Trinasolar

Power Beyond Solar

The World Leading PV and Smart Energy IoT Total Solution Provider

Vertex Product information

For more information regarding Vertex N module,
Please follow our social media accounts or scan the QR code to visit our website.

Trinasolar

Trina Solar

210 Vertex N

Product Whitepaper

210+N

Vertex N

CONTENTS

1.N-type technology background

> The last eight years have been the warmest on record, making every heatwave more intense and life-threatening, especially for vulnerable populations.
>
> ——Statement by the United Nations World Meteorological Organization at the Opening Ceremony of COP27.

There is a rare global consensus among countries to address climate change, reduce carbon emissions and achieve carbon neutrality. To this end, energy transformation, the realization of a high proportion of renewable energy structure has become the world trend! Constructing new power system with new energy as the main part has become the direction of our energy transformation.

Photovoltaic is the core force of the new energy industry, and the pursuit of power station owners for the return on investment of photovoltaic power generation and the reduction of the levelized cost of energy (LCOE) is the constant theme of the development of the photovoltaic industry. The traditional P-type module development has reached the extreme due to the process cost reduction route, and the efficiency of P-type mass production cells has been infinitely close to the bottleneck of efficiency. Under the market development trend aiming at cost reduction and efficiency improvement for customers, N-type solar cells have the advantages of higher power, higher efficiency, higher power generation and higher reliability comparing with P-type solar cells. With the rapid progress of solar cell technology and process, N-type solar cells are increasingly more competitive considering the levelized cost of energy (LCOE) in the project life cycle.

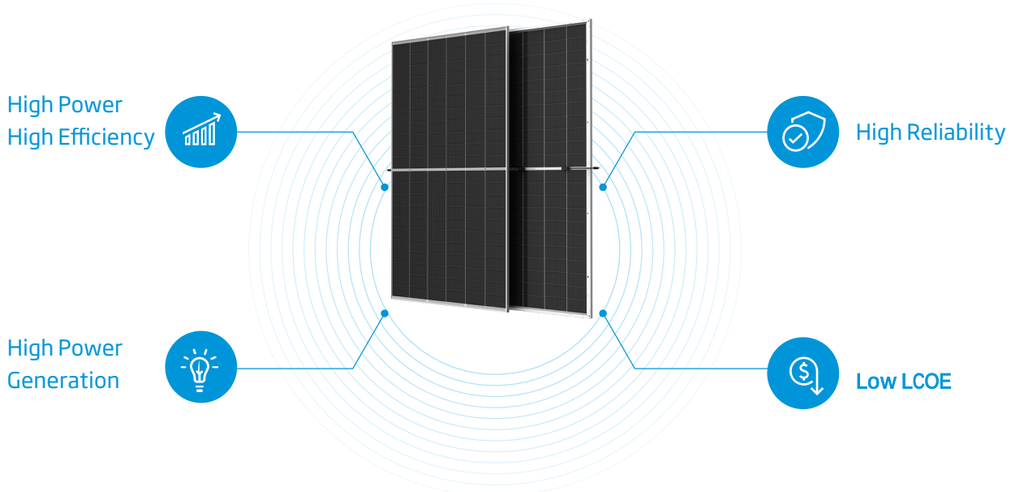


Figure 1: The four keys unlocking low LCOE

Levelized Cost of Energy is the power generation cost calculated after leveling the cost and power generation within the life cycle of the project, which means the present value of cost within the life cycle divided by the present value of power generation within the life cycle. When other factors are relatively fixed, the effective way to reduce levelized cost of energy is to reduce the BOS cost of the system and improve the power generation and reliability of the modules. Based on the "Four-high & One-low Idea" 210 product technology platform, the Vertex N series modules fully meet the requirements of high power, high efficiency, high power generation, high reliability and lower levelized cost of energy.

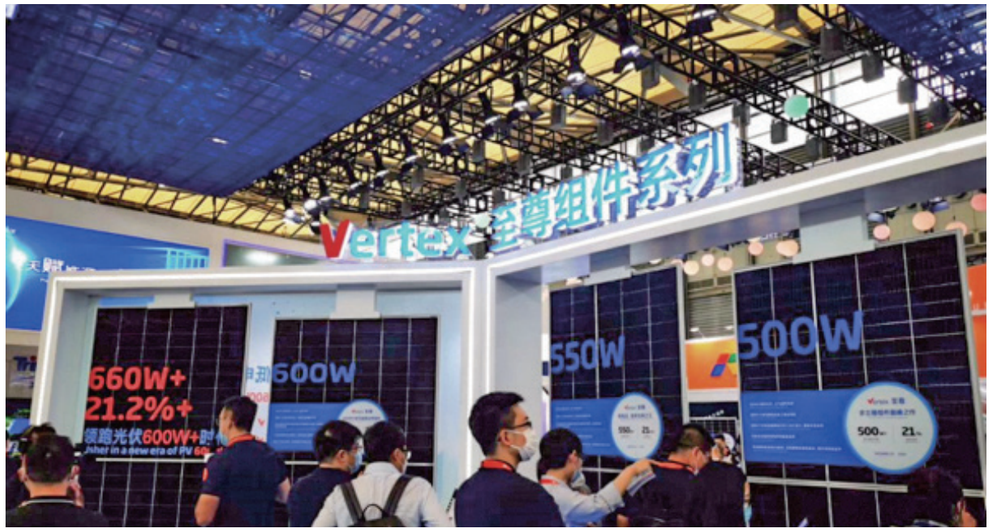


Figure 2: Trina Solar Vertex modules exhibition

In early 2021, Trina Solar released the Vertex 670W module with an efficiency of up to 21.6%, accelerating the industry into the 600W+ high-power era. Further play the P type photovoltaic module value, to make a great contribution to the photovoltaic industry. By Q3 of 2022, global shipments of 210 modules exceed 70GW, and Trina Solar shipments about 40GW. No matter whether any technology is advanced or not, it is difficult to maximize its value without industry recognition and industrial ecological support. In the N-type era, Trina Solar's 210 modules based on i-TOPCon technology will magnify the advantages of 210 on the basis of 210 600W+ matured industrial chain, making the lead even more advanced.

