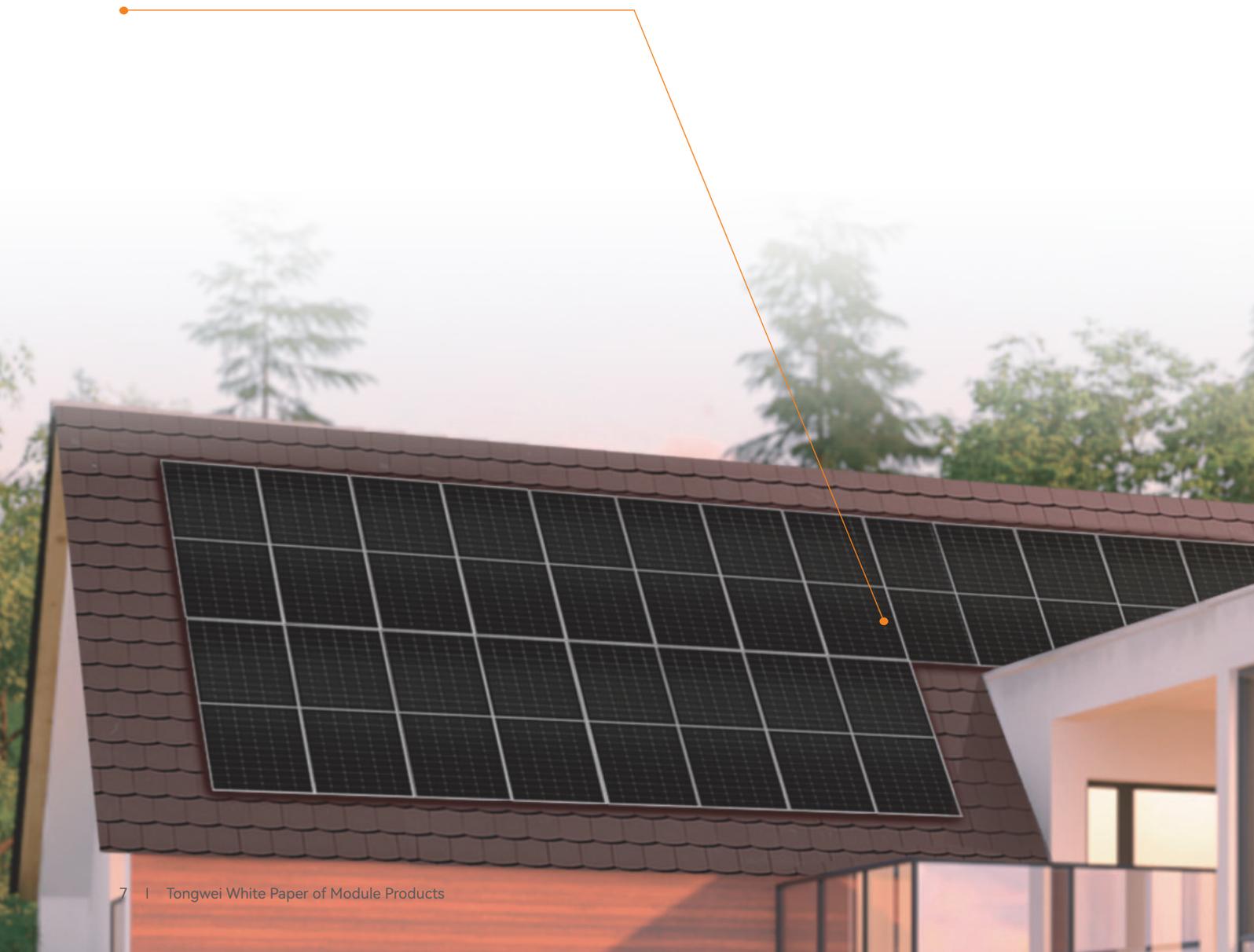
## Residential Rooftop

Recommendation:  
TNC G12R-48 Bifacial Full-black (< 2 m<sup>2</sup>)  
TNC G12R-54 Bifacial (> 2 m<sup>2</sup>)

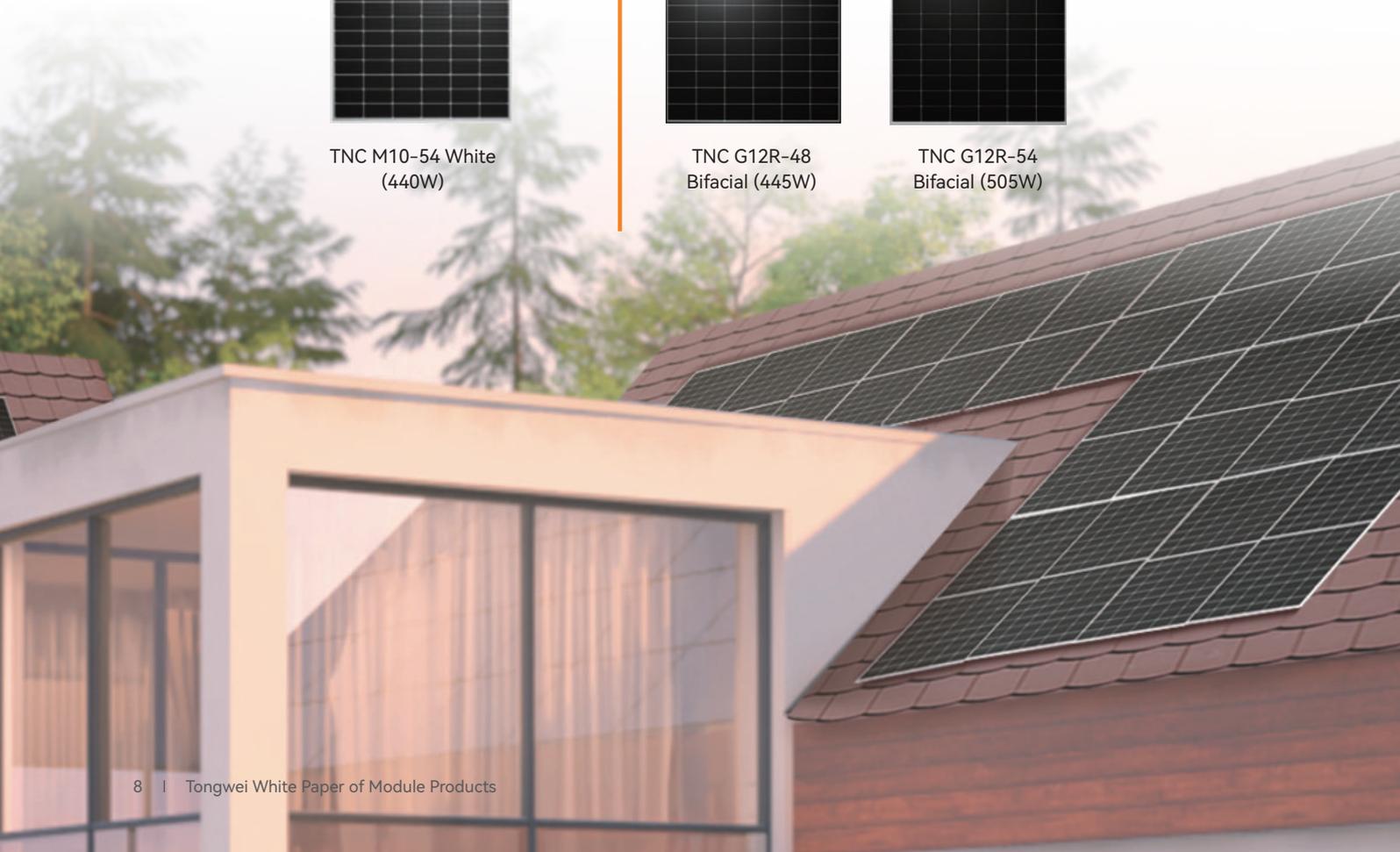
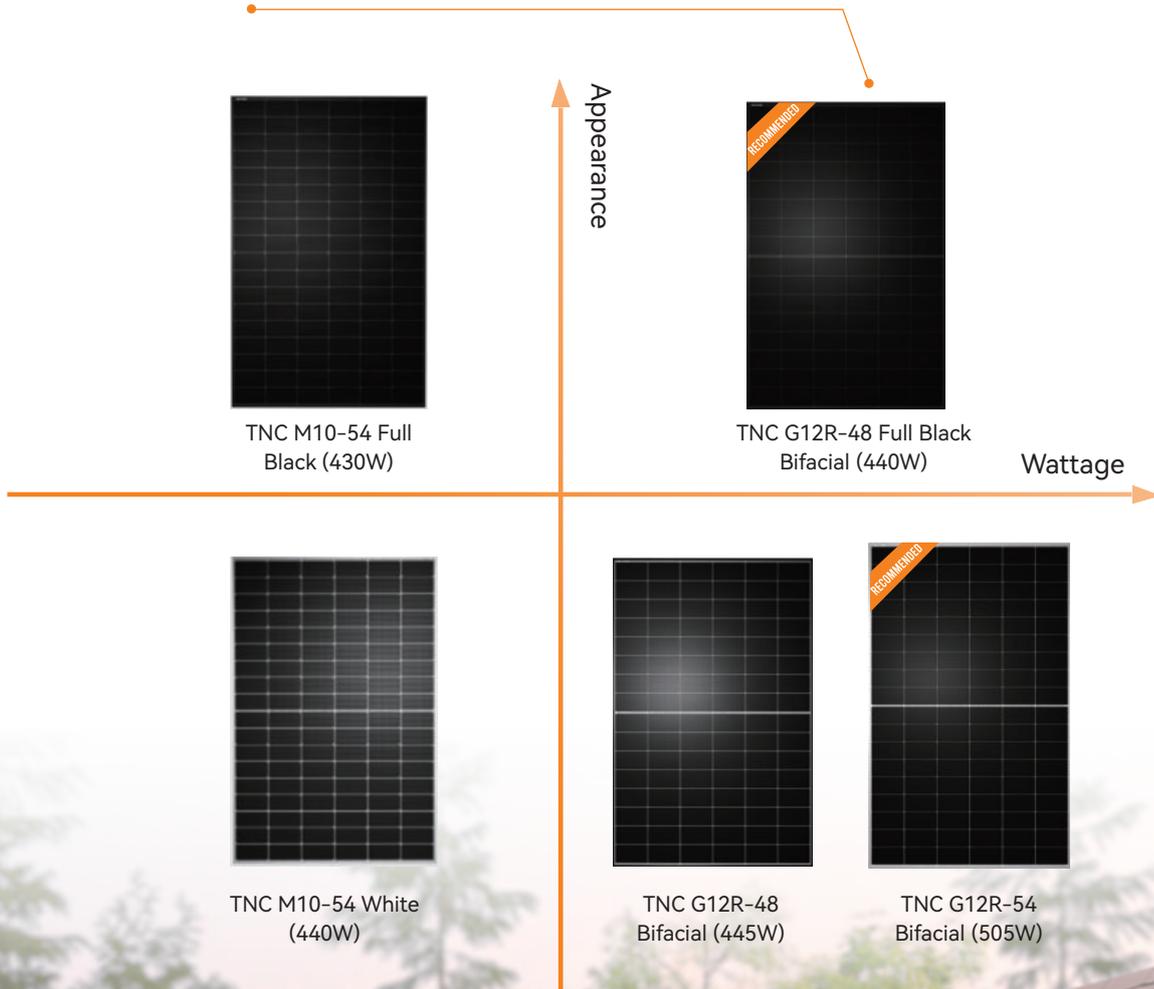
**Market Background:** Industry standard, flat-mounting close to roof surface, tiny scale, high aesthetic demanding.

**Market Features:** Small size, aesthetic appearance and higher wattage.

### Perfect Rooftop Fit , Perfect Aesthetics



TNC G12R-48 All-black Bifacial products (< 2 m<sup>2</sup>) and TNC G12R-54 Bifacial products (> 2 m<sup>2</sup>) are highly recommended while considering marketing requirements. Additional options are available according to the needs and preferences of customers.



## Commercial & Industry

Recommendation:  
 Steel rooftop: TNC G12R-66 Monofacial  
 Concrete rooftop: TNC G12R-66 Bifacial

**Market Background:** ① Unique wattage and dimensions are required to comply with C&I rooftop regulations, panels are typically installed in portrait way.

② Rooftop type: Steel rooftop and concrete type.

