Trinasolar

Power Beyond Solar

The World Leading PV and Smart Energy IoT Total Solution Provider

Vertex Product information

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

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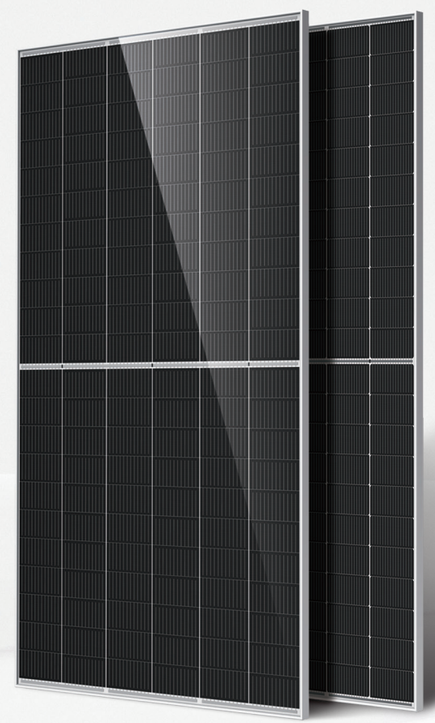
210 Vertex N

Product Whitepaper



210+N

Vertex N

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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.

Photovoltaics is at the core of the new energy industry, and its constant development theme is the pursuit of the power plant owners for the return on investment of photovoltaic power generation and the reduction of the levelized cost of energy(LCOE).The traditional p-type module development has reached its greatest process cost reduction , and the efficiency of p-type mass produced cells has approached its upper limit. In line with the trend of market development and with the aim of reducing costs and improving efficiency for customers, n-type solar cells have the advantages of higher power, higher efficiency, higher power generation and higher reliability compared to p-type solar cells. With the rapid progress of solar cell technology and its processing, n-type solar cells are increasingly more competitive considering the levelized cost of energy (LCOE) in the project life cycle.

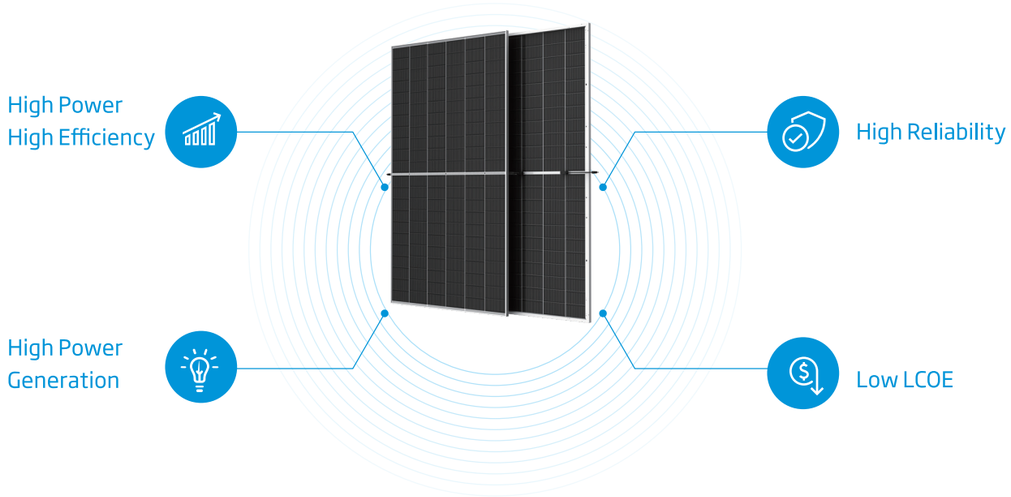


Figure 1: The four keys unlocking low LCOE

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 total cost within the life cycle divided by the total 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 balance of system (BOS) cost of the system and improve the power generation and reliability of the modules. Based on the "Four-high & One-low Idea" of the 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.