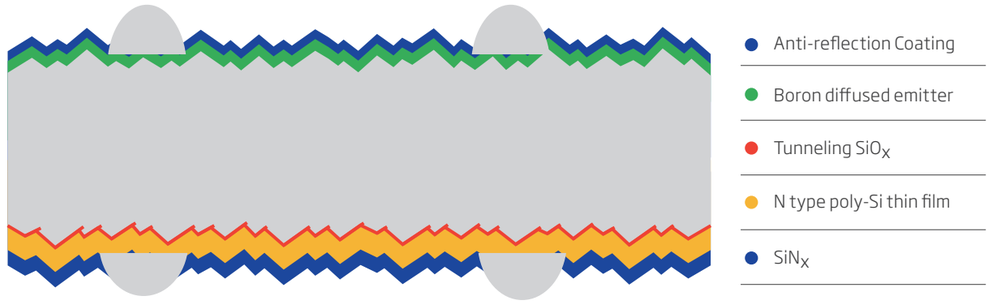


Figure 3: Diagram of N-type solar cell structure

Trina Solar N-type i-TOPCon solar cell has an innovative structure. N-type i-Topcon solar cell uses N-type silicon wafer as substrate, the passivation contact technology on the back side effectively reduces the recombination of carriers at the metal contact region, effectively achieves the carrier transmission, and significantly improves the cell efficiency. Trina solar N type i-TOPCon solar cells have no boron-oxygen pair, and their LID (Light Induced Degradation) is significantly lower than P-type PERC solar cells. Combined with advanced hydrogen treatment technology, N-type solar cells also obtain low LeTID (Light and elevated temperature-induced degradation).

2.Trina Solar N type i-TOPCon core technology

The efficiency of P-type solar cells is approaching the upper limit of theoretical conversion efficiency year by year. It is imperative to develop the next generation of high-efficiency solar cells. However, only with sufficient technology accumulation, can technology leadership be achieved and the most valuable products be provided to customers.

Relying on years of high efficiency solar cell research and development experience of Trina Solar State Key Laboratory of Photovoltaic Science and Technology (PVST), Trina Solar has completed the development of independent N-type i-TOPCon technology, and led the way in the industrialization of N type module products. In 2018, Trina Solar was selected as the "Top Runner program" Super Technology Leader Demonstration project. It takes the lead in achieve the industrialization of N-type i-TOPCon solar cell in the industry. The project "Key Technology and Application of High Efficiency and Low cost crystalline silicon solar cell interface Manufacturing" applied by Trina Solar also won the second prize of the national technological invention award in 2020. Trina Solar has built up a solid foundation and launched 210+N type full scene solution in 2022. The new generation of N type i-TOPCon modules has been fully mass-produced.

Figure 4: Yellow River Hydropower Qinghai High Voltage Power Station 135M project

Figure 5: Tongchuan 250M "Top Runner program" technology leader project

Through long-term development and project accumulation, Trina Solar N-type i-TOPCon has accumulated a variety of core technologies and obtained many patents:

Boron selective emitter SE technology

Trina Solar has developed multiple laser selective emitter technologies to greatly reduce the contact resistance of the metal electrode and the composite current density in the metal zone, thereby improving the solar cell open circuit voltage and fill factor to increase solar cell conversion efficiency. At the same time, the thermal damage to the silicon substrate is greatly reduced, and the original suede structure can be completely retained, thus the effect of laser damage on solar cell conversion efficiency is avoided. And take the lead in pushing it to mass production, achieving an efficiency increase of more than 0.2-0.3%.

High efficiency hydrogen passivation technology

Trina Solar has independently developed an efficient hydrogen passivation technology to change the quasi-Fermi level state and hydrogen charge state of the solar cell during the process, repair the defects inside the solar cell and at the interface, effectively improve the solar cell's minority carrier life and photoelectric conversion efficiency.

N-type solar cell patent invention

Since 2015, Trina Solar has developed TOPCon technology and implemented patent layout, covering regions such as Central, Europe and the United States. Trina's N-type i-TOPCon technology has overcome key technologies such as selective emitter and hydrogen passivation, greatly optimizing the process and improving the efficiency of the solar cell. Trina Solar, which has cultivated TOPCon technology for many years, has formed an independent intellectual property system.

Figure 6: Display of some patents of Trina

Trina Solar technology development team made continuous efforts to the combination with advanced i-TOPCon solar cell technology on the basis of 210N silicon wafers, overcome the technical problems of selective boron emitter, large area tunneling silicon oxide and doped polycrystalline silicon preparation, high efficiency hydrogen passivation technology, and adopt mass-produced solar cell equipment. On the 210mm * 210mm size large area N-type monocrystalline silicon substrate with high minority carrier life, it has broken the efficiency record of N-type cells for many times. In 2022, Trina Solar State Key Laboratory of Photovoltaic Science and Technology (PVST) announced that its self-developed 210mm*210mm size high-efficiency i-TOPCon solar cell has been tested and certified by the third party of the Chinese Metrology Academy of Sciences. The highest cell efficiency reached 25.5%, which created a new world record for large area industrial N-type monocrystalline silicon i-TOPCon cell efficiency.