**Market Features:** light-weight (steel rooftop), long-narrow shape and high wattage.

TNC M10-72 Monofacial



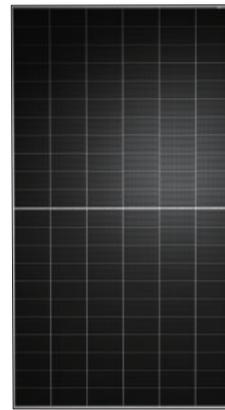
2278\*1134mm  
 (27KG)  
 595W

TNC G12R-66 Monofacial



2382\*1134mm  
 (29KG)  
 620W

TNC G12-66 Monofacial



2384\*1303mm  
 (32.1KG)  
 710W

Product Type	Dimension for Installation	Wattage	Weight
TNC M10-72 Monofacial	Great		Great
<b>TNC G12R-66 Monofacial</b>	<b>Great</b>	<b>Good</b>	<b>Great</b>
TNC G12-66 Monofacial		Great	

**Steel Rooftop (C&I):** TNC G12R-66 Monofacial is recommended primarily due to the lower load capacity of the steel roof, the modules can only be laid flat on the roof surface as a result of wasting the bifacial contribution as well as the market prefer to use long-narrow shape and high wattage in C&I scenarios.



TNC M10-72 Bifacial



2278\*1134mm  
590W

TNC G12R-66 Bifacial



2382\*1134mm  
615W

TNC G12-66 Bifacial



2384\*1303mm  
705W

TNC M10-78 Bifacial



2465\*1134mm  
635W

Product Type	Dimension for Installation	wattage
TNC M10-72 Bifacial	Great	
<b>TNC G12R-66 Bifacial</b>	<b>Great</b>	<b>Good</b>
TNC G12-66 Bifacial		Great
TNC M10-78 Bifacial	Good	Good

**Concrete rooftop:** TNC G12R-66 Bifacial is recommended primarily due to the strong load capacity of the concrete rooftop, the modules could be arranged on fixed structures leading to a higher bifacial gains as well as the market use to long-narrow shape and high wattage in C&I scenarios.

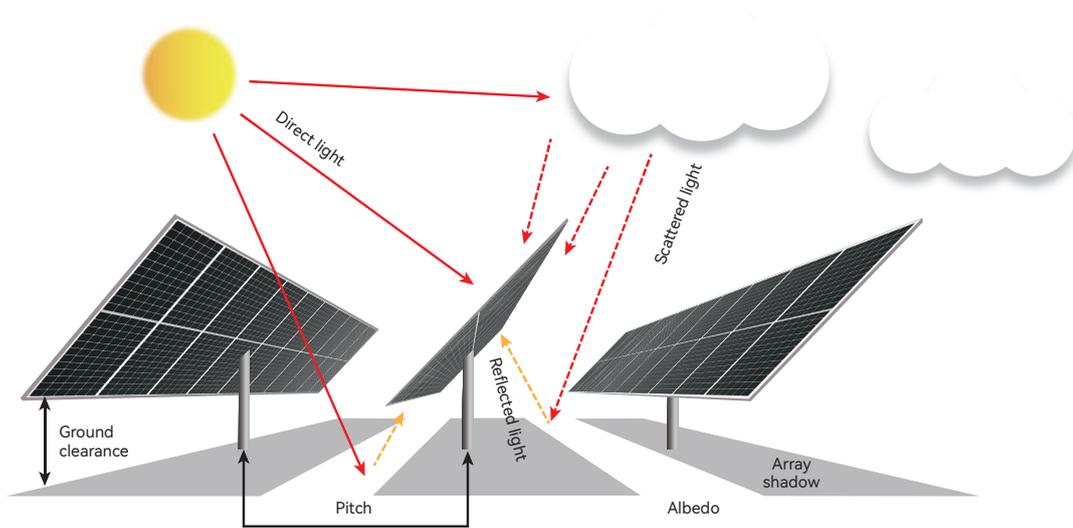


## Utility Plant

Recommendation:  
TNC G12R-66 Bifacial  
TNC G12-66 Bifacial

**Market Features:** Lower LCOE and higher system yield;

The bifacial module is highly recommended in utility scenarios due to its ability to harvest from both sides, contributing to better system performance than monofacial.



Schematic of Bifacial Gain



### Project introduction

Location: Haixi Mongol and Tibetan Autonomous Prefecture, Qinghai Province (Temperate Continental Climate)

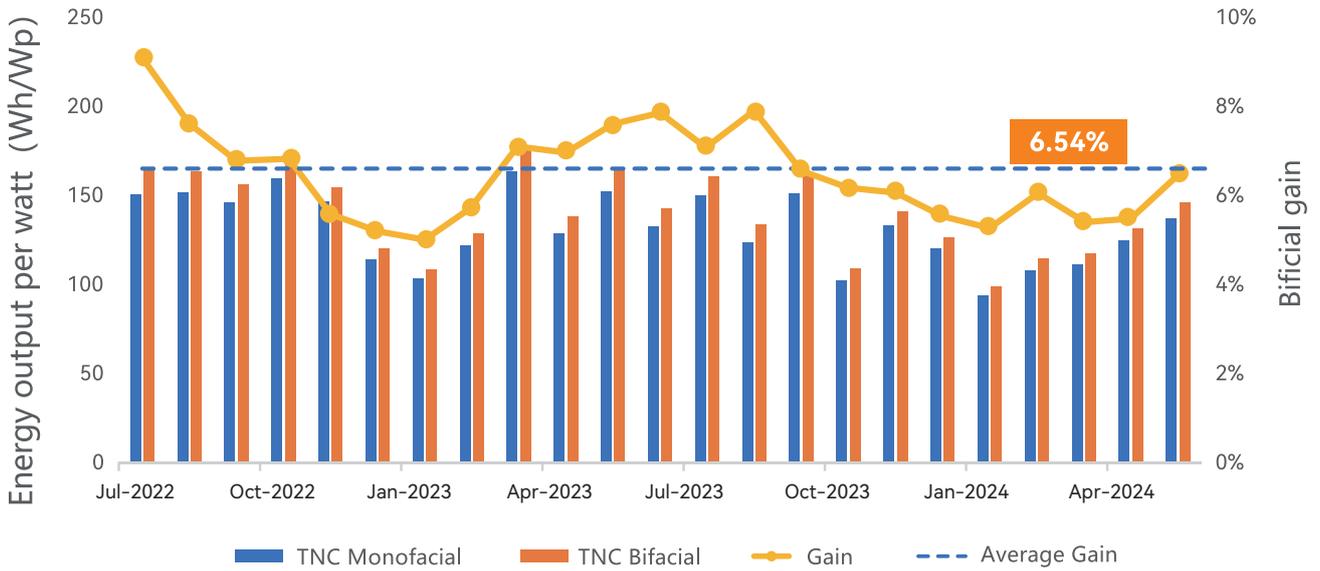
Structure: Fixed racks

Bracket pitch: 11 m

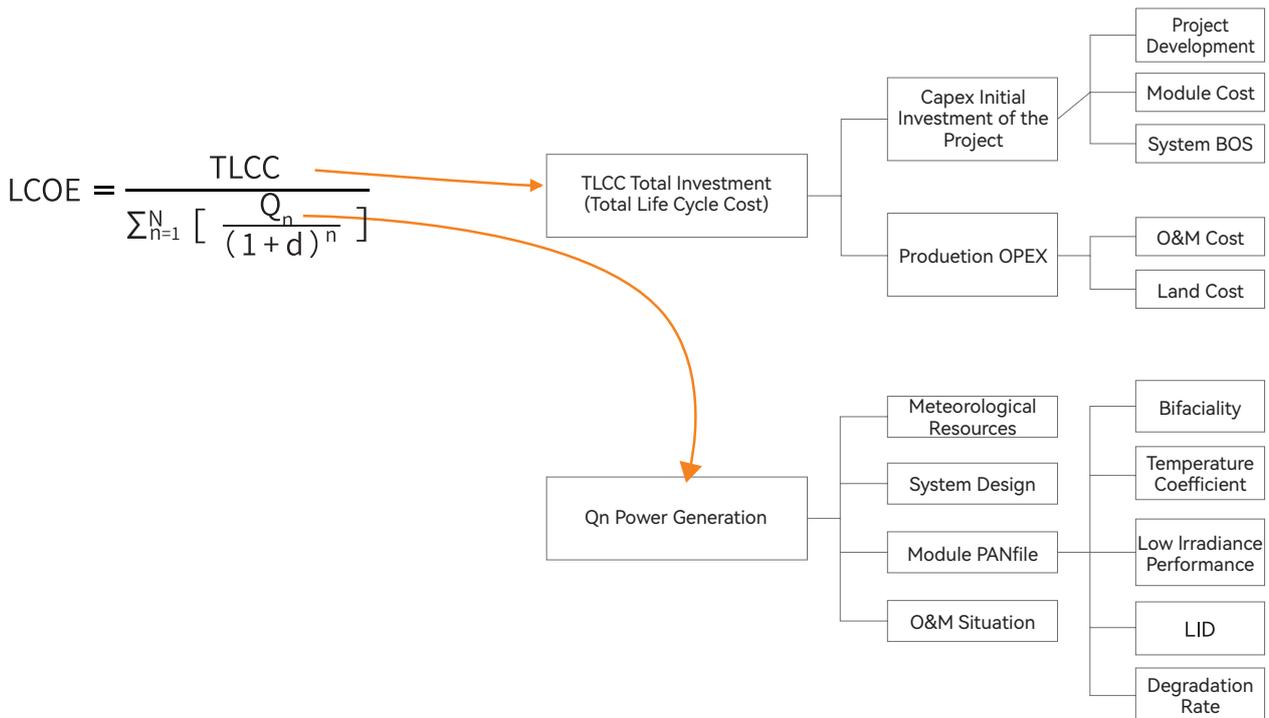
Land surface type: Sandy soil

Module type and quantity: TNC M10-72 Bifacial 570W\*8, TNC M10-72 Monofacial 575W\*8

### Field Test of Bifacial Performance

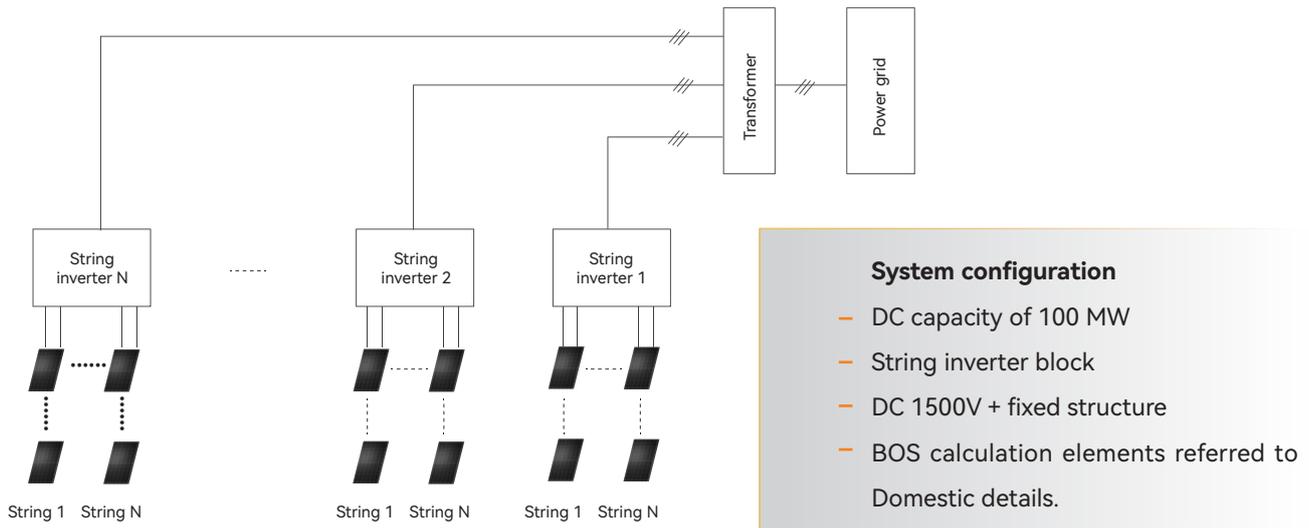


LCOE (Levelized Cost of Electricity) is a critical indicator for measuring the economic properties of PV systems.