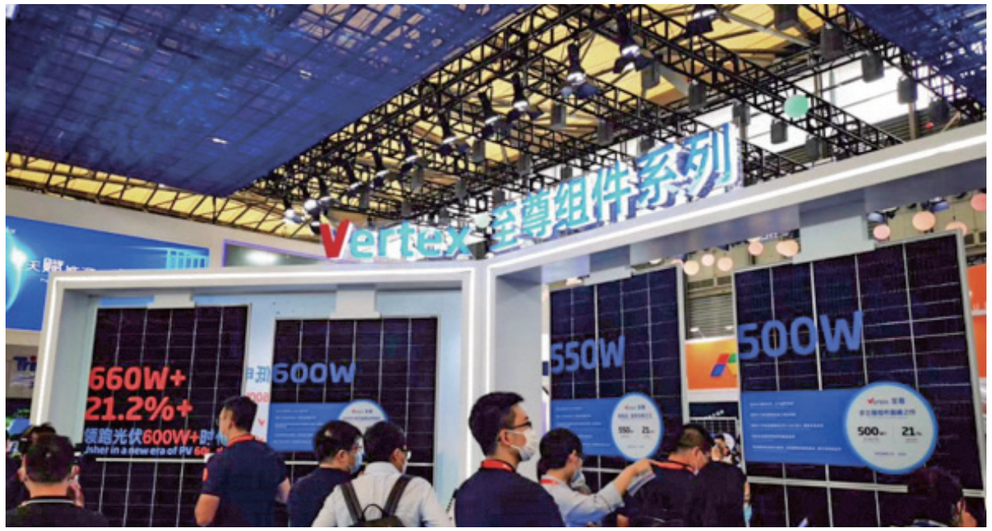


Figure 2: Trina Solar Vertex modules exhibition

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. These modules were made with 210 mm *210mm p-type cells, the mainstram of the photovoltaic industry. By Q3 of 2022, global shipments of 210 modules exceeded 70 GW, and Trina Solar shipments reached about 40 GW. No matter whether a technology is advanced or not, it is difficult to maximize its value without the support of the whole industry. In the n-type era, Trina Solar's 210 modules based on i-TOPCon technology are about to strengthen the advantages of 210 modules with a mature 210 600W+ industrial chain, making the lead even more advanced.

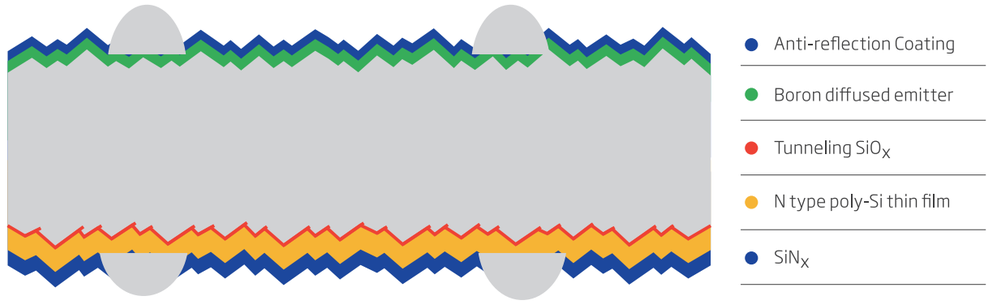


Figure 3: Diagram of N-type solar cell structure

Trina Solar n-type i-TOPCon solar cells have an innovative structure. They use n-type instead of p-type silicon wafers as substrate. Their passivating contact technology on the back side effectively reduces the losses in the metal contact region and reduces resistive losses,resulting in significantly improved the cell efficiency. Trina solar n type i-TOPCon solar cells have no Light Induced Degradation (LID) as there are no boron-oxygen pairs.

Combined with advanced hydrogen treatment technology,n-type solar cells also exhibit 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 its potential conversion efficiency. It is imperative to develop the next generation of high-efficiency solar cells. However, only with sufficient technology experience can technology leadership be achieved and the most valuable products be provided to customers.