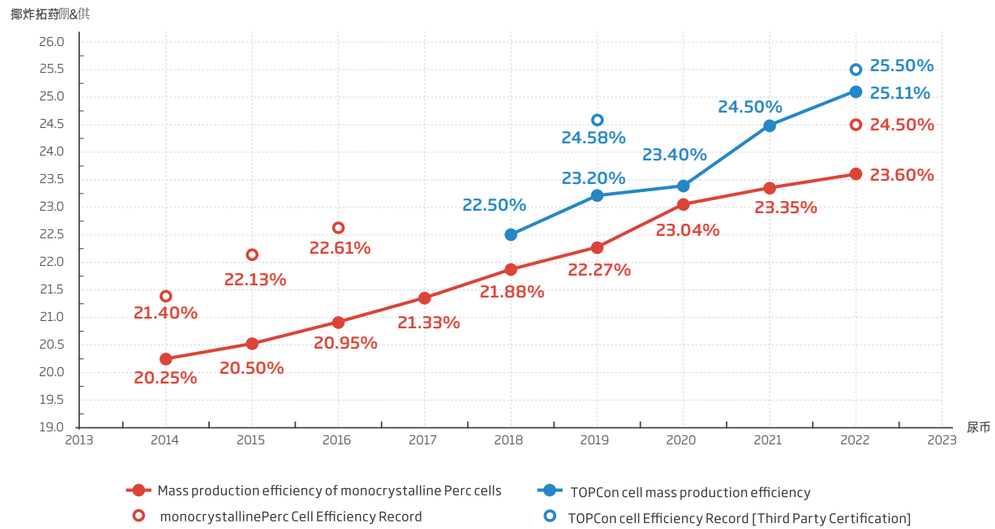


Figure 7: Efficiency records of Trina P - and N-type solar cells

After years of experience accumulation of N-type i-TOPCon technology system, Trina Solar has accumulated matured design, process and test technology system, which lays a solid foundation for ensuring the mass production of N-type i-TOPCon technology and makes full preparation for N-type industrialization.

3.210+N makes the lead even more advanced

3.1 Vertex N modules, 210+N "four high and one low" advantage is obvious

The core essence of 210 product technology platform lies in "four high and one low" : high power, high efficiency, high power generation, high reliability and low LCOE. N-type solar cell technology itself has the characteristics of high efficiency, high bifaciality and high power generation. 210 technology platform +N type technology, combining the advantages of the two , which will further magnify the leading advantage of 210 technology platform.

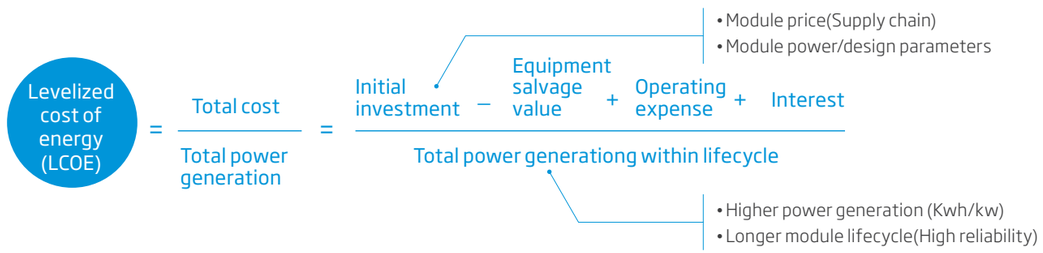


Figure 8: LCOE (levelized cost of energy) formula

Trina Solar 210+N product family starts from the levelized cost of energy, the concentration is attributed to the levelized cost of energy. The levelized cost of energy (LCOE) is the total cost of the plant over its life cycle divided by the total amount of electricity generated over its life cycle. According to the formula content, the core elements of reducing the levelized cost of energy of photovoltaic power generation are firstly started.

The "numerator" in the division formula is the initial investment. In addition to the price of the module itself, the crucial point is the cost of the system. Module quality, module power and design reasonability are of great significance to the reduction of the system cost. Due to the high power and efficiency of 210N module, the advantages of high string power can reduce the BOS cost of the system, reduce the initial project investment and reduce the numerator.

The "denominator" is to increase the total amount of power generation during the life cycle of the power station, which is the key to reducing the levelized cost of energy. The first is the power generation capacity per watt, the second is the product sustainability, high reliability. Modules with high power generation and high reliability can directly increase the total amount of power generation in the whole life cycle of a power station project and increase the denominator. Obviously, the smaller the numerator, the larger the denominator, the levelized cost of energy will continue to decrease.

According to the LCOE formula, high power, high efficiency, high reliability and high power generation are the four core elements of photovoltaic module products, and also the necessary ability to continuously reduce the levelized cost of energy. Trina Solar Vertex N module family is such product series that fully meet the requirements of "four high and one low". It has been fully verified in the actual projects of customers and has been recognized by customers. In the manufacturing, system side, the cost is reduced.

3.1.1 High power, high efficiency

Thanks to the advantages of module layout and N type i-TOPCon solar cell efficiency, the power of Vertex N module is generally 30-80W higher than that of similar N-type modules in the market.