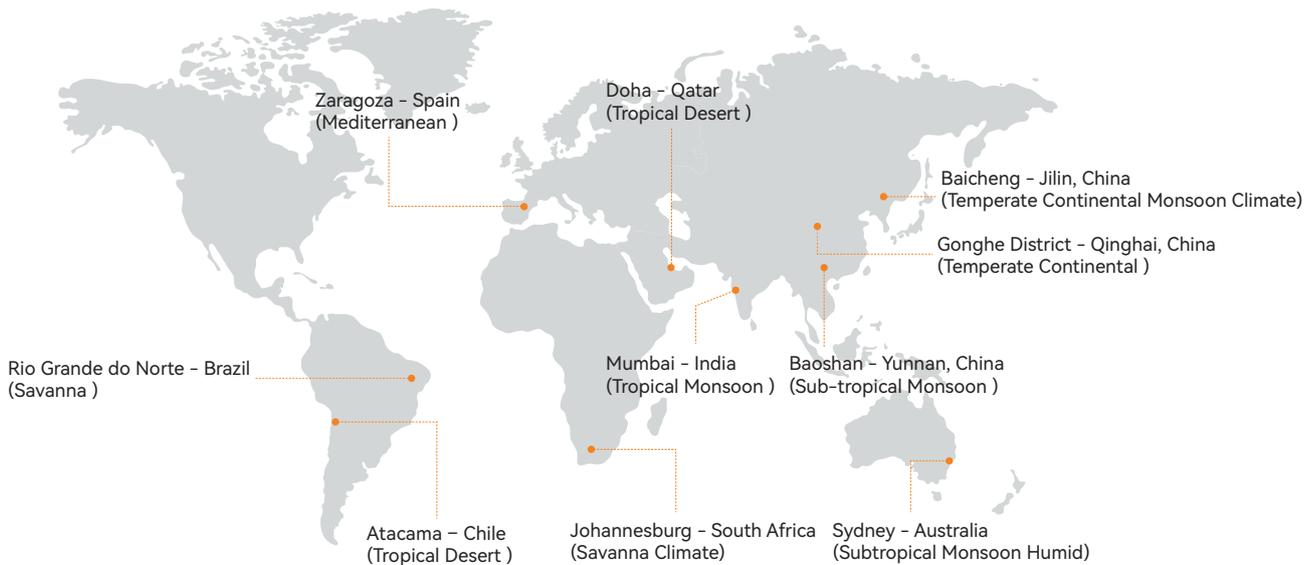


# System CAPEX Analysis

## System design



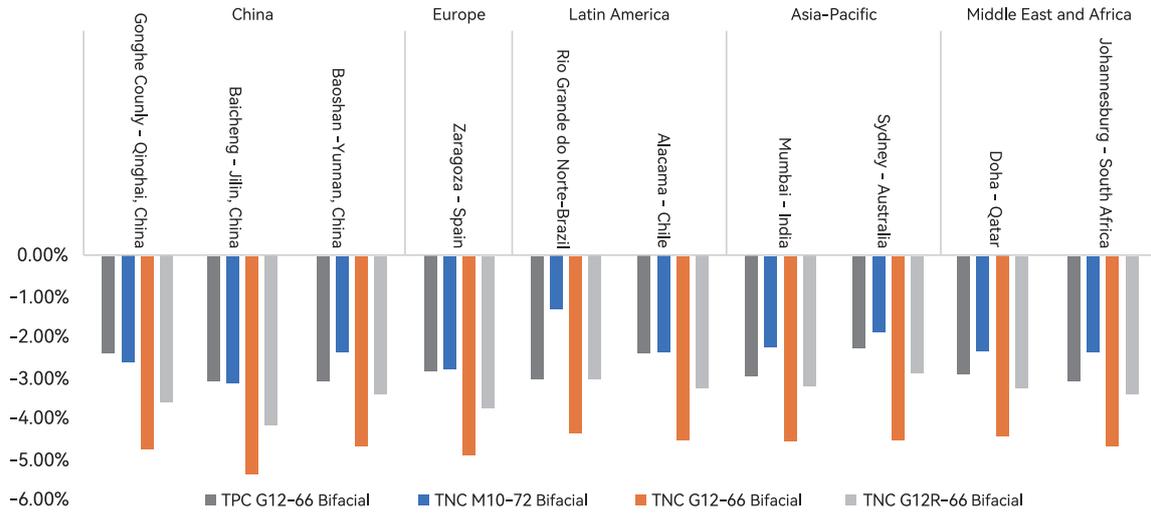
Several regions with the most popular markets in this year's forecast, covering all kinds of climate types, have been selected for field generation and relevant economic analysis.



## BOS Analysis

**TNC G12-66 Bifacial < TNC G12R-66 Bifacial < TPC G12-66 Bifacial < TNC M10-72 Bifacial < TPC M10-72 Bifacial.**

G12R-66 and G12-66 of TNC bifacial products have superior BOS cost, lower land and structure cost, due to it can achieve larger string size, contributed by its unique electrical parameters and dimension.



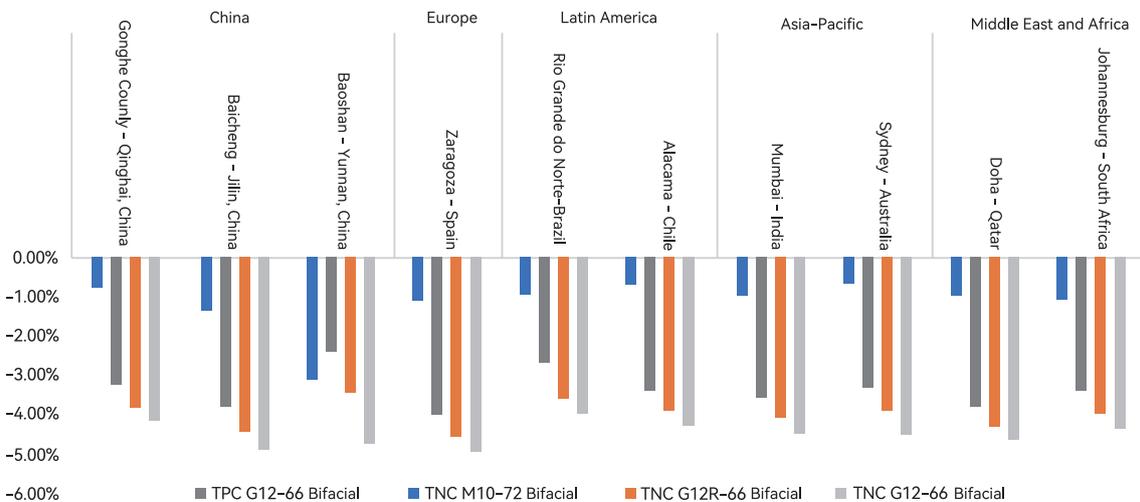
\* TPC M10-72 bifacial 555W as the baseline

## BOS Analysis

## LCOE Analysis

**TNC G12-66 bifacial and G12R-66 bifacial LCOE are relatively superior.**

Depending on its excellent dimensional design and the wonderful generating performance contributed by TNC technology, it achieves better LCOE performance.



\* Measured based on mainstream market prices

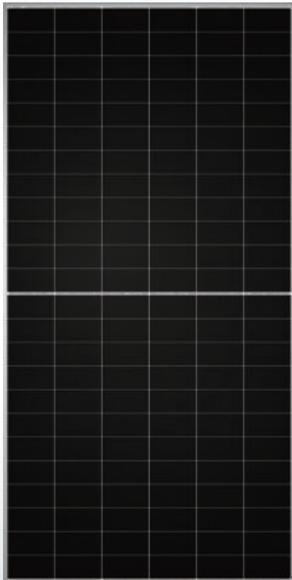
\* TPC M10-72 bifacial 555W as the baseline

## LCOE Analysis

## Utility Plant

Primary Recommends:  
TNC G12R-66 Bifacial  
TNC G12-66 Bifacial

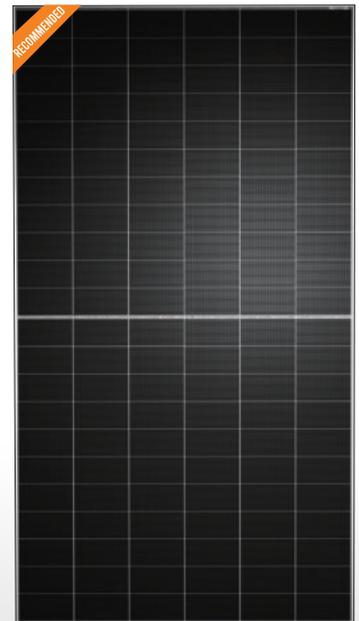
G12R-66 and G12-66 of TNC bifacial modules have lower BOS and LCOE owing to better dimensional design and advantages of TNC series products such as low-temperature coefficient, low degradation, and high bifaciality. Therefore, for utility projects, these products are the best choice. The rest of options also available to meet customers' preference.



TNC M10-72  
Bifacial



TNC G12R-66  
Bifacial



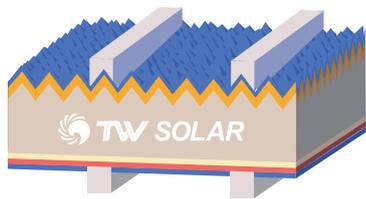
TNC G12-66  
Bifacial

# Product Benefits ➤ Technical Advantages



## High-Efficiency Cell Technology

Based on the typical TPC technology, Tongwei has launched TNC cells, which adopts self-developed and industry-leading tube based PE-TOX & Poly routes. In combination with the MCR technology, good quality contacts can be realized by reducing damage to the passivation layer significantly. Cell mass production efficiency reaches 26.5%+.



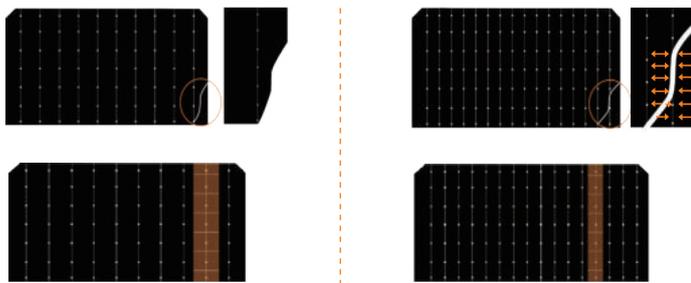
TNC Cell Structure



- PV cell efficiency: 0.4%+ increased
- Temperature coefficient: better performance

## SMBB Design

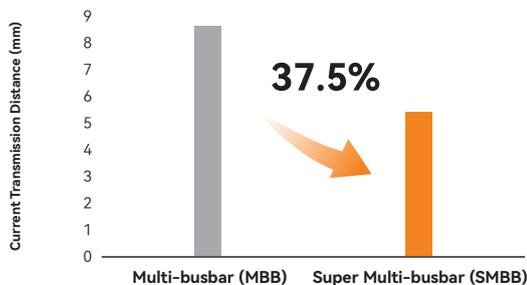
The thinner fingers are introduced to minimize current collection distance and uniform soldering stress. All improvements can make micro-crack loss reduced significantly.



Multi-busbar (MBB)

Super Multi-busbar (SMBB)

- P**  
Minimize the crack loss
- I**  
Shorten Current collection path



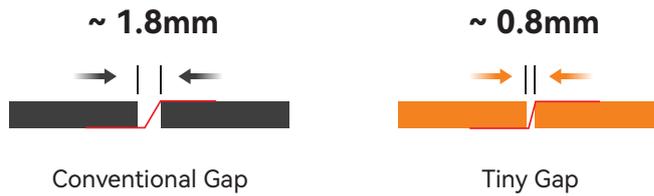
Significantly Reduced Current Transmission Distance



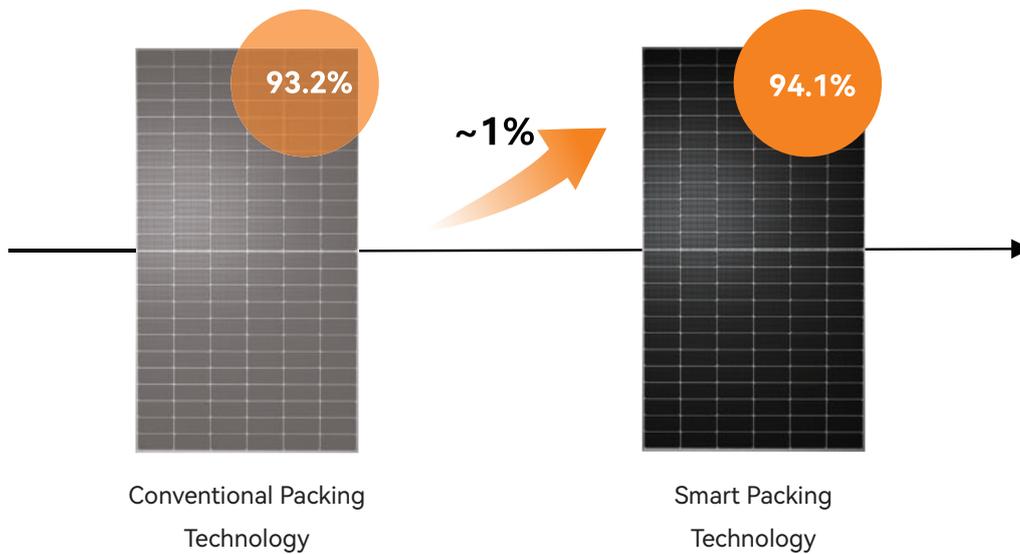
## SMART Packing Technology

Both G12R and G12 modules adopt tiny gap packing technology as shown, which improves packing density leading to higher module efficiency.