Relying on years of experience with high efficiency solar cell research and development in Trina Solar's State Key Laboratory of Photovoltaic Science and Technology (PVST), Trina Solar has completed its independent development of n-type i-TOPCon technology, and is leading the way in the industrialization of n-type module products. In 2018, Trina Solar was selected in the "Top Runner program" for a Super Technology Leader Demonstration project. It then took the lead in achieving the industrialization of n-type i-TOPCon solar cells. Trina Solar applied to the project "Key technology and application of high efficiency and low cost crystalline silicon solar cell interface manufacturing" and wit this won the second prize of the national technological invention award in 2020. Trina Solar has built up a solid foundation and launched its 210+N type solution in 2022. The new generation of n-type i-TOPCon modules is 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's n-type i-TOPCon has accumulated a variety of core technologies and obtained many patents:

PECVD Poly technology

The passivating contact layer is the core of TOPCon solar cells. Trina Solar has developed PECVD technology to deposit passivating contact layers, which enables in situ doping and has the advantages of high doping concentration, good uniformity and high productivity. The poly-Si layer thickness prepared by PECVD is lower than that of LPCVD, thus reducing optical losses on the back and further enhancing energy conversion efficiency.

Boron selective emitter SE technology

Trina Solar has developed multiple laser selective emitter technologies to greatly reduce the contact resistance of the metal contact and the recombination losses in the metal area, thereby improving the open circuit voltage and fill factor and the energy conversion efficiency. At the same time, the thermal damage to the silicon substrate is greatly reduced, and the original texturing structure can be completely retained, thus the effect of laser damage on cell efficiency is avoided. With pushing it to mass production, an efficiency increase of more than 0.2-0.3% is achieved.

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 in the solar cell during the process, This repairs the defects inside the solar cell and at the interfaces, effectively improving the solar cell's excess carrier life time and energy conversion efficiency.

N-type solar cell patent invention

Trina Solar started already in 2015 with developing TOPCon technology and has been extending its patent portfolio, covering regions such as Central Asia, Europe and the United States. The portfolio includes key technologies such as selective emitter formation, hydrogen passivation, and greatly optimizing the fabrication process. Trina Solar has formed an independent intellectual portfolio over many years.

Figure 6: Display of some patents of Trina

The technology development team at Trina Solar continuousely advanced i-TOPCon technology on 210N silicon wafers. it overcame the technical problems of selective boron emitter formation,large area tunneling silicon oxide and doped polycrystalline silicon preparation, highly efficient hydrogen passivation technology, and adapted equipment for mass-production of solar cells. On 210mm * 210mm large area n-type monocrystalline silicon wafers with high excess carrier life time, it has broken the efficiency world record of n-type cells for many times. Finally in 2022, Trina Solar's State Key Laboratory of Photovoltaic Science and Technology (PVST) announced that some of its i-TOPCon solar cells have been tested and certified by the third party of the Chinese Metrology Academy of Sciences. The highest cell efficiency reached 25.5%, a new world record for large area industrial n-type monocrystalline silicon i-TOPCon cell efficiency.

