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Trina Solar

pv magazine webinars

Reliability analysis of n-type modules

13 July 2023
10:00 am – 11:00 am | EDT, New York City
11:00 am – 12:00 pm | BRT, São Paulo
4:00 pm – 5:00 pm | CEST, Berlin, Madrid

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RETC

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Welcome!

Do you have any questions? ❓

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

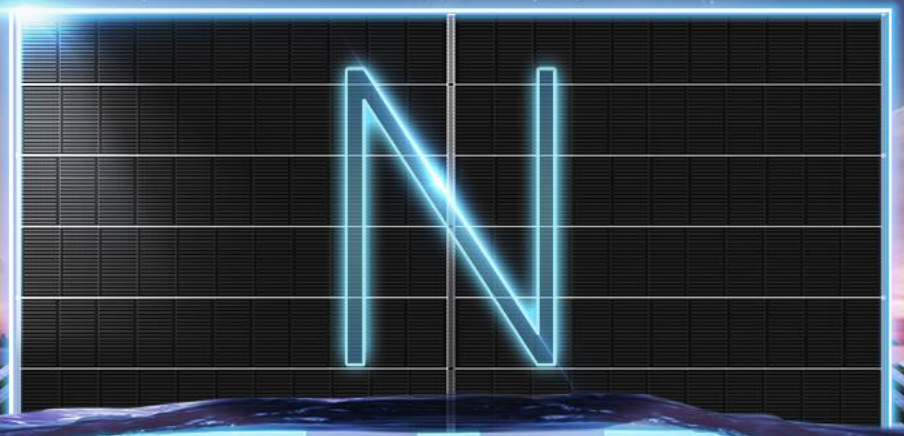
You can also let us know of any tech problems there.

We are recording this webinar today. 📹

We‘ll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

Trinasolar

Leading in the N era of solar energy



Catalog

Trina Solar i-TOPCon technology development roadmap

Trinasolar 25TH

2015~2019

Module power up to 430W

i-TOPCon

- Innovative Hydrogen passivation technology, The cell efficiency is 0.2% better than that of the product in the same period
- Wafer size 158.75mm×158.75 mm
- Mass production efficiency 23.5%
- 500 MW production line

In 2015, Base on Trina Solar's State Key Laboratory of Photovoltaic Science and Technology(PVST) ,i-TOPNCon Lab was established.

In 2019, the first TOPCon Cell World Record in China, 24.58% (ISFH certification)

2020~2022

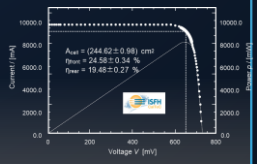
Module power up to 680W

i-TOPCon PLUS

- Wafer size 210mm×210mm+ 18BB
- Average mass production cell efficiency 24.5%
- Cell efficiency 25.15% (ISFH certificate)
- 500 MW TOPCon Pilot Line

Cell efficiency record

- 25.25% (2022/2, ISFH certificate)
- 25.42%(2022/3, ISFH certificate)
- 25.5%(2022/3, China National Metrology Institute certificate)



2023~2024

Module power up to 700W

i-TOPCon ADVANCED

- Selective emitter, backside micro-structure reflector, high doping and low composite TOPCon structure. Cell efficiency: 26.2%
- Wafer size: 210,210R
- Mass production efficiency 25.5%
- Full-scale mass production, Production Capacity 40GW+
- Comprehensive product portfolio!

2025+

735W | 785W

i-TOPCon ULTRA|TANDEM

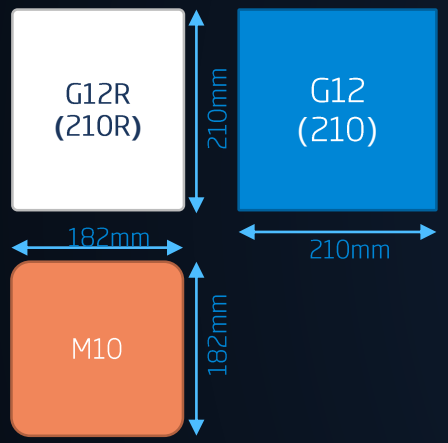
- i-TOPCon + Full frontal passivation contact cell technology： Efficiency >27%
- i-TOPCon + tandem cell Technology: Cell Efficiency >30%