Tongwei's Smart Packing Tech. ensures the perfect balance between efficiency and reliability.



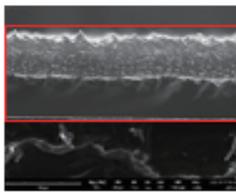
**Packing Density Boosted by Smart Packing Tech.**  
(take M10-72 type as an example)



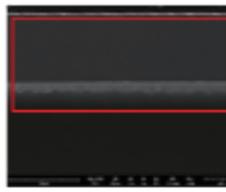


## Non-destructive Cutting Technology

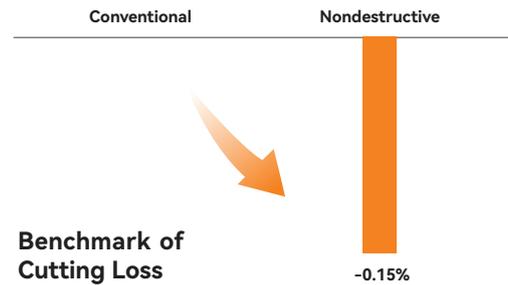
- The technology helps reduce laser cutting depth, the principle is creating a temperature gradient on the surface of cell through laser thermal-cooling stress control system to split cells.
- It could make the cutting section smooth and uniform. This would reduce the risk of microcracking by over 50%, improving product reliability.
- The CTM has been significantly improved by eliminating 0.15% of the power loss, resulting in higher efficiency at module level.



Cross-section by  
Conventional Cutting

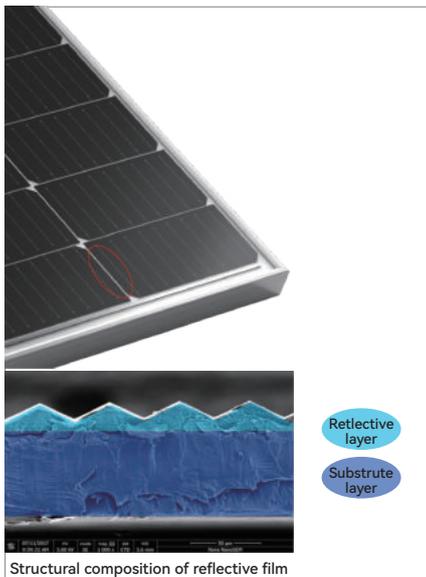


Cross-section by  
Nondestructive Cutting

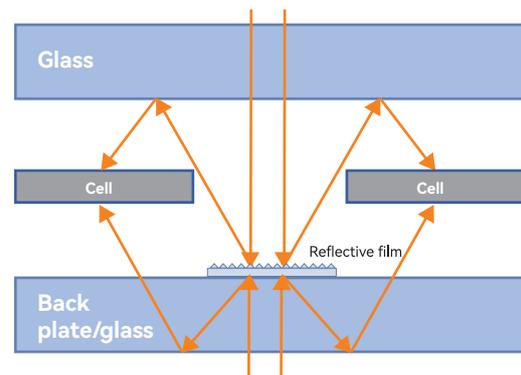


## SLTT (Superior Light Trapping Technology)

SLTT is realized by new process which introduced new reflective tape into the gap between cell-strings as expressed in courtesy picture. Such new material is granted with marvelous adhesion and aging-proof which leads to high reliability performance. Meanwhile it could raise 2.5W and 1W in respect of large and tiny gap stringing module by it's optical scheme shown in the Sketch drawing.



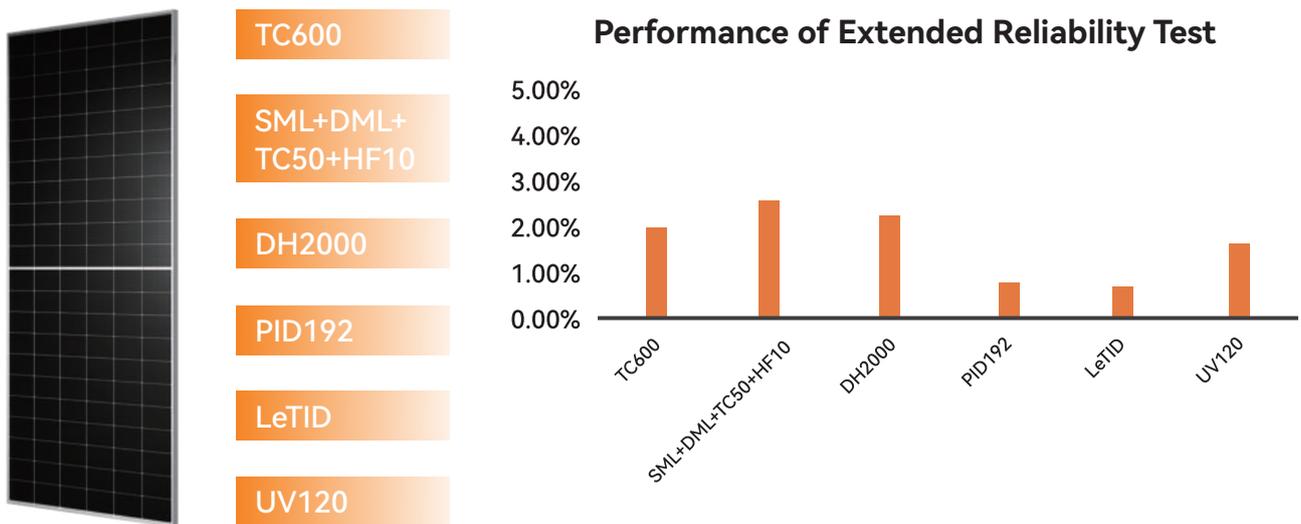
Reflective Film Profile



# Product Benefits ➤ Product Reliability

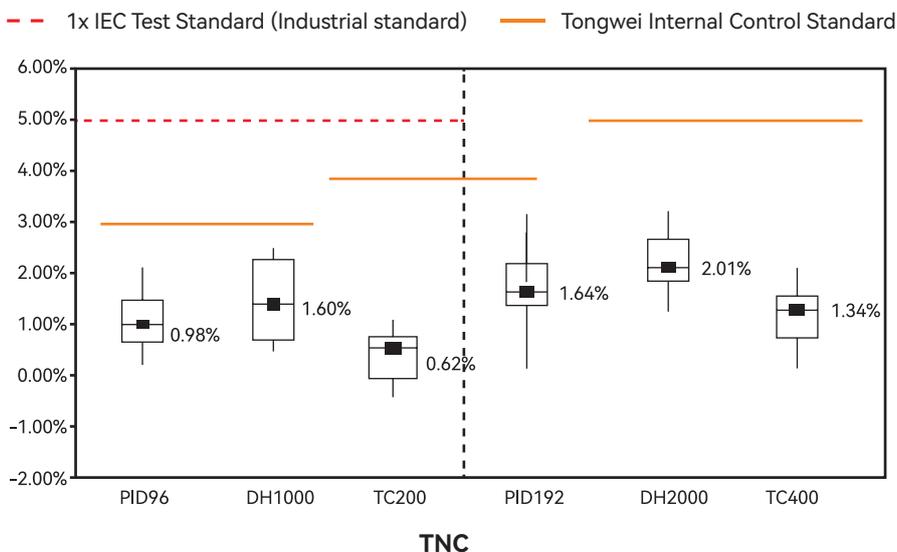
## Extended Test

Tongwei TNC series products, which adopt self developed TOPCon technology, have excellent reliability. The products have passed IEC 63209 extended tests, which includes a series of reliability tests such as TC600, DH2000, composite test of dynamic and static load, strict UV test, PID192h test, LeTID, and so on.



## Strict management system of IEC test

Tongwei has established a strict internal quality management system with double IEC standard testing, the test results of TNC products are much better than the internal control line, resulting in a stable and reliable quality performance.



## International Certification

Tongwei half-cell modules have obtained IEC61215/IEC61730 basic certification from TUV agency. Additionally, the modules have obtained access certifications in multiple countries and regions worldwide, such as CQC, Japan JPEA, Brazil INMETRO, and Italy fire resistance. Furthermore, it also has successfully passed other individual tests such as PID, salt mist, ammonia, and sand. The acquisition of these international authoritative certifications validates the outstanding product reliability of Tongwei modules.



## Carbon Footprint Introduction

The company has created lots series of products with low-carbon emission via the full life cycle management system. Till now, numbers of products have passed qualification of the French ECS successively, as well as ISO 14067: 2018 certifications. In addition, Tongwei TNC high-efficiency modules have been awarded the French Carbon Footprint Certification, which covers the entire life cycle of Tongwei silicon, wafers, cells and modules.

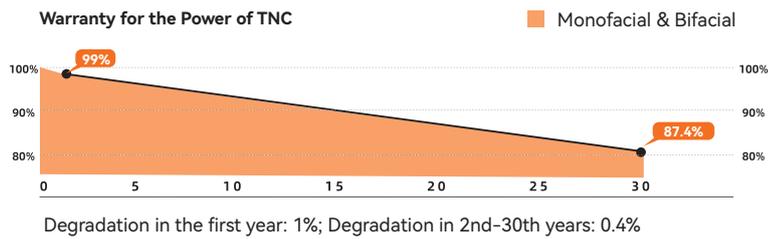
Cetification	Briefs
Carbon footprint of products	At the beginning of 2022, Tongwei started the French carbon footprint certification process. Till now, 14 series of TNC modules had been certified by the French Certisolis' laboratory.
Green Fabrication	Tongwei Solar (Anhui) Co., Ltd. was listed in "Green Manufacturing List 2023" by MIIT. Tongwei Solar (Jintang) Co., Ltd. was awarded as "Green Factory in Sichuan Province" in 2023.

# Product Benefits ➤ Product Reliability

## Products Warranty

**Material & Workmanship warranty:** 15 years for Tongwei TNC series G12R-48 and G12R-54 products, and 12 years for the rest modules.

**Performance warranty:** 30 years for TNC series modules.

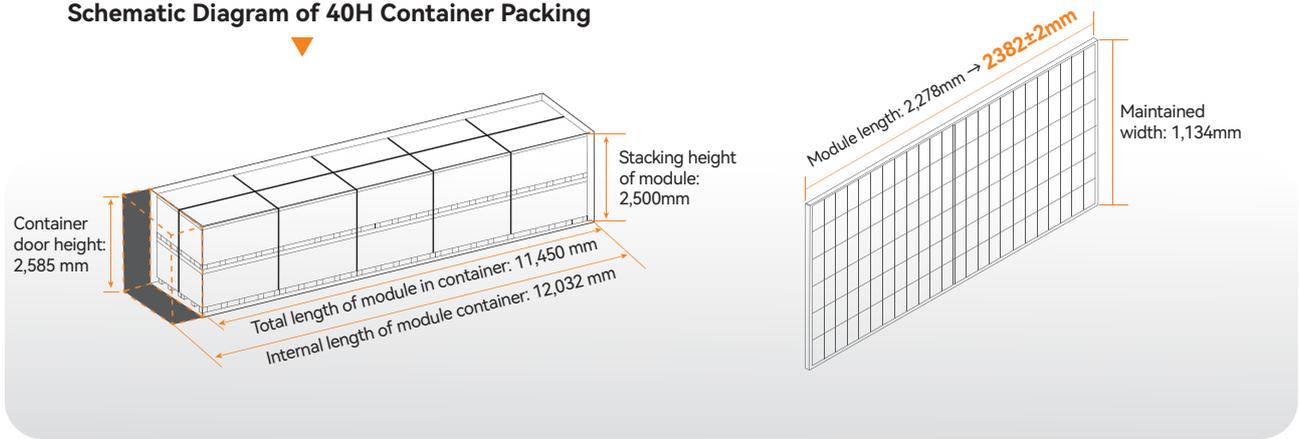


- The 1st year degradation  $\leq 1\%$ .
- Annual degradation from 2nd year  $\leq 0.4\%$ .