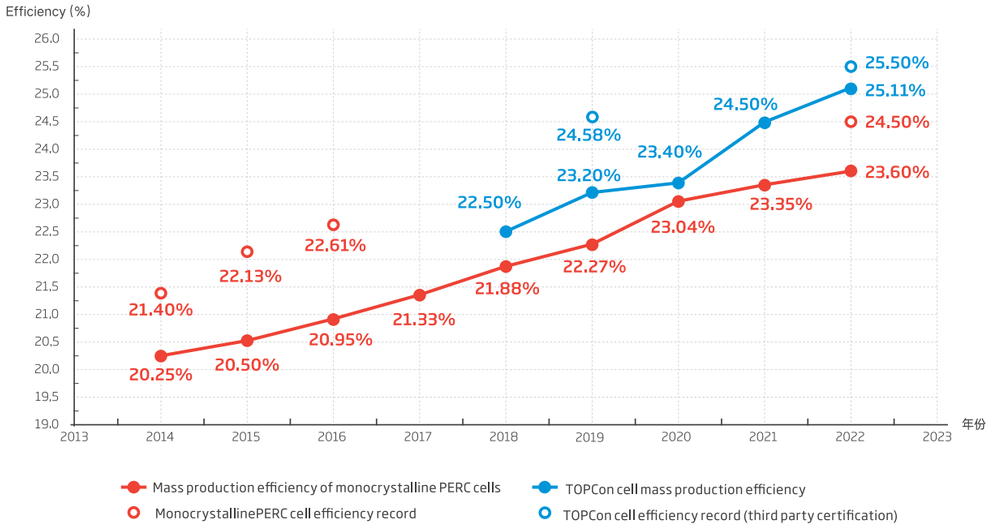


Figure 7: Efficiency records of Trina Solar's p - and n-type solar cells

After years of experience with n-type i-TOPCon technology , Trina Solar has reached a mature design, process and test technology system, which lays a solid foundation for ensuring the mass production of n-type i-TOPCon technology.

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, combines the advantages of the two and further magnifies the leading advantage of the 210 technology platform.

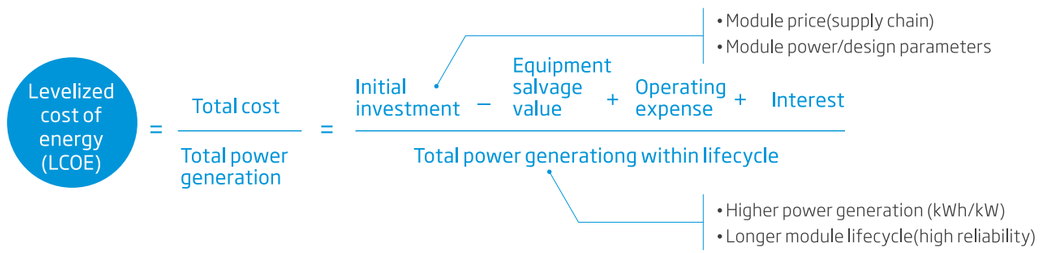


Figure 8: LCOE (levelized cost of energy) formula

The Trina Solar 210+N product family starts from the levelized cost of energy(LCOE), which 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, the core elements of reducing the levelized cost of energy of photovoltaic power generation are as follows.

The numerator in the 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 reasonable design reduce the system cost. Due to the high power and efficiency of 210N modules and 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 system, 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 and 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 project and increase the denominator. Obviously, the smaller the numerator and the larger the denominator, the smaller the levelized cost of energy.

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's Vertex N module family is a 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 and system side, the cost is reduced.

3.1.1 High power, high efficiency

Thanks to the advantages of the module layout and the high efficiency of i-TOPCon solar cells, the power of Vertex N modules is generally 30-80 W 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 reference project conducted in Minnesota, USA, The Vertex 670W 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. As fewer modules are required, installation and transportation costs are reduced correspondingly.