	210 Vertex N series	182N type series
Module power	Up to 605W，695W	570W，610W
Module efficiency	22.4%/22.4%	21.8%/22.1%
Open circuit voltage	~48V	~51V/55V

Trina Solar's low voltage design features, combined with the high power efficiency of the modules, can significantly increase the string power, reduce the system BOS cost, thus saving the initial investment of the photovoltaic system. In the simulation test conducted in Minnesota, USA, Trina Solar Vertex 670V module increased the string power by 34%. Under the condition of the same installed capacity, the number of the strings was reduced, saving the consumption of PV cable, trackers, etc. Due to fewer modules are required, installation and transportation costs are reduced correspondingly.

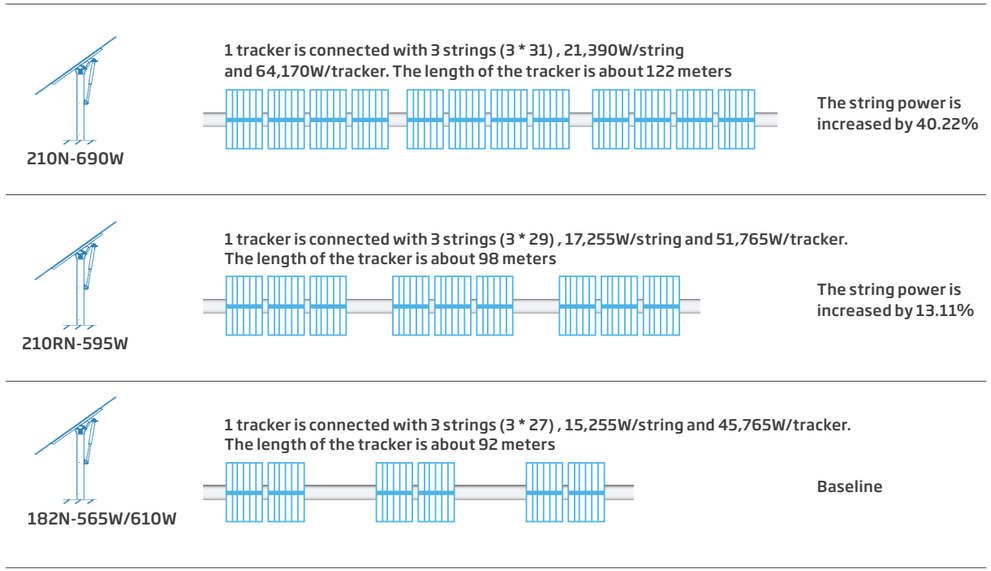


Figure 9: Power comparison between Vertex N modules and typical 182N-type modules

Shipping costs have been greatly reduced

Take dual glass module as an example	182-72pcs P	182-72pcs N	182-78pcs N	210R-66pcs N	210 - 66pcs N
Module Power（W）	550	565	610	595	685
Module quantity per containerpackage（PCS）	720	720	576	720	594
Total power in 40' container（W）	396,000	406,800	351,360	428,400	406,840
Shipment capacity difference per container	-2.6%	BL	-13.6%	+5.3%	+0.0%

Figure 10: Comparison of shipping cost between Vertex N and Typical 182 Type

3.1.2 High Power Generation

Bifaciality 80% (±5%)

Higher bifaciality means that N-type modules have higher power generation under the condition that the irradiation intensity received by the back side is the same. In different surface reflection scenarios, N-type modules can obtain a power generation gain of 3%-5% according to the simulated power generation results of typical system design as a reference.

Annual power gain kWh/kWp/yr	Grass land Albed0=0.2	Sand Albed0=0.4	Snow field Albed0=0.7
Vertex N 80 (±5%)	+3.34% 1423	+4.40% 1517	+5.42% 1652
PERC 70 (±5%)	1377	1453	1567

Figure 11: Comparison of power generation between Vertex N type bifacial dual glass module and P type bifacial dual glass module

Benefit by the excellent characteristics of the N-type solar cell, the bifaciality of the Vertex N module reaches 80%, which is about 10% higher than that of the P-type. According to different application scenarios, the annual power generation gain can be achieved by 3.34% on the grass, 4.40% on the sand and 5.42% on the snow.

Excellent temperature coefficient -0.30%/C

The solar cell temperature of 25 ° C is the standard temperature for rated power of the module. In fact, the solar cell temperature of the module is much higher than 25 ° C. Taking the actual solar cell 45° C temperature of the module as an example, the difference between the standard temperature of 25 ° C and the actual operating temperature of the module solar cell is 20 ° C. Since the temperature coefficient of N-type module is -0.30% / ° C, the temperature coefficient of P-type module is 0.34% / ° C. It is calculated that the power loss of N-type modules is about 0.8% lower than that of P-type modules at the operating temperature of 45° C.