# Packaging & Transportation

With the ultimate type design, the length of G12R module is further optimized to be more suitable for the container dimensions, improve the container utilization rate to **98.5%**, and thus reduce the transportation cost.

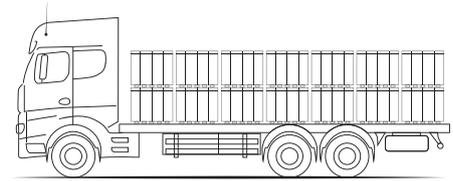
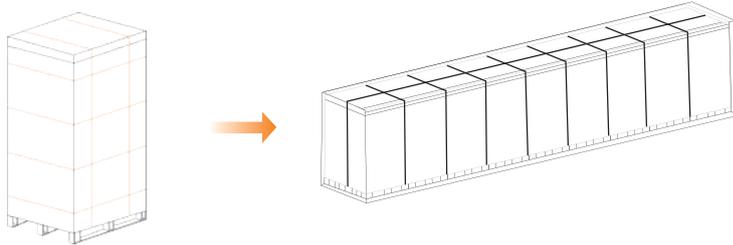
### Schematic Diagram of 40H Container Packing



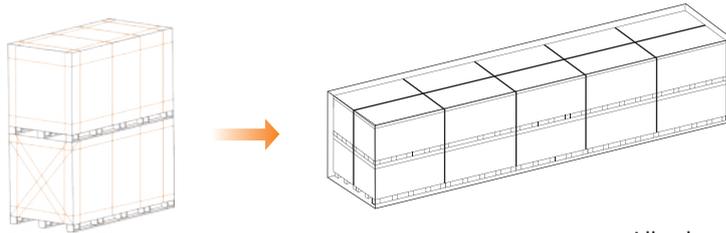
This section compares the transportation of G12R-66 Bifacial and M10-72 Bifacial modules. On the left, a 3D view shows two modules stacked, with a vertical dimension line indicating the original length of 2,278 mm and the current length of 2,382 mm. In the center, a grid diagram shows the length comparison. On the right, images of a truck and a ship carrying containers are shown. The text states: "G12R-66 Bifacial vs M10-72 Bifacial". Below this, it says "The costs of 40HQ, 17.5m flat, decreased by 4%." with a downward arrow.

# Transportation

## Vertical Deployment



## Horizontal Deployment



All schematics of packaging & transportation for reference

Module Type	Module Size	Loading deployment	Pcs/ Pallet	40HQ PCS/ Container	17.5m Flat PCS/vehicle	13m Flat PCS/vehicle
M10-72 Monofacial	2278*1134*35	Horizontal	31	620	930	682
M10-72 Bifacial	2278*1134*30	Horizontal	36	720	864	792
M10-78 Bifacial	2465*1134*30	Horizontal	36	576	792	720
G12-66 Monofacial	2384*1303*35	Horizontal	31	248	744	558
		Vertical	31	558	806	558
G12-66 Bifacial	2384*1303*33	Horizontal	33	264	726	594
		Vertical	33	594	726	594
G12R-48 Bifacial	1762*1134*30	Horizontal	36	936	1296	1008
G12R-54 Bifacial	1961*1134*30	Horizontal	36	864	1080	864
G12R-66 Monofacial	2382*1134*35	Horizontal	31	620	868	620
G12R-66 Bifacial	2382*1134*30	Horizontal	36	720	864	720

# System Compatibility

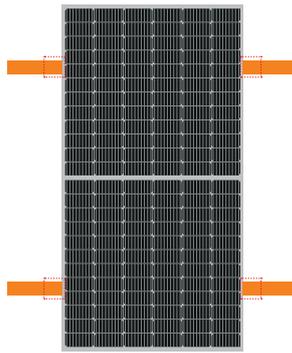


## Racks

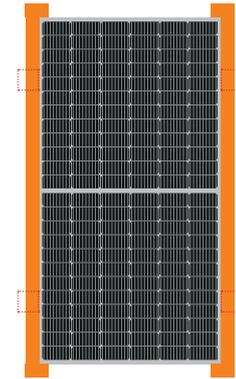
Tongwei modules consist with the industry's mainstream in terms of size and provide multiple installation options, compatible with various types of PV racks.

- **Standard Mounting Method by Tongwei**

Long Side Mounting  
(Bolt/Clamp)

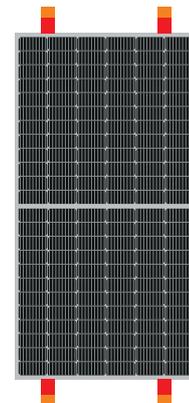
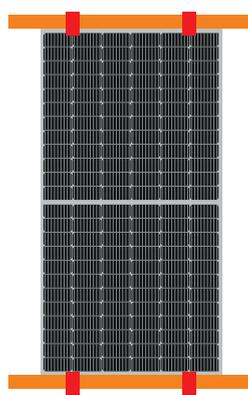


(+5400/-2400Pa)



(+3600/-2400Pa)

Short Side Mounting  
(Clamp)



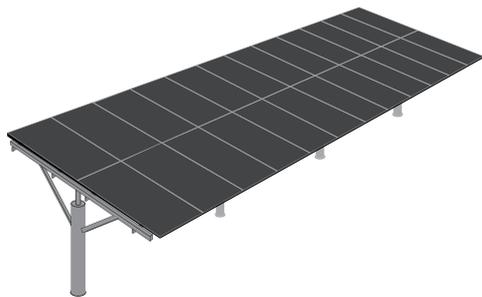
More Details refer to Tongwei Installation manual

# System Compatibility

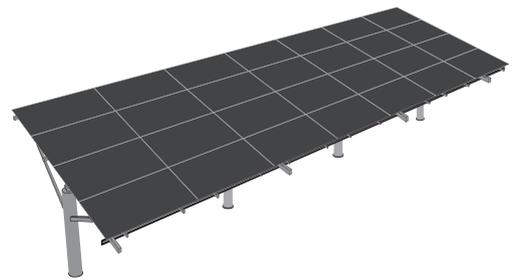


## Racks

- Mainstream Racks



Portrait Installation



Landscape Installation



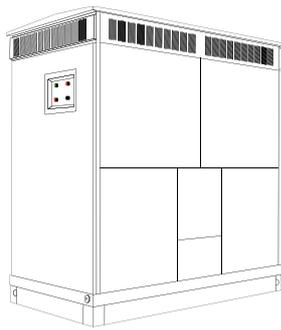
# System Compatibility



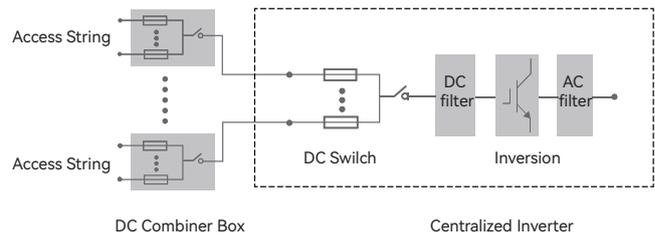
## Inverter

### • Central Inverter

Modules and inverters could be compatible by proper selection of DC combiner box.



Central Inverter



Single Diagram of Central Inverter System

### • String Inverter

Tongwei modules can match the string inverters made by mainstream manufacturers in the market.

Application Scenarios	Isc of Module	String Input Current	Matching Mainstream Inverter Brands
Residential	M10: ~14A G12R: ~16A	≥ 16A	   
Utility-Scale Commercial & Industrial	M10: ~14A G12R: ~16A	≥ 18A	 
	G12: ~18A G12R: ~16A	≥ 20A	    



## Inverter

### • Compatible Residential String Inverter for Tongwei G12R-48 Modules :

European Region (String Inverters)	
Brand	Inverter Type
Fronius	Primo-16.0-8.2 KW
	Symo-33.0-8.2 KW
	Primo GEN243.0-10.0 KW
	Primo GEN24 Plus3.0-10.0 KW
	Symo GEN24 Plus6.0-10.0 KW
	Symo Advanced10.0-20.0 KW
Kostal	PLENTICORE G34.0-20.0 KW
	PIKO 10-2010.0-20.0 KW
SMA	Sunny Boy3.0-6.0 KW
	Sunny Tripower8.0-10.0 KW
	Sunny Tripower X12.0-25.0 KW
Kaco	NX3 M23.0-20.0 KW
Huawei	SUN2000 M212.0-20.0 KW
	SUN2000 M512.0-25.0 KW
Sungrow	SG RS-S2.0-3.0 KW
	SG RS3.0-6.0 KW
	SG RT7.0-20.0 KW
Goodwe	GW-XS-300.7-3.0 KW
	GW-DNS-303.0-6.0 KW
	GW SDT-204.0-20.0 KW
	GW MS-305.0-10.0 KW
Solis	S6-GR1P K-M3.6 KW
	S6-GR1P K-S2.5-6.0 KW
	S6-GR1P K27.0-8.0 KW
	Solis-3P 4G12.0-20.0 KW
SolarX	S5-GR3P3.0-20.0 KW
	X1-T-D/N6.0-8.0 KW
	X3-MIC-G23.0-10.0 KW
	X3-Pro G28.0-20.0 KW

European Region (Microinverters)	
Hoymiles	HMS C-4T1800/2000 KW
	HMS 2T (Wi-Fi integrated)900/1000 KW
	HMS1T (Wi-Fi integrated)450/500 KW
	HMT 4T (3-PHASE)1800/2000 KW
APSystem	DS3-L255-550 W
	DS3300-620 W
	DS3-H330-660 W
	DS3D315-660 W
	QT2315-660 W

**European Compatible Rules:**  $I_{mp} \leq$  Inverter's DC String  $I_{mp}$ . (STC Condition)

Australian Region (String Inverters)	
Brand	Inverter Type
Fronius	Symo-33.0-20.0 KW
	Primo-15.0-8.2 KW
SMA	Symo Advanced 10.0-20.0 KW
	Sunny Boy3.0-6.0 KW
Solaredge	SE25K
	SE30K
	SE33.3K
Huawei	SUN2000 M212.0-20.0 KW
	GW-DNS-303.0-6.0 KW
Goodwe	GW SDT-20 5.0-6.0 KW
	GW KAU-DT 8.0-20.0 KW
	GW MS-C30 7.0-10.0 KW
Sungrow	SG RS3.0-5.0 KW
	SG-D8.0 KW
	SG RT7.0-20.0 KW
Goodwe	GW-XS-300.7-3.0 KW
	GW-DNS-303.0-6.0 KW
	GW SDT-204.0-20.0 KW
	GW MS-305.0-10.0 KW
Solis	Solis-mini4G 3.6 KW
	Solis-1P 5G7.0-8.0 KW
	Solis-3P-4G-AU5.0-20.0 KW
SolarX	Solis-3P-4G-AU-MX5.0-6.0 KW
	X1-T-D/N6.0-8.0 KW
	X1-BOOST-G4 2.5-6.0 KW
	X1-SMT G2 5.0-10.0 KW

Australian Region (Microinverters)	
APSystem	DS3-L255-550 W
	DS3300-620 W
	DS3-H330-660 W
	DS3D315-660 W
	QT2315-660 W

**Australian Compatible Rules:**  $I_{mp} \leq$  Inverter's DC String  $I_{mp}$ ,  $I_{sc} * 1.25 \leq$  Inverter's DC String  $I_{sc}$ . (STC Condition)

Optimizers	
Brand	Optimizers Type
TIGO	TS4-X-O
	TS4-A-O
Solaredge	S500B
	S650B

# Energy Yield Performance

Due to its low degradation and low temperature coefficient, the energy yield of TNC high efficiency module is 4.48% higher than that of TPC module in per watt.