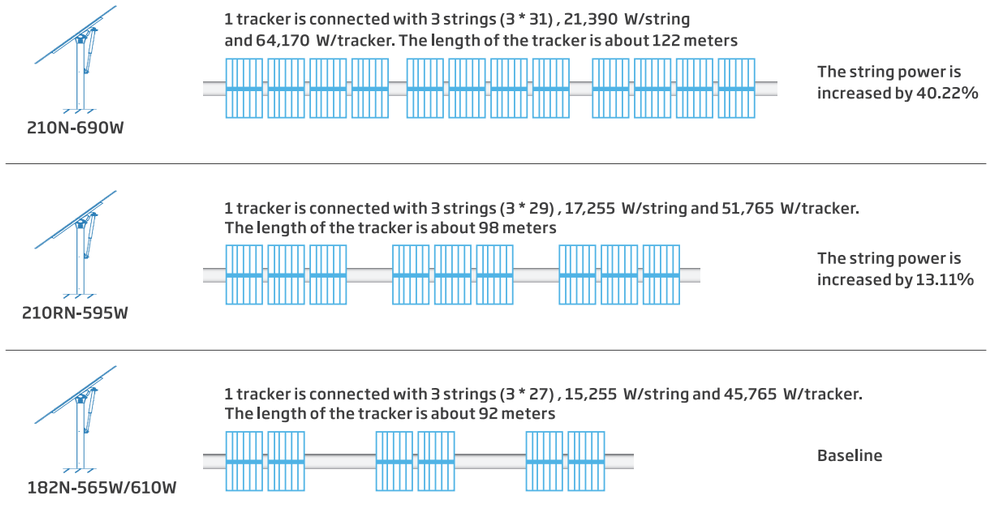


Figure 9: Power comparison between Vertex N modules and typical 182N-type modules

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%	Baseline	-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 of 80% (±5%)

Higher bifaciality means that n-type modules have higher power generation under irradiation from the back side. 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.

Figure 11: Comparison of power generation between Vertex n-type bifacial dual glass module and p-type bifacial dual glass module

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, an annual power generation gain can be achieved by 3.34% on grass, 4.40% on sand and 5.42% on snow.

Excellent temperature coefficient of-0.30%/℃

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 often much higher than 25 ° C. Let's take the actual solar cell temperature of 45° C in the module as an example, which is 20° C higher than the standard. Since the temperature coefficient of n-type modules is -0.30% / ° C, the temperature coefficient of p-type module is 0.34% / ° C. 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.

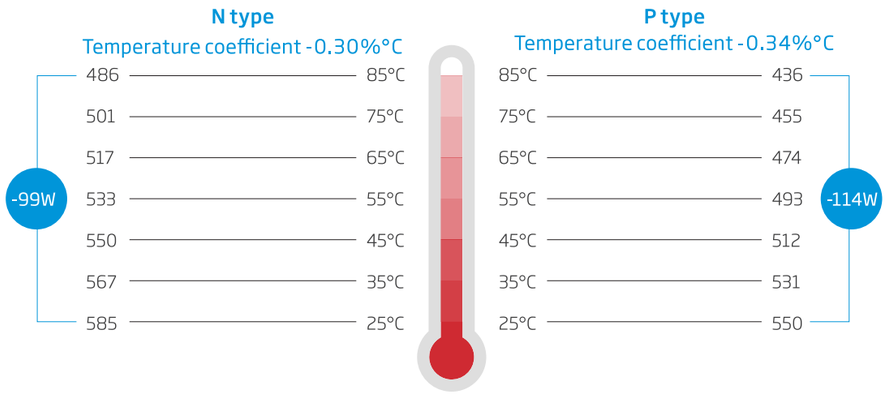


Figure 12: Comparison of power loss caused by temperature coefficient between Vertex N-type and p-type modules

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

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

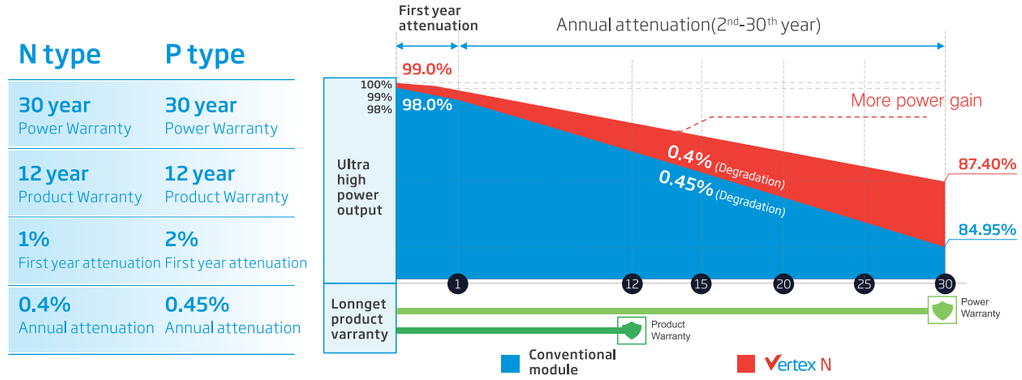


Figure 13: Comparison of power warranty between Vertex N and P modules

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 atoms, and the phosphorus doping technology on N-type silicon wafers base is not susceptible to LID (Light Induced Degradation) .