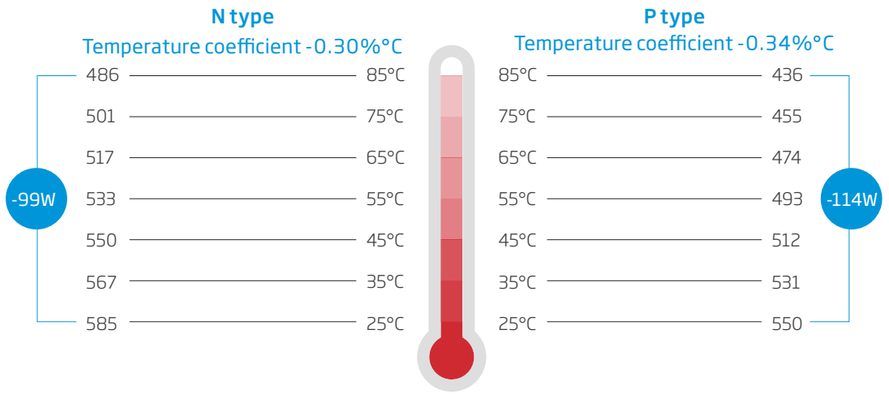


Figure 12: Comparison of power attenuation caused by temperature coefficient between Vertex N-type and P-type modules

Power degradation is 1% in the first year and 0.4% yearly after that.

N-type power degradation is 1% in the first year and 0.4% yearly after that. Compared with P-type power degradation of 2% in the first year and 0.45% yearly after that, the module power degradation after 30 years of use is 2.45% lower than P-type power degradation. Due to lower power degradation, this is one of the important reasons that module get more 3% power gain over the 30 years power warranty period.

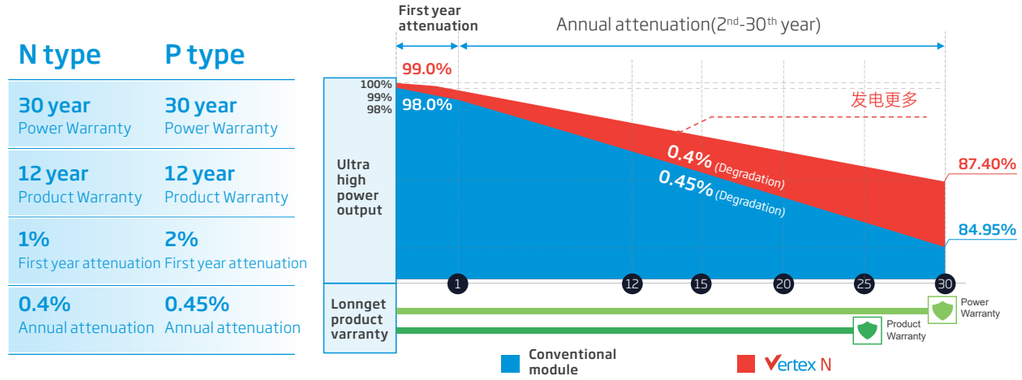


Figure 13: Comparison of power warranty between Vertex N and P modules

3.1.3 High Reliability

Light induced degradation (LID)

Compared with P-type silicon wafers, N-type silicon wafers have longer minority carrier life, N-type silicon wafers are not susceptible to the introduction of impurity elements, and the phosphorus doping technology on N-type silicon wafers base is not susceptible to LID (Light Induced Degradation) caused by B-O complex due to the absence of boron oxidation.

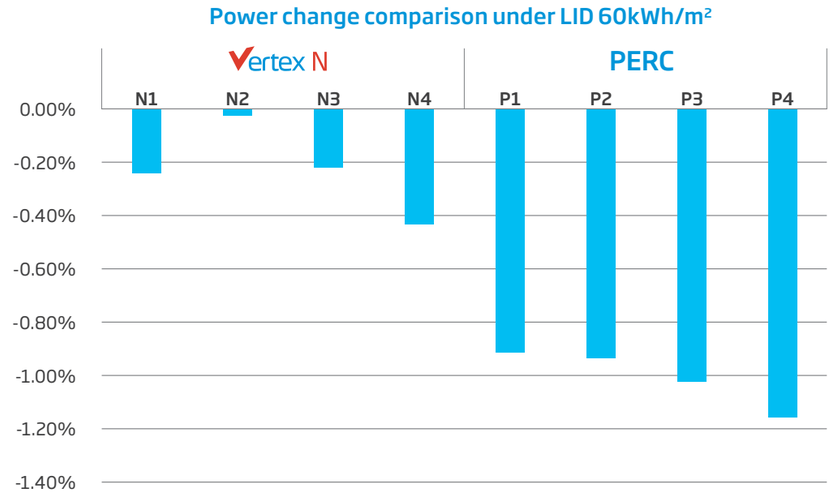


Figure 14: LID test comparison between Vertex N modules and ordinary P-type modules

In LID test of Vertex N modules, B-O complex is not easily generated under the condition of 60kWh/m2 because there is no influence of boron oxidation. The average power attenuation of LID decreases to about 0.2%, while the average power attenuation of P-type PERC technology modules is about 1.2%. Thus, under the same conditions, the average power attenuation of N-type LID is about 1% better than that of P-type LID, which can significantly reduce the energy loss caused by module attenuation.

LeTID（Light and Elevated Temperature Induced Degradation）

LeTID- Light and Elevated Temperature Induced Degradation, Trina Solar Vertex N adopts hydrogen passivation technology, effectively optimize the LeTID attenuation.