## Project Introduction

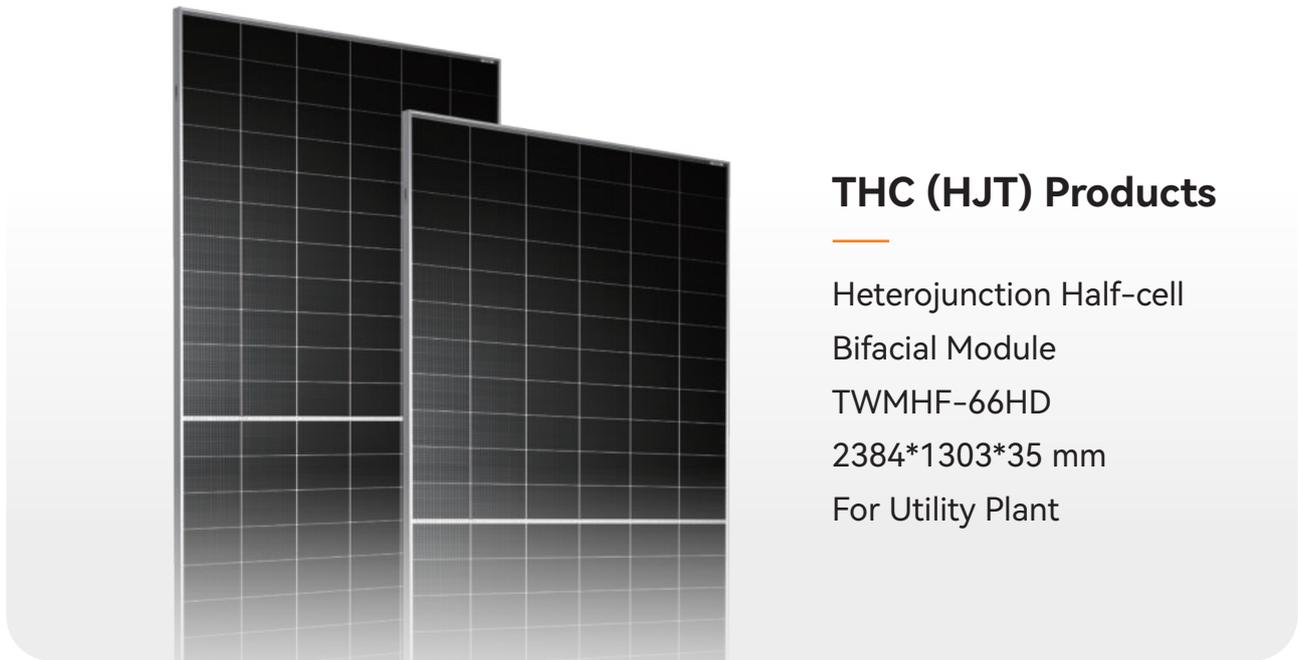
Location:	Sanya, Hainan (Tropical Monsoon Oceanic Climate)
System type:	Horizontal single-axis
Land surface type:	Grey soil
Module type and quantity:	TPC M10-72 Bifacial *8, TNC M10-72 Bifacial *8

Comparison of Field Test Performance between TNC&TPC Modules



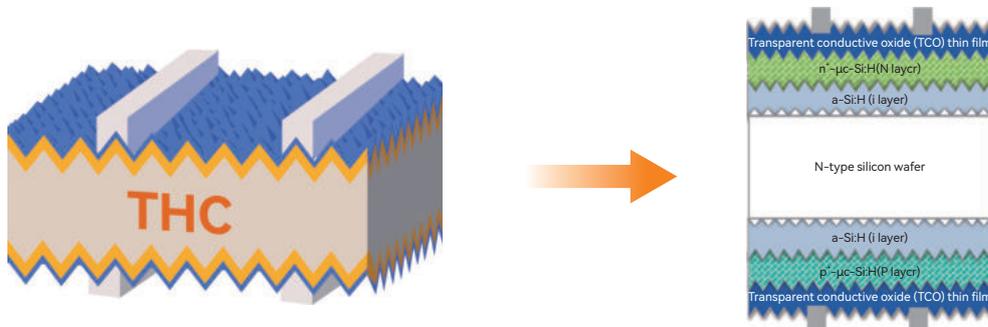
# Ultra-high Power Products - THC Series

To meet the diversified needs of customers, Tongwei provides THC (HJT) series products with ultimate power generation capacity.

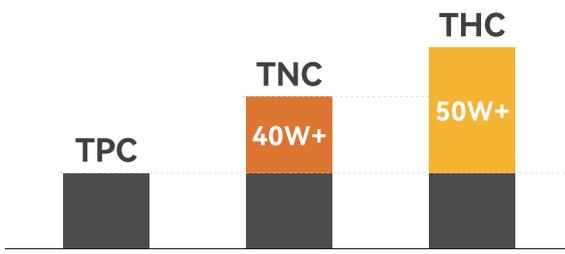


## Ultra-High efficiency cell technology

Tongwei has launched Industry-leading N Type HJT technology which is called THC internally, sort of bifacial NC-Silicon, symmetrical architecture and advanced amorphous silicon deposition , gaining 1.5% higher than TPC type.

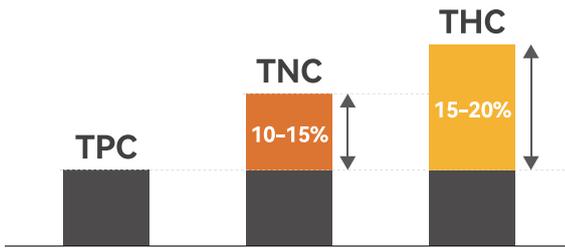


### 01 Higher Power Output



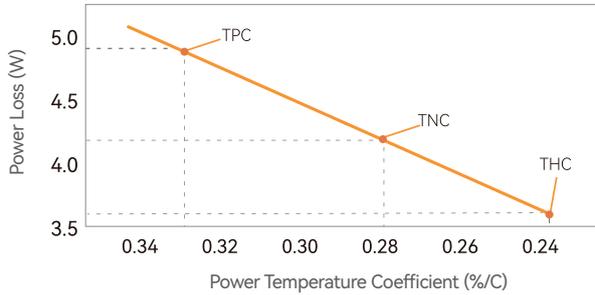
For the G12-66 bifacial modules, the power of THC modules is **50W+** higher than that of TPC modules.

### 03 Higher Bifaciality



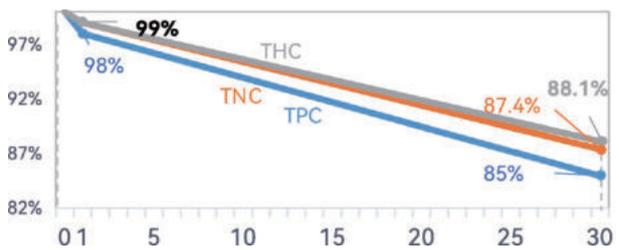
In terms of bifaciality, compared to TPC modules, TNC modules are 10-15% higher, and THC are **15-20%** higher.

### 02 Excellent Power Temperature Coefficient



Regarding temperature coefficient, TPC modules is  $-0.33\%/^{\circ}\text{C}$ , TNC modules is  $-0.28\%/^{\circ}\text{C}$ , and THC module is as low as  $-0.24\%/^{\circ}\text{C}$ , which brings superior high temperature energy yield performance.

### 04 Low Degradation

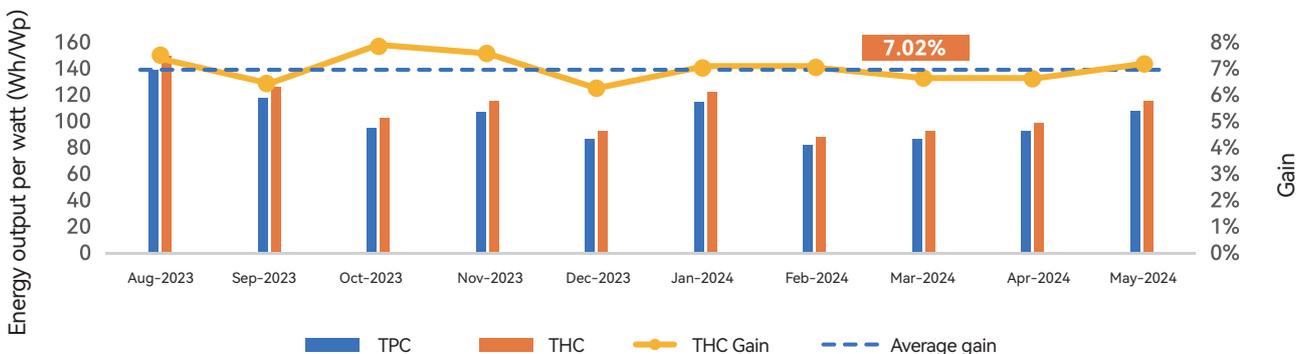


In contrast with TPC and TNC modules, THC modules have a lower power degradation with **1% degradation in the first year and no more than 0.375%** annual degradation in following years. Thus it will allow no less than **88.1%** of rated power after 30 years.

## Generation Performance in field test

According to the data from Tongwei field test base in Sanya, Hainan, compared with TPC module, the power generation gain of THC module is 7.02%.

Empirical comparison between THC and TPC modules



# Offshore PV Module

Compared with grounding PV projects, offshore PV projects occupy less land and are fully supported by the government. By avoiding the land acquisition issue, offshore PV projects have great promising on market potential. For offshore PV projects, which are characterized by no obstructions, long sunlight hours and high radiation, offshore PV modules have higher light-utilization efficiency and significantly improved power generation. However, offshore PV projects also are required to deal with many challenges due to their unique operating environment.



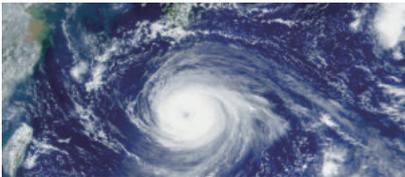
## Wave Impact and Vibration

Waves and vibration have a great impact on the load resistance of the module.



## Strong-UV, High temp & Humidity

Water vapor corrodes the glass and cells, which affects the power generation performance. At the same time, the ingress of water vapor into the box end affects the insulation and safety of the module.



## Extreme Weather (such as typhoon)

Extremely high requirements are made for the module, rack, and system, and the module and system are designed with strong wind uplift resistance to resist extreme weather such as typhoon.



## High SMC & Biodeterioration Corrosion

High salt mist corrodes the frame, glass, and rack and affects the safety of the module. Biological corrosion has such impacts as hot spot.

## Solution

In order to prevent modules from being destroyed by extreme marine environment (waves, SM corrosion Bio drops, high temp & humidity).Tongwei has made a targeted all-round upgrade design for offshore PV products to achieve higher reliability, load resistance, and corrosion resistance.

## Solution for Offshore PV Modules



### Cell

- Non-destructive cutting
- Tightened control against hot spot



### Encapsulant

- Reinforced glass with high reliable coating
- Anti-PID encapsulant with Low acetate ion
- Anti-corrosion soldering material



### Frame

- Reinforced structure for AL-frame
- GRPU frame



### Junction Box

- Reinforced sealing of cable-JB
- Enhanced thermal control
- Dual-sealing of connectors

### Material Upgrade



### Extended test for Modules



### Load capacity

- SML extended test
- Multiple cycles of extended dynamic load



### Salt Mist

- SMC test Level 8
- SMC & PID combination test



### Complex Environment

- SML+DML+TC+HF
- DH 1000 & UV combination test



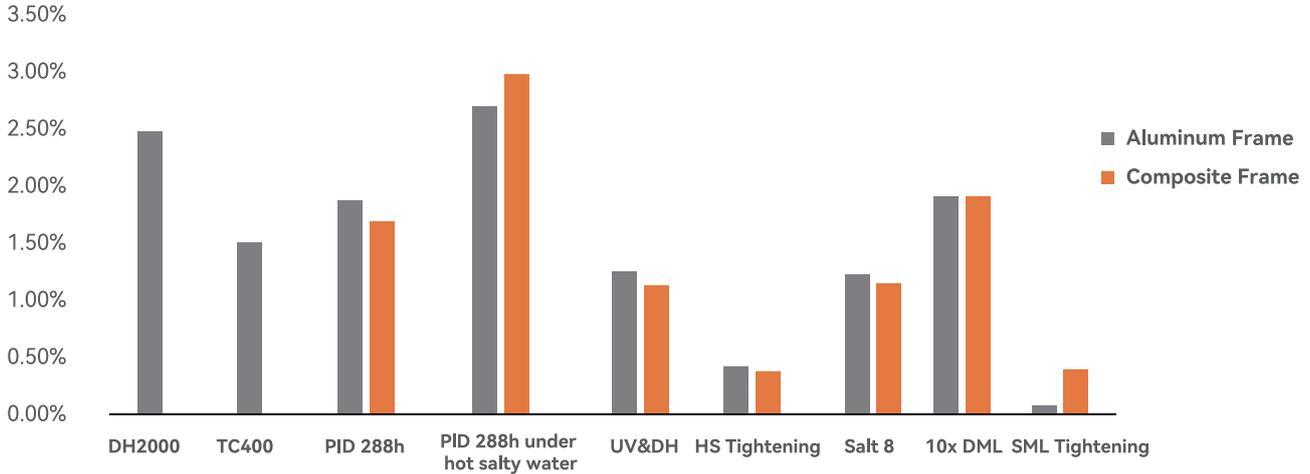
### PID

- Extended PID test
- PID under hot salty water

## High Reliability

Extremely high requirements for the reliability of the PV system are made due to severe offshore environment, including high air humidity, strong corrosion of salt mist, and frequent occurrence of strong wind and wave. Therefore, high reliability is the key to long-term stable operation of modules in the offshore environment. Tongwei offshore PV modules have passed a series of rigorous reliability tests by verifying them in terms of high humidity, high ultraviolet, long-term aging, high load, and high salt mist. Due to this, Tongwei has obtained the authentication certificates of offshore PV products and Grade 8 salt mist issued by TÜV NORD, a third-party organization, as well as the authentication certificate of "Deep Blue Ocean" issued by CPVT for its offshore PV modules.