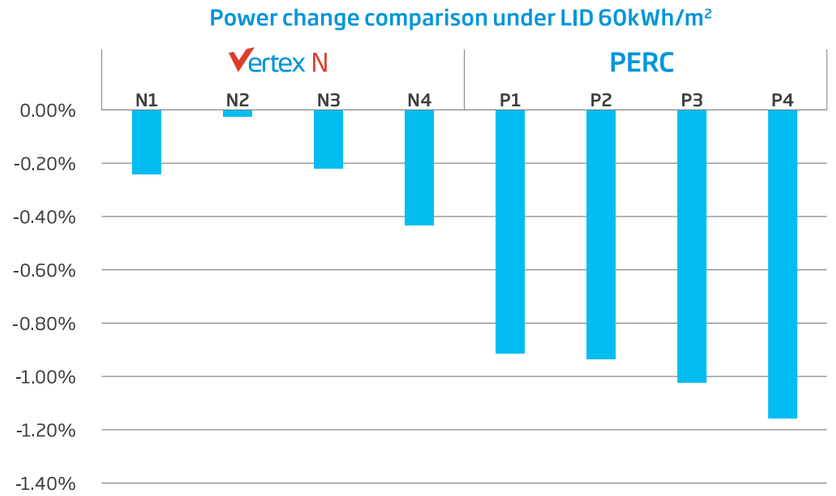


Figure 14: LID test comparison between Vertex N modules and ordinary P-type modules

In LID test of Vertex N modules, B-O complex is not easily generated under the condition of 60kWh/m2. 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）

Trina Solar's Vertex N adopts hydrogen passivation technology, causing the Light and Elevated Temperature Induced Degradation to be weaker.

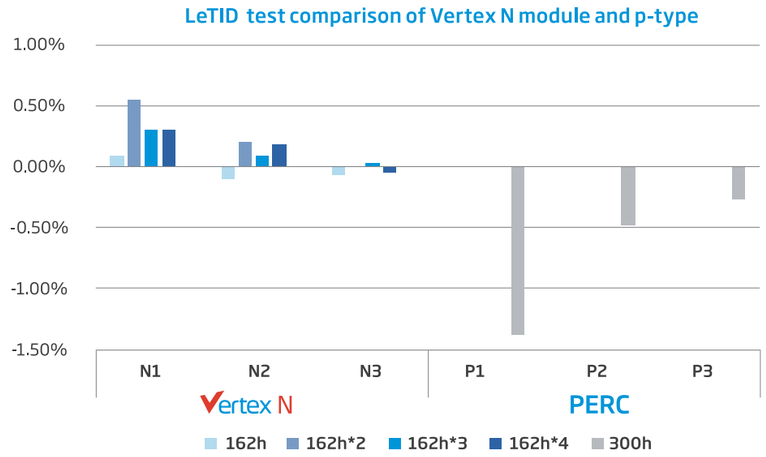


Figure 15: LeTID test comparison of Vertex N modules and p-type modules

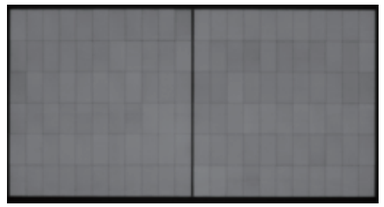
According to the LeTID test results of Vertex N modules, the degradation of the Vertex n-type module is less than 0.2% after completing 162h * 4 testing, while the degradation of p-type modules is less than 1.5% after completing 300h testing, This is mainly due to the hydrogen passivation technology 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 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