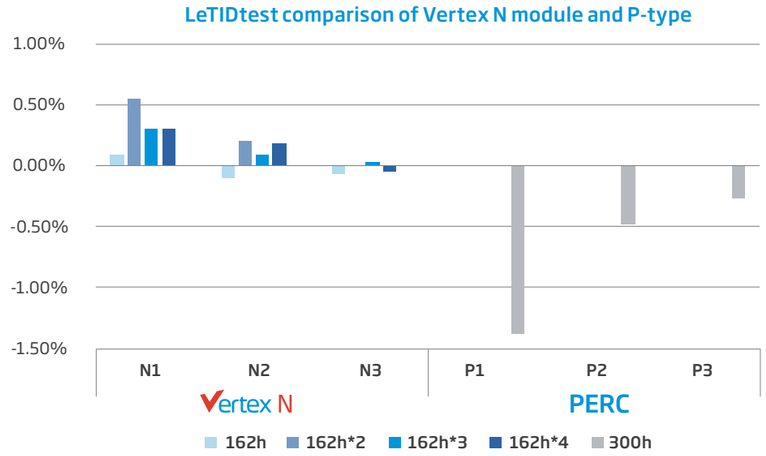


Figure 15: LeTID test comparison of Vertex N module and P-type module

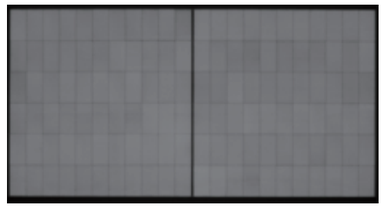
According to the LeTID test results of Vertex N modules, the attenuation of the Vertex N-type module is less than 0.2% after completing 162h * 4 testing, while the attenuation of the P-type PERC technology module is less than 1.5% after completing 300h testing, which is mainly due to the hydrogen passivation technology adopted by Trina Solar Vertex N-type. The LeTID attenuation performance of the Vertex N modules is significantly better than that of the P-type modules.

A variety of harsh tests, highlight the "powerful" product

NEG21C.20 passes IEC TS 63397: Enhanced Hail test.

Test sequence	Power change
DH200+Hail+DML+TC50+HF10	-0.48%


太阳能产品认证
检测报告
TEST REPORT



EL result after test

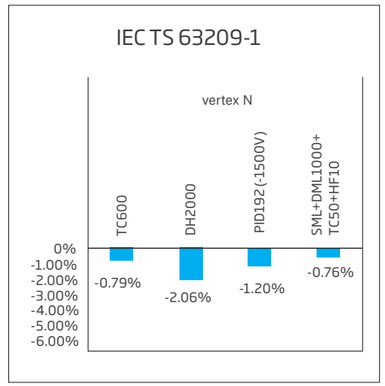
Figure 16: Harsh test results of Vertex N-type IEC TS 63397

IEC61215 test standard does not include the solar cell micro crack impact caused by the hail crash, and then take a long time environmental simulation test (such as dynamic mechanical load test, thermal cycle test, etc.) test on additional power loss of module. IEC TS 63397 is designed to simulate the potential solar cell micro crack risk caused by hail impact, and conduct long-term dynamic mechanical load test and thermal cycle test. The final power after test only reduces 0.48%. Trina Solar fully considers that customers may encounter severe hail climate conditions, under strict test simulation environment, Trina's Vertex N type modules continue to perform exceptionally well.

The NEG21C.20 has passed IEC TS 63209-1: Enhanced load tests, including harsh UV tests.

IEC TS 63209:2021 Photovoltaic Modules - Extended Stress Testing, officially published in April 2021, extends the basic IEC 61215 and IEC 61730 tests by designing an extremely rigorous series of five tests for different environmental stress effects.

	IEC 61215-1:2021 (IEC standard sequence)	IEC TS 63209-1
TC	TC200	TC600
DH	DH1000	DH2000
PID	PID96	PID192
UV test sequence	UV15+DML+TC50+HF10	SML+DML+TC50+HF10
		DH200+(UV60+TC50+HF10)*3+UV6.5



Trina Solar Vertex N passed IEC TS 63209 with excellent performance under the conditions of 3x thermal cycle test, 2x humid heat test, 2x PID test and extremely harsh UV test sequence.

Power station level demonstration project

In order to verify the advancement and reliability of i-TOPCon technology, Trina Solar established a N-type power station demonstration base in 2016. The demonstration base adopted Trina Solar N-type bifacial dual-glass module, and adopted P-type bifacial dual-glass module for comparison. The demonstration base is located in Changzhou, Jiangsu Province. It is an early demonstration base of N-type modules in the industry. The 5MW agricultural, fishery and optical complementary power station project invested and constructed by Menghe Town is the leading agricultural, fishery and optical demonstration project in Jiangsu Province and even in the whole country. The bifacial and dual-glass N-type module is installed on the fishpond, and the power generation data is of directive significance to the N-type application of the agriculture, fishery and light project.

Year	P type PERC technology dual glass product power generation per watt(kWh/kW)	N type PERC technology dual glass product power generation per watt(kWh/kW)	Comparison on power generation of N type modules VS P type per watt
2017	1275.869702kWh/kW	1313.19376kWh/kW	2.93%
2020	1413.201236kWh/kW	1466.786398kWh/kW	3.79%
2021	1343.9141916kWh/kW	1354.6476464kWh/kW	3.12%

N-type modules have high bificiality and good temperature coefficient, which can maximize the advantages of the product when applied in the area with high surface albedo and high temperature. The average reflection of water surface is low, which will affect the performance of N-type modules. In the first year of 2017, the power generation of N-type modules was 2.92% higher than that of P-type modules. In the whole empirical study, N-type modules showed obvious advantages over P-type modules, and the power generation of N-type modules in 2021 was still 3.12% higher than that of P-type modules according to the latest statistics.

If the N-type product is used in conventional grassland or sand, the surface reflection will be further improved, and the power generation gain of N-type modules will be more obvious.