### Difference Test on Offshore PV Module



Tongwei offshore PV modules have passed the wind tunnel test conducted by a third party. (70 m/s ultra-high wind speed, equivalent to a strong typhoon environment of magnitude 17 or above)



In order to meet the challenges such as sea water impact and wave vibration, these modules have passed more rigorous 10x dynamic load test and high-temperature load test.



These modules have passed DH+UV180 tightening test, hot spot test, and thermal cycle test in a high-humidity environment.



With excellent PID resistance, these modules have passed 3x PID test (PID 288 h) after Grade 8 salt mist test.

### Product Authentication Certificate

The product also passed UL Solutions' Test which is "ASTM E1597-10 Saltwater Pressure Immersion and Temperature Testing of Marine Environmental Photovoltaic Modules".



# Solution for Plateaus PV Module

High latitude means a high cold climate and possible snow accumulation problems in long winters, which test PV power plants' low-temperature resistance and load capacity. Due to the high altitude and thin air in the plateau region, the weakening effect of the atmosphere on solar radiation is weaker, and the intensity of ultraviolet rays rises significantly, which also means that the encapsulation materials and back panel materials of PV modules are facing the threat of faster and more severe aging, and the significant temperature difference between day and night in the plateau region requires a higher resistance to the temperature difference of PV modules.

TW Solar's module products have undergone stringent inspection and testing at the raw material stage, including, but not limited to, the four-point bending strength test of the glass, to ensure a reliable load-bearing capacity of the glass material of the modules. In addition, TW Solar conducts a 10-time dynamic load test on the modules with reference to the IEC TS 62782 standard, reaching 10,000 cycles.

In addition, the probability of hailstorms in the plateau region is higher than in other regions. The higher frequency of hailstorms and ambient temperatures also pose a tougher challenge to the anti-impact performance of the module glass. In addition to passing the regular 25mm diameter hail test, TW Solar's high-power modules will also undergo the 45mm hail test to fully guarantee the anti-hail impact performance of the modules in low-temperature environments. After passing the IEC 63209 reliability test, TW Solar TNC modules performed well in TC600, DH2000, PID192, SML+DML+TC+HF tests, and the power degradation was far lower than TW Solar's internal control standards.



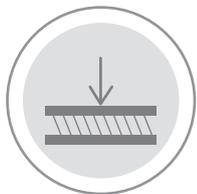
## 01 Impulse

Due to the low air density in the high altitude area and the reduced strength of the insulating medium, the module should require to have sufficient breakdown resistance when used in the high altitude environment. TNC modules meet the conditions at 4000-5000m high-altitude scenarios when pass the pulse voltage test of up to 27.5KV.



## 02 Hail

For the special climatic conditions in the high altitude area, Tongwei TNC modules passed the hail test with a diameter of 45mm and a speed of 30.7m/s.



## 03 Enhanced Static Load Test

Tongwei TNC modules not only passed the static load test of +5400Pa/-2400Pa, but also passed the IEC dynamic load test with 10 times load ( $\pm 1000\text{Pa}$ , 10000 cycling) and uneven snow load test (snow thickness 2.2m), it can bear large snow loads to ensure long-term stable operation in snow environment.



## 04 Enhanced Environmental Test

High altitude area has long sunshine time and large temperature difference. TNC module are also pass the enhanced IEC 63209 certification, it is guaranteed stable and reliable performance in high-altitude environments.

# Solution for Plateaus PV Module

Snow cover is distributed widely and lasts for a long time in the plateau area. Since most of the modules are installed at an inclined Angle, due to gravity the snow will slide along the surface of the module and accumulate at the bottom of the module. When the snow accumulates a large amount at the bottom of the module especially it will cause uneven pressure which can generate to excessive local pressure of the module easily. These reasons bring about damage to frame and glass. Faced with this situation, Tongwei TNC modules based on IEC 62938 standards are subjected to rigorous non-uniform snow load tests. The uniform snow load test evaluates the ability of PV modules to withstand such uneven pressure when encountering heavy snow. It avoid more effectively the application of modules in snow areas and provide the best solution to client.



▲ Fig 1. TUV Nord IEC 63209 Certificate of Tongwei TNC Module



▲ Fig 2. Uneven Snow Load Certificate of Tongwei TNC Module



▲ Fig 3. Ice, Snow, and Polar Environment Adaptability Certificate



▲ Fig 4 Sichuan Garzi 120MW High Altitude Project

# Next Generation

Tongwei continues focusing on product leadership, propelling THC G12 Series as next generation which has more competitiveness.

Product: THC G12-66 Bifacial  
Dimensions: 2384\*1303\*33mm  
Power: 740W

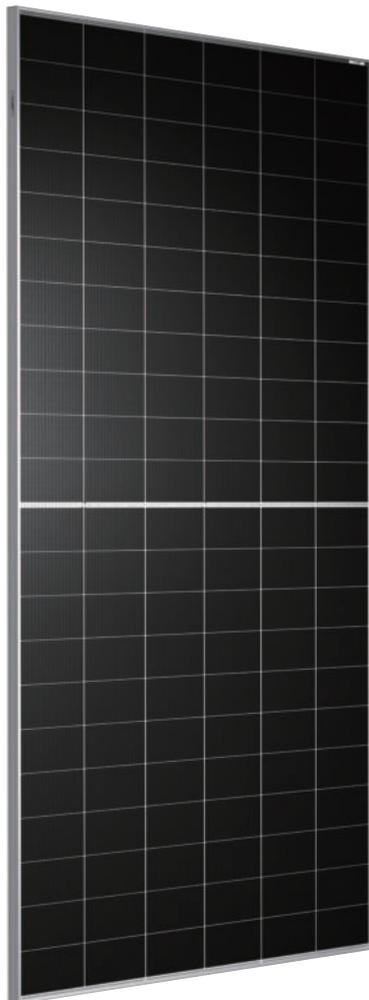
Higher Power Output  
**740W**

**23.8%**  
Higher Efficiency

More Electricity Generation

Lower BOS Cost

Lower LCOE



**Advanced Metallization Technology:**

Utilizing industry-advanced silver-plated copper and THL technology while ensuring reliability, by silver-reduced or silver-free to enhance product market competitiveness.

**ZBB and  $\mu\text{-Si}$  Technology:**

Utilizing independently developed ZBB technology, coupled with  $\mu\text{-Si}$  Technology, significantly improves product power.

**Outstanding Anti-PID Performance:**

Optimized technology and materials to resist PID effect.

**Excellent Bifacial Generating Performance:**

The bifaciality is as high as 90%.

**Excellent Low Irradiance Performance:**

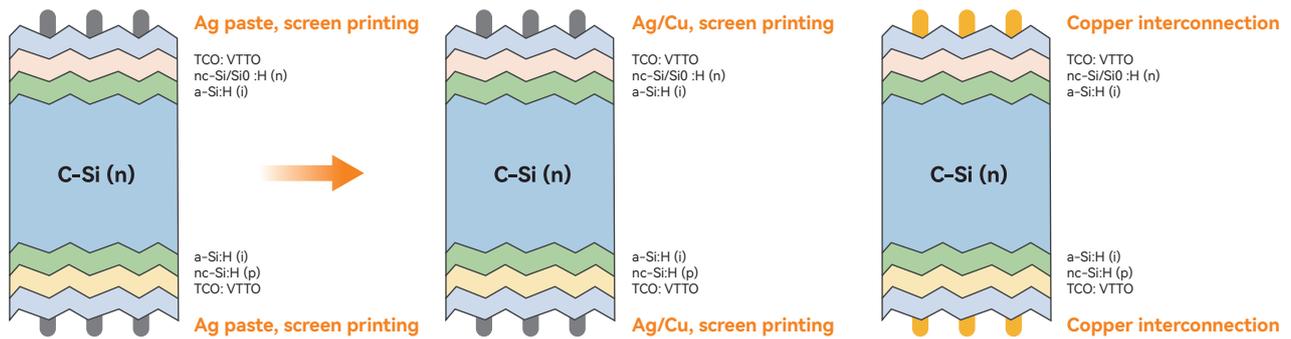
Compared with conventional modules, these modules have higher power output and longer power generation time throughout the day under low light conditions such as Hazy and cloudy days.

**Lower Power Degradation:**

For phosphorus-doped N-type silicon wafer, the degradation in the first year is 1.00%, and the annual degradation in the following years is 0.375%.

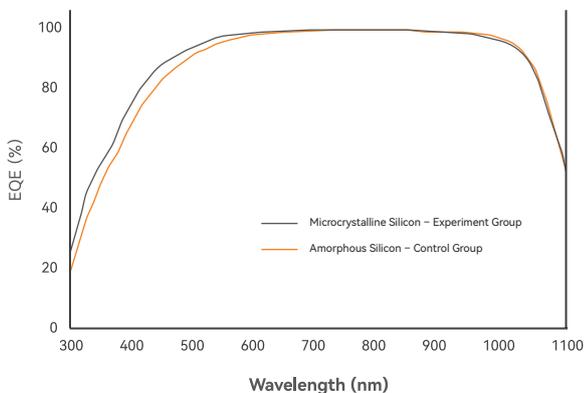
# Next Generation

The new generation of THC-G12 series products through metallization upgrade, combined with the latest ZBB technology and  $\mu$ -Si Technology, further improve the competitiveness of THC series module products.



## • $\mu$ -Si Technology

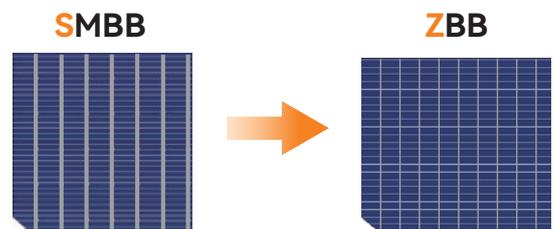
Microcrystalline silicon features higher light transmittance, lower defects and higher conductivity. It is made suitable for replacing doped amorphous silicon(a-Si) that will achieve an improvement of over 1%.