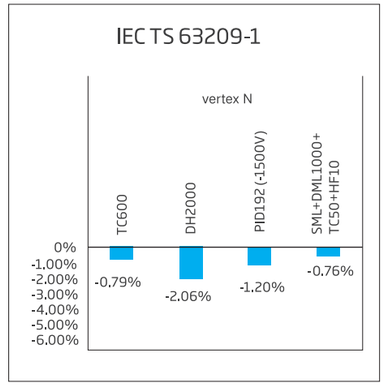
Figure 16: Harsh test results of Vertex N-type IEC TS 63397

IEC61215 test standard does not include micro cracks due to hail, hence we additionally perform a long time environmental simulation test (such as dynamic mechanical load test, thermal cycle test, etc.) .However, the IEC TS 63397 test is designed to imitate the potential micro crack risk caused by hail, and tests long-term dynamic mechanical load test and thermal cycles. The final power after this test is only reduced by 0.48%. Trina Solar fully considers that customers may encounter severe hail conditions. Under strict test simulation environment, Trina's Vertex N type modules continue to perform exceptionally well.

The NEG21C.20 has passed the IEC TS 63209-1 test,enhanced load tests, and harsh UV tests.

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 the IEC TS 63209 test 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. It uses Trina Solar N-type bifacial dual-glass module, and p-type bifacial dual-glass module for comparison. The demonstration base is located in Changzhou, Jiangsu Province. It is an early demonstration base for N-type modules in the industry. The 5 MW 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 modules were installed on the pond, 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 a small 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 rather 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.

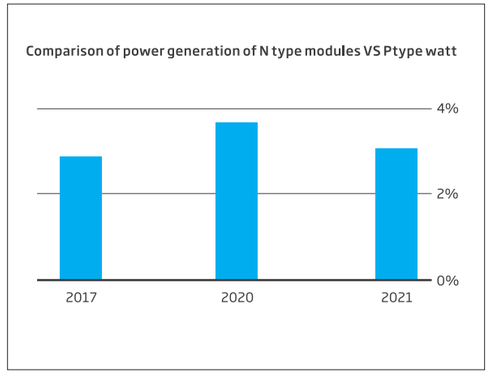


Figure 17: Comparison of power generation of N type modules VS P type per watt

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

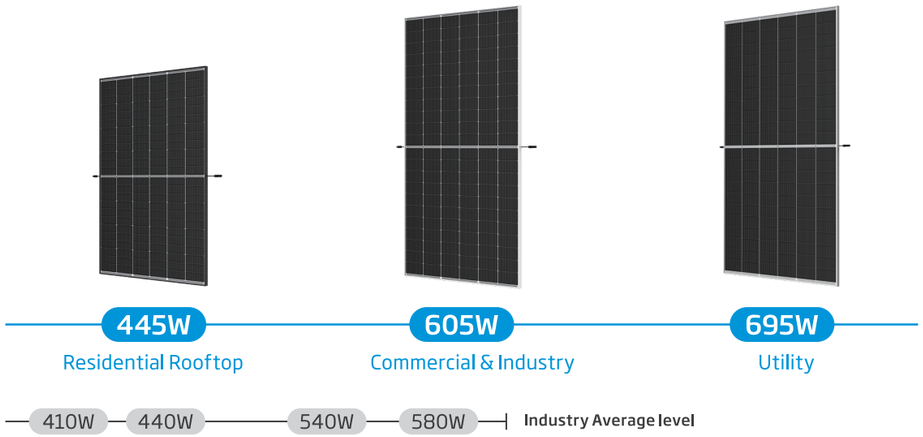


Figure 18: The Vertex N product family

To help users gain high profits in multiple scenarios, Trina Solar created the Vertex N small, middle and large size module layouts, covering residential rooftop, C&I, mountain, water surface, desert, and other typical environments. It can fully meet the different needs of users.