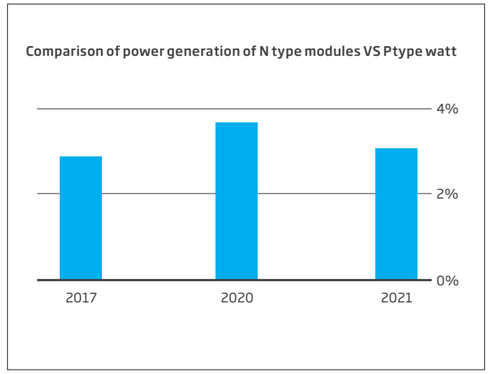


Figure 17: Comparison of power generation of N type modules VS P type per watt

3.2 The Vertex N product family builds the application ecology of the whole scene

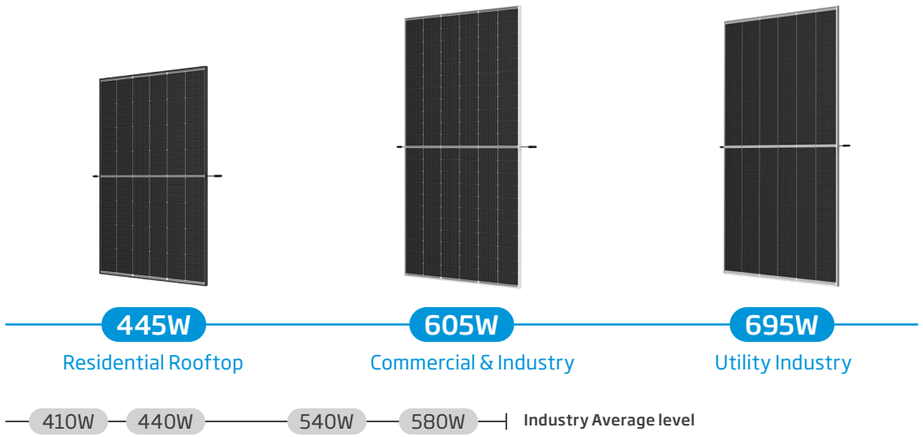


Figure 18: Vertex N Product Family

To help users gain high profits in multiple scenarios, Trina Solar creates the Vertex N small, middle and large size module layouts of the product family, covering residential rooftop, C&I, mountain, water surface, desert, Gobi and other typical scenes. It can fully meet the different needs of users and achieve 210+N all-scene solutions, expanding the broad application space.

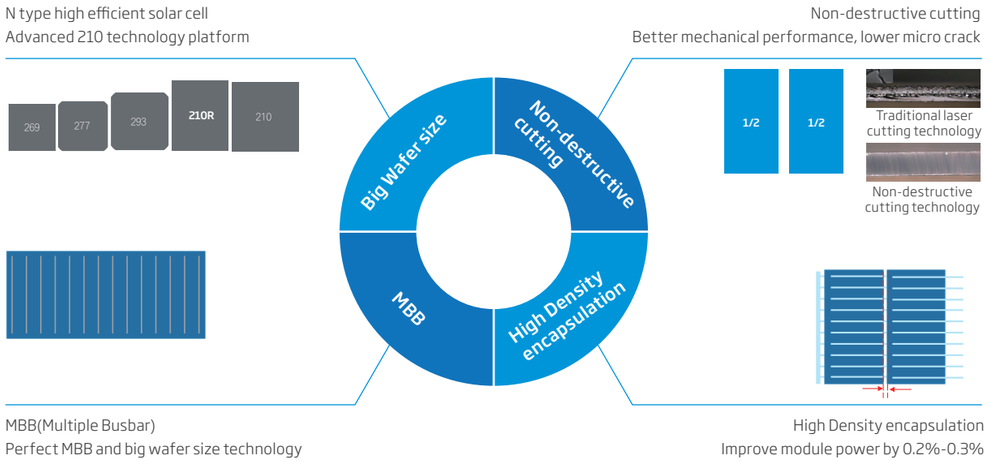


Figure 19: 210+N technology features

Trina Solar N-type product family is based on advanced 210 technology platform :multi-Busbar (MBB), high density encapsulation technology, Non-destructive cutting technology, superposition N-type technology, which further expand product system value and improve power generation.

3.3 NEG19RC.20 - Excellent balance of compatibility and value

The new generation of the Vertex N Type 605W modules adhering to the characteristics of the Vertex product family of low voltage and high string power, has the advantages of high power, high efficiency, high power generation and high reliability. The highest output power of 605W module, compared with the general N-type modules on the market, the power increase up to 30W, module efficiency is up to 22.4%. Vertex N type 605W module adopts 210R rectangular solar cell technology and N type i-TOPCon technology. With the extreme size design and low voltage advantage, N-type 605W module makes perfect use of a group of 104 meters of tracker length. Compared with the industry general N-type 72 pieces and 78 pieces of modules, it can string 6-12 more pieces of modules without wasting any length. Maximize the use of tracker can be described as the "best partner", which once again reduce BOS cost. It is suitable for utility stations and some industrial and commercial distributed scenarios, especially for flexible use in areas with more terrain restrictions. Higher product reliability coupled with lower LCOE provides maximize the value to customers.