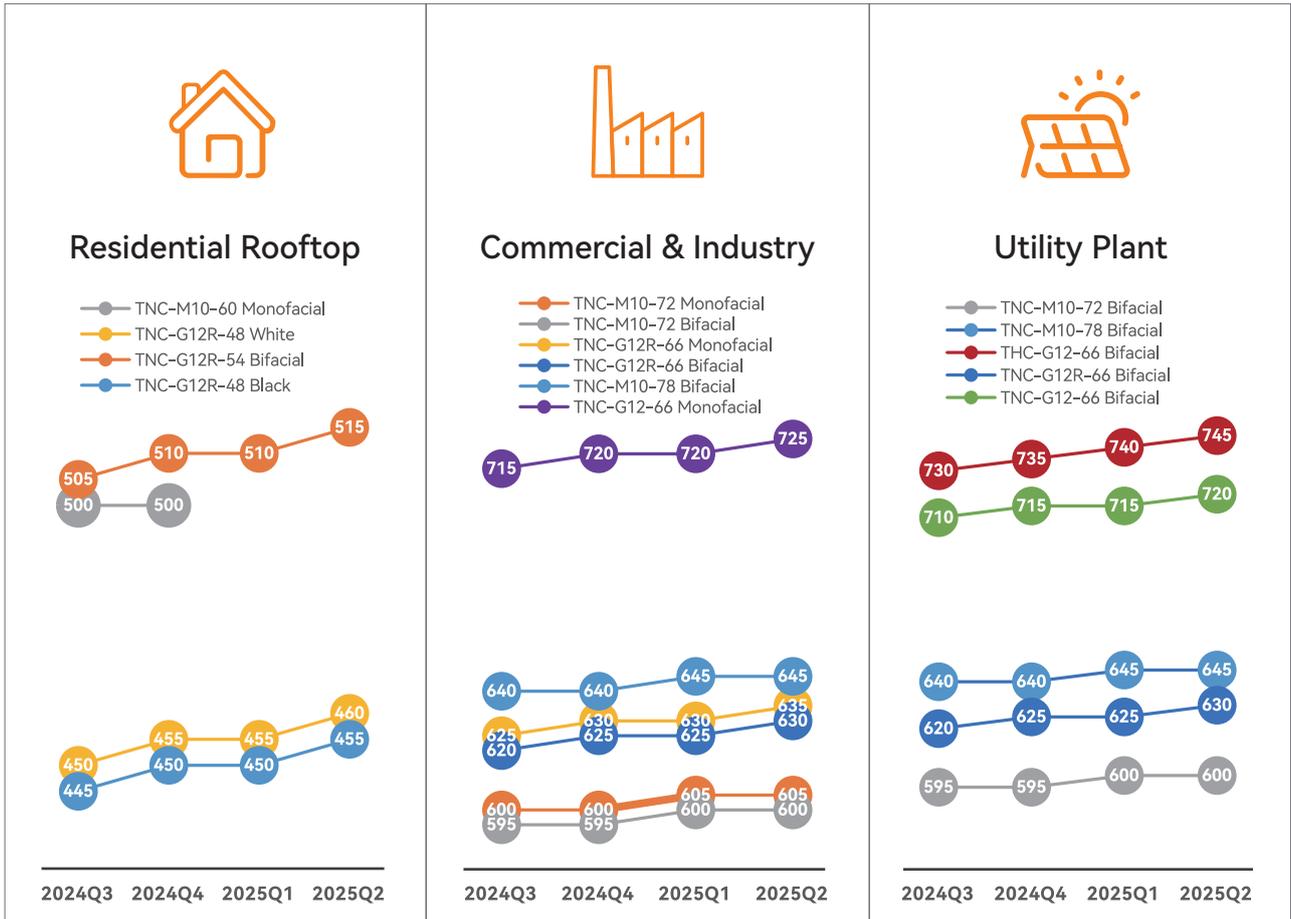
Compare of  $\mu$ -Si and a-Si QE

## • ZBB Technology

Compared with SMBB, ZBB eliminates the main busbar, the ribbons covers less area and the current transmission distance is shorter, the series resistance is lower which can increase the module power more than 2W (e.g. G12R-66); ZBB adopts a dense printing busbar design on the contact point between the fingers and the busbar that the cell stress distribution is more uniform, and reduce the fragmentation rate and hidden cracks of cell.



# Power Roadmap



# Application Cases



## Utility Scale Project Case (Anti-desertization)

<b>Project Name</b>	200,000 KW PV Desertification Control Project of Hangtai New Energy Development Co., Ltd. in Liangzhou District, Wuwei
<b>Project Location</b>	Wuwei, Gansu Province
<b>DC capacity</b>	100MW
<b>Model</b>	TWMPD-72HD545/550
<b>Project Profile</b>	200,000 KW PV Desertification Control Project of Hangtai New Energy Development Co., Ltd. in Liangzhou District, Wuwei: Located in the PV Desertification Control Demonstration Park in Jiuduntan, Liangzhou District, Wuwei, Gansu Province at the edge of the Tengri Desert, The continuous array of photovoltaic power generation matrix extends all the way covering the vast desert with layers of blue “armor”.

# Application Cases



## Utility Scale Project Case (PV + Agriculture)

<b>Project Name</b>	China Resources Power 300 MW Agriculture-PV-Energy Storage Integrated PV Power Generation Project in Taiping, Wuming, Nanning
<b>Project Location</b>	Nanning, Guangxi Zhuang Autonomous Region
<b>DC capacity</b>	300MW
<b>Model</b>	TWMPD-72HD545
<b>Project Profile</b>	The project is of the business pattern of "PV power generation, planting under PV panel, scientific development, and comprehensive utilization" to further promote the organic integration of green energy and modern agriculture. The project will be of intelligent management and operation mode after being put into operation. After full-capacity grid connection, the annual average power generation is expected to reach 388.6433 million kWh, 118,000 tons of standard coal can be saved, and 358,900 tons of carbon dioxide emissions can be reduced per year.

# Application Cases



## Utility Scale Project Case (PV + Animal Husbandry)

<b>Project Name</b>	100 MW Animal Husbandry-PV Complementary PV Power Generation Project (Phase I) in Huode Village, Nyêmo County, Lhasa, Tibet of Huadian
<b>Project Location</b>	Lhasa, Tibet
<b>DC capacity</b>	100MW
<b>Model</b>	TWMND-72HD575
<b>Project Profile</b>	The project is the second highest PV power plant in the world, which is located at Huode Village, Xumai Town, Nimu County at an altitude of 4,700 m to 4,900 m, with a rated installed capacity of 100,000 kWh and annual average on-grid energy of 200.72 million kWh. It is of husbandry-PV complementary development mode and has significant economic and ecological benefits in promoting local economic development, optimizing resource allocation, and protecting the ecological environment.

# Application Cases



## Utility Scale Project Case (PV & Fishery)

<b>Project Name</b>	Shandong Dongying Kenli (China Resources) Solar Farm 800 MW PV Power Generation Project
<b>Project Location</b>	Dongying, Shandong Province
<b>DC capacity</b>	400MW
<b>Model</b>	TWMPD-72HD540/545/550
<b>Project Profile</b>	Located in the Hongguang Fishery Demonstration Zone in Kenli District, Dongying, Shandong Province, the Shandong Dongying Kenli (China Resources) Solar Farm 800 MW PV Power Generation Project is divided into eight phases and is one of the renewable energy base construction projects in Shandong Lubei Saline-alkali Tideland with a capacity of tens of millions of kilowatts of wind and solar energy storage integration during the "14th Five-Year Plan" period.

# Application Cases



## Utility Scale Project Case

<b>Project Name</b>	25 MW Centralized PV Project in Austria
<b>Project Location</b>	Austria
<b>DC capacity</b>	25.14MW
<b>Model</b>	TWMPF-66HS665
<b>Developer</b>	LANDSEA EUROPE R&D GmbH
<b>Project Features</b>	The project, which covers an area of 23 hectares at Dürnröhr, Austria, is planned to be put into operation in January 2024. The project is just built above the former site of Dürnröhr coal-fired power plant, marking the transformation of the old coal-fired power plant for sustainable development. This PV system has an annual power output of 27.3 GWh. As a key component of renewable energy development in Lower Austria, the PV project is a PV power generation demonstration project with both economic and ecological benefits as it contributes to the local economy by actively participating in energy transformation and plays an important role in promoting the optimal allocation of resources and realizing clean energy production.

# Application Cases



## Distributed Project Case (Commercial & Industrial Rooftop)

<b>Project Name</b>	Jinan Shizhong District Whole County Photovoltaic Project
<b>Project Location</b>	Distributed in 40 schools and public places of Shizhong District, Jinan, such as Quanrun Elementary School and Yuxiu Elementary School
<b>DC capacity</b>	20MW
<b>Model</b>	TWMPD-72HS550
<b>Developer</b>	Shandong Fanhai Energy Co., Ltd.
<b>Project Features</b>	This project is the pilot project of distributed PV for the green campus in Shizhong District, Jinan.

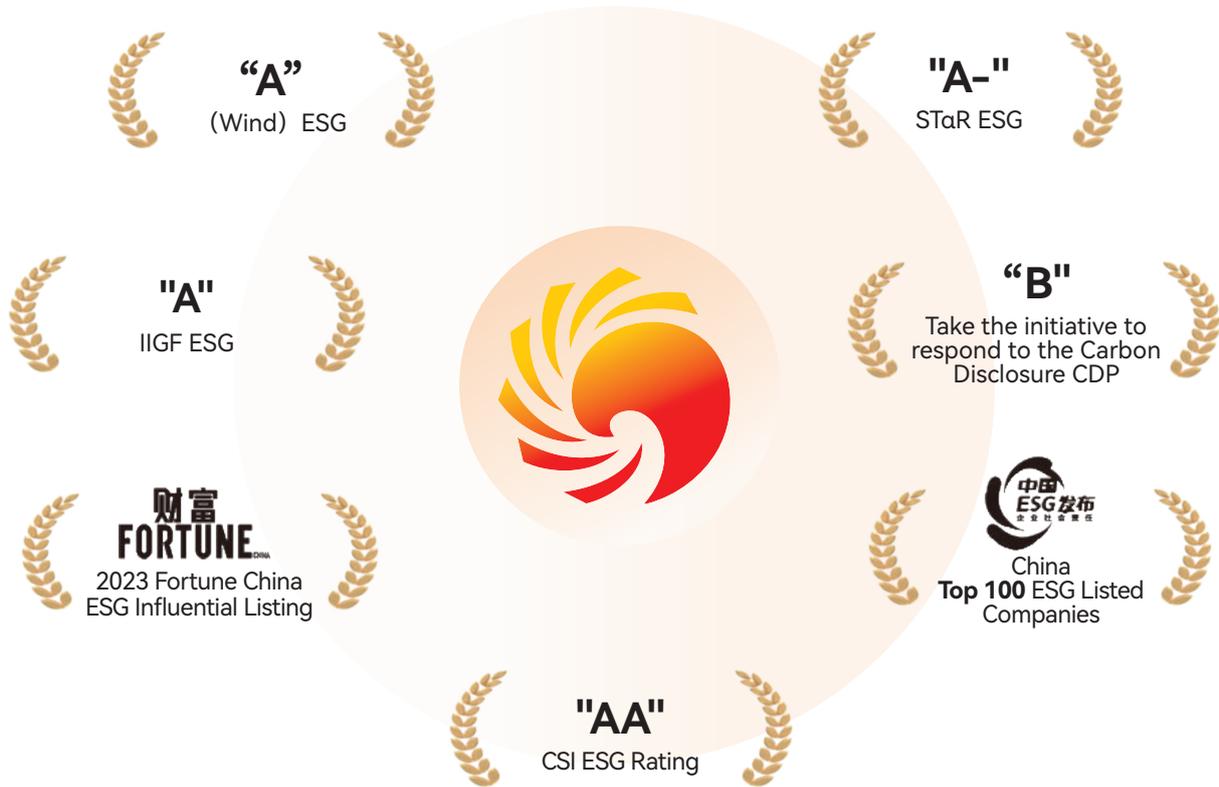
# Application Cases



## Distributed Project Case (Residential Rooftop)

<b>Project Name</b>	Zhejiang Xinsheng Hainan Lingshui Distributed Residential Project
<b>Project Location</b>	Lingshui County, Hainan Province
<b>DC capacity</b>	4MW
<b>Model</b>	TWMPD-72HD550
<b>Developer</b>	Zhejiang Xinsheng New Energy Technology Co., Ltd.
<b>Project Features</b>	The project is run by Xinsheng and reports handsome overall income and a fast cycle of grid connection.

# ESG Honors



Top 50 Forbes China ESG Innovative Enterprises 2023 

TOP 50 Forbes China Sustainable Industrial Enterprise 

EY ESG Enterprise of the Year Prize 2023 

China ESG Golden Awards 2023 

Silver Medal  

Top 50 Bloomberg Green ESG-Enterprises 2023 

First Prize of Clean Energy UNIDO Global Call 2023 

Top 10 'Zero-Carbon China' Innovative Technology Award 2023 



Add: No. 588, Middle Section of Tianfu Avenue,  
Wuhou District, Chengdu City, Sichuan Province  
Sales Hotline:4000566888  
<https://www.tw-solar.com/>