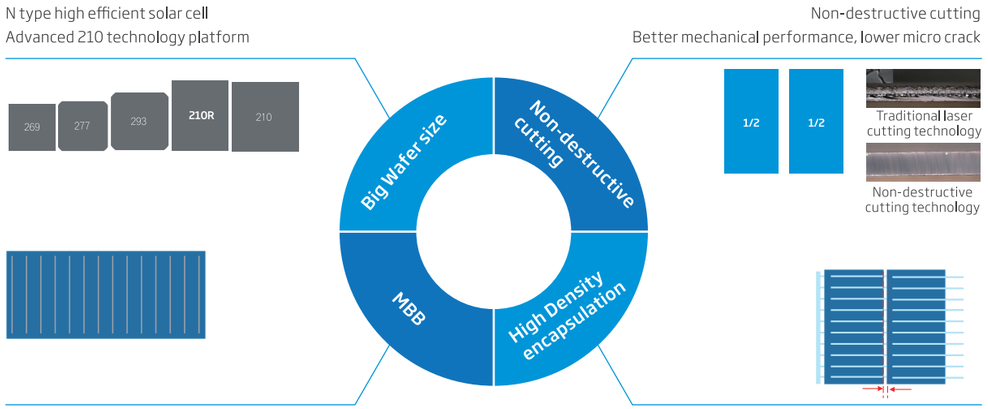


Figure 19: 210+N technology features

Trina Solar's 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 is up to 30 W, and module efficiency is up to 22.4%. Vertex N type 605W modules adopt 210R rectangular solar cell technology and N type i-TOPCon technology. With the extreme size design and its advantage of low voltage , N-type 605W modules make perfect use of a group of 104 meters of tracker length. Compared with the industrie's general N-type 72 pieces and 78 pieces modules, it can string 6-12 more pieces of modules without wasting any length. The maximized the use of trackers 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 maximized value to customers.

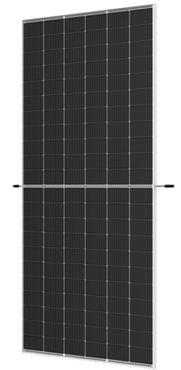


Figure 20: NEG19RC.20 Appearance

System advantage analysis of NEG19RC.20

Taking a distributed project in Dubai as an example, the standard array DC capacity of the project is 2.5 MW, string inverters are used, and the advantage 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 $/W	-0.0055	Baseline

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

The Vertex N type 695W module has 70W more power than similar products, and efficiency is up to 22.4% , which is beneficial for all kinds of large utility stations. The Vertex N 695W is "the star of LCOE" for utility stations. Ultra-low degradation improves the power generation during the whole life cycle, optimized bificiality brings higher returns, the low 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 .

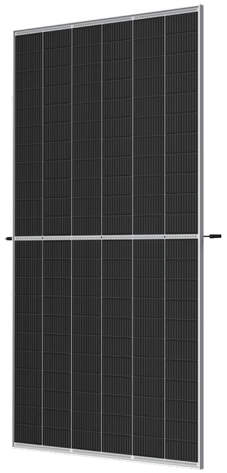


Figure 21: NEG21C.20

System advantage analysis of NEG21C.20

A project in Brasil as an example, The standard array DC capacity of the project is 4 MW, 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	
	Number of inverters	10	10	10
Layout	Number of strings	30	26	28
	String power	20700W	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 $/W	-0.0140	0.0004	BL

4.Trina Solar reference projects of N type products

4.1 Tongchuan 250MW "Top Runner" technology leader project

Tongchuan is one of the first national photovoltaic power generation technology leading bases, located in Yijun County, Trina Solar was contracted to build 250MW, which covers an area of about 638 hectares, with Trina Solar N type bifacial and dual-glass modules, fully considering the characteristics of local resources and the environment, and strives 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, which 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 one of the longest distance in the world. As one of the world's first designated solution suppliers for UHV photovoltaic projects, Trina Solar provided 135 MW 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

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