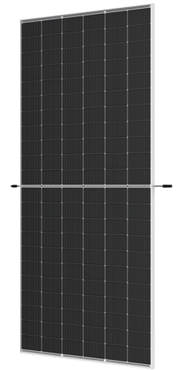


Figure 20: NEG19RC.20 Appearance

System advantage analysis of NEG19RC.20

Taking a distributed project in Dubai as an example, the standard array DC capacity of the project is 2.5MW, the inverter adopts string inverter, and the advantage comparison information of the module system is as follows

Item	Module type	210RN-595W	182N-565W
Module	Module power	595W	565W
	Module size (mm)	2384×1134×30	2278×1134×35
Mounting	Installation	1P tracker	
	Pitch	E-W 6.91m	E-W 6.60m
Inverter	Inverter type	MVPS 4000	
	Inverter power (AC)	4000 kW	
	Inverter number	1	1
Layout	Module/string	30	28
	String power	17850W	15820W
	Layout	1P×90	1P×84
	String/tracker	3	3
	String number	277	312
	Tracker units	93	104
	Module number	8310	8736
	GCR (%)	34.50%	34.51%
Capacity	DC capacity (kW)	4944.45	4935.84
	AC capacity (kW)	4000	4000
	DC/AC ratio	1.236	1.234
BOS Comparison	Total BOS	0.1848	0.1902
	BOS saving	-0.0055	Baseline

3.4 NEG21C.20 – Ground-mounted Power Station "The Star of LCOE"

Vertex N type 695W module is significantly increased 70W more power than the market similar general N type modules and efficiency is up to 22.4% which is Perfect for all kinds of large utility stations. The Vertex N 695W is "the star of LCOE" for utility stations. Ultra-low degradation ensures the power generation of the whole life cycle, optimizes the bificiality performance to bring higher returns, ultra-low operating temperature coefficient makes the power generation more secure, and the innovative low voltage and high power design achieves higher string power and reduces the LCOE to a lower level.

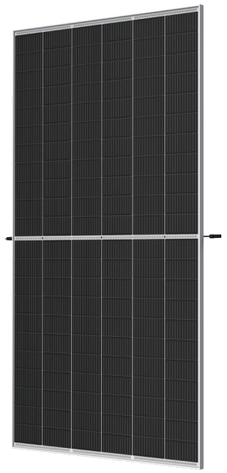


Figure 21: NEG21C.20

System advantage analysis of NEG21C.20

Take a project in Brasilia as an example, the standard array DC capacity of the project is 4MW, the inverter adopts the string inverter, and the system advantage comparison is as follows:

Item	Module type	210N-66P-690W	182N-78P-610W	182N-72P-565W
Module	Module power	690W	610W	565W
	Module size (mm)	2384×1303×33	2465×1134×30	2278×1134×30
Mounting	Installation		Tracker 1P	
	Pitch	E-W 6.44m	E-W 6.66m	E-W 6.16m
Inverter	Inverter type		SG320HX	
	Inverter power (AC)		320	
	Inverter number	10	10	10
Layout	Module/string	30	26	28
	String power	20700	15860	15820
	Layout	1V×60 Mod	1V×52 Mod	1V×56 Mod
	String/tracker	2	2	2
	String number	200	258	258
	Module number	5930	6708	7224
	GCR (%)	35%	35%	35%
Capacity	DC capacity (kW)	4091.70	4091.88	4081.56
	AC capacity (kW)	3200	3200	3200
	DC/AC ratio	1.279	1.279	1.275
BOS Comparison	Total BOS	0.1596	0.1740	0.1736
	BOS saving	-0.0140	0.0004	BL

4.Trina Solar reference projects of N type product

4.1 Tongchuan 250MW "Top Runner" technology leader project

Tongchuan photovoltaic power generation technology Leading base is one of the first national photovoltaic power generation technology leading bases, located in Yijun County, Trina Solar contracted to build 250MW, covers an area of about 638 hectares, using Trina Solar N type bifacial and dual-glass modules, fully considering the characteristics of local resources and environment, and strive to maximize power generation benefits. The project was connected to the grid in June 2019.

Figure 22: Tongchuan 250MW technology leader project

4.2 Changzhi 250MW "Top Runner" technology leader project

Changzhi photovoltaic power generation technology Leading base is one of the first national photovoltaic power generation technology leading bases, Trina Solar participated in the construction of Pingshun County 250MW project, covers an area of about 919 hectares, using Trina Solar N type bifacial and dual-glass modules, combined with dual-glass encapsulation technology and other advanced technology, to achieve dual-glass power generation. The project was connected to the grid in June 2019.

Figure 23: Changzhi 250MW technology leader project

4.3 Yellow River Hydropower Qinghai Ultra-High Voltage Power Station 135MW Project

The ±800 kV UHV transmission channel from Qinghai, Hainan to Zhumadian, Henan Province is an UHV channel that delivers 100% renewable energy over a long distance in the world. As one of the world's first designated solution suppliers for UHV photovoltaic projects, Trina Solar provided 135MW N-type high efficiency modules for the project, which were successfully delivered in September 2020.

Figure 24: Yellow River Hydropower Qinghai Ultra-High Voltage Power Station 135MW Project

Disclaimer

This White Paper content of Trina Solar Vertex N Modules (hereinafter referred to as the "white paper") is for the purpose of product consultation and reference of Trina Solar Group (hereinafter referred to as "Trina Solar" or the "Company") customers, the white paper shall not be deemed to form part of any product sales contract of the Company. Trina Solar reserves the right to modify or change the contents of this white paper at any time without prior notice. Trina Solar owns all intellectual property rights, title and final interpretation rights in this white paper. No party shall modify, reproduce, distribute, publish or license this White Paper in any form without Trina Solar's prior written consent.