PCE (%)	Voc (V)	FF(%)	Jsc(mA/cm2)
28.5	1.84	75.9	20.4

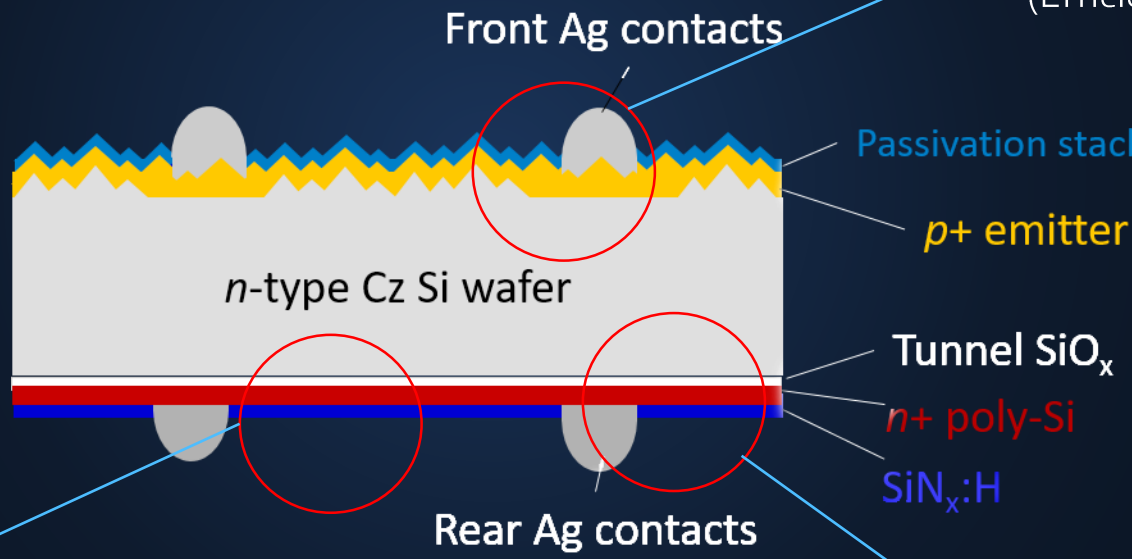
Vertex N i-TOPCon advanced Technology

i-TOPCon advanced: Cell efficiency up to 26.2% (210R rectangle cell， selective emitter， back side micro-structure reflector ，high doping and low composite TOPCon structure.)

i . The industry-leading innovative rectangle cell



ii .Large area boron doped by laser, selective emitter technology (Efficiency increase by 0.2-0.3%)



iii Backside micro-structure reflector (Inner back reflectivity increased by 25%)

iv High doping and low composite TOPCon structure.(Adopt PECVD route， doped density up to $6\times10^{20}\,cm^{-3}$， 2-3 times higher than normal LPCVD)

Catalog

Vertex N i-TOPCon advanced high efficiency module products

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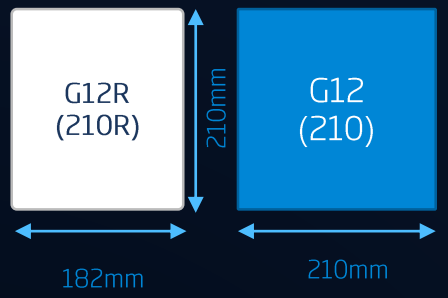

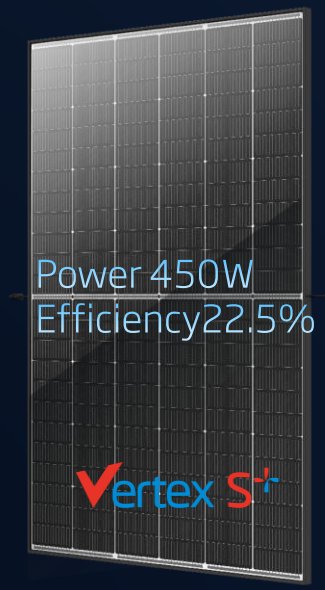

G12 R 48pcs NEG9R.28

UP to 450W

G12 R 66pcs NEG19RC.20

UP to 605W

G12 66pcs NEG21C.20

UP to 700W

Industry average level

425W 575W 620W

Trina solar N-iTOPCon Vertex high efficiency series solar modules ,fit for all kinds of application scenarios.

Vertex N i-TOPCon advanced- Vertex S+ roof solar module

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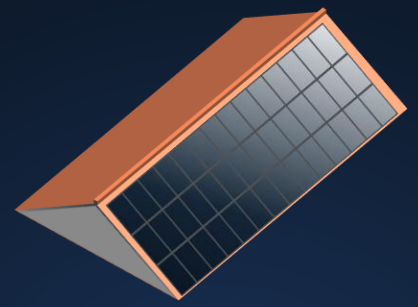
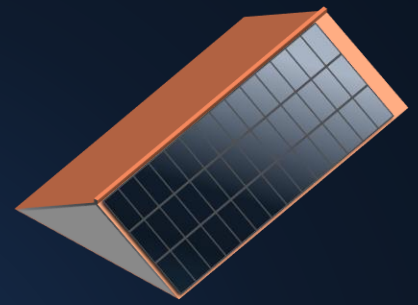
i-TOPCon plus

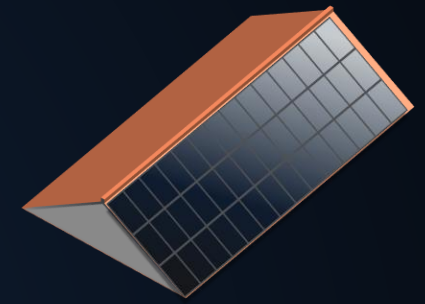
i-TOPCon advanced



210(40) 420W
42pcs(3*14)
17.64kW

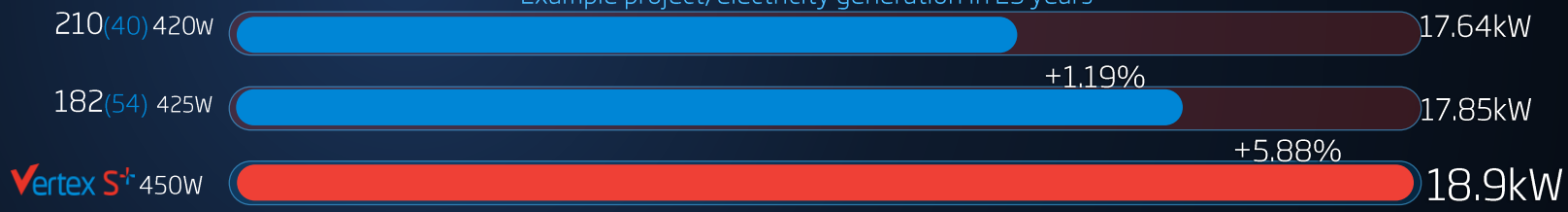


182(54) 425W
42pcs (3*14)
17.85kW



Vertex S+ 450W
42pcs(3*14)
18.9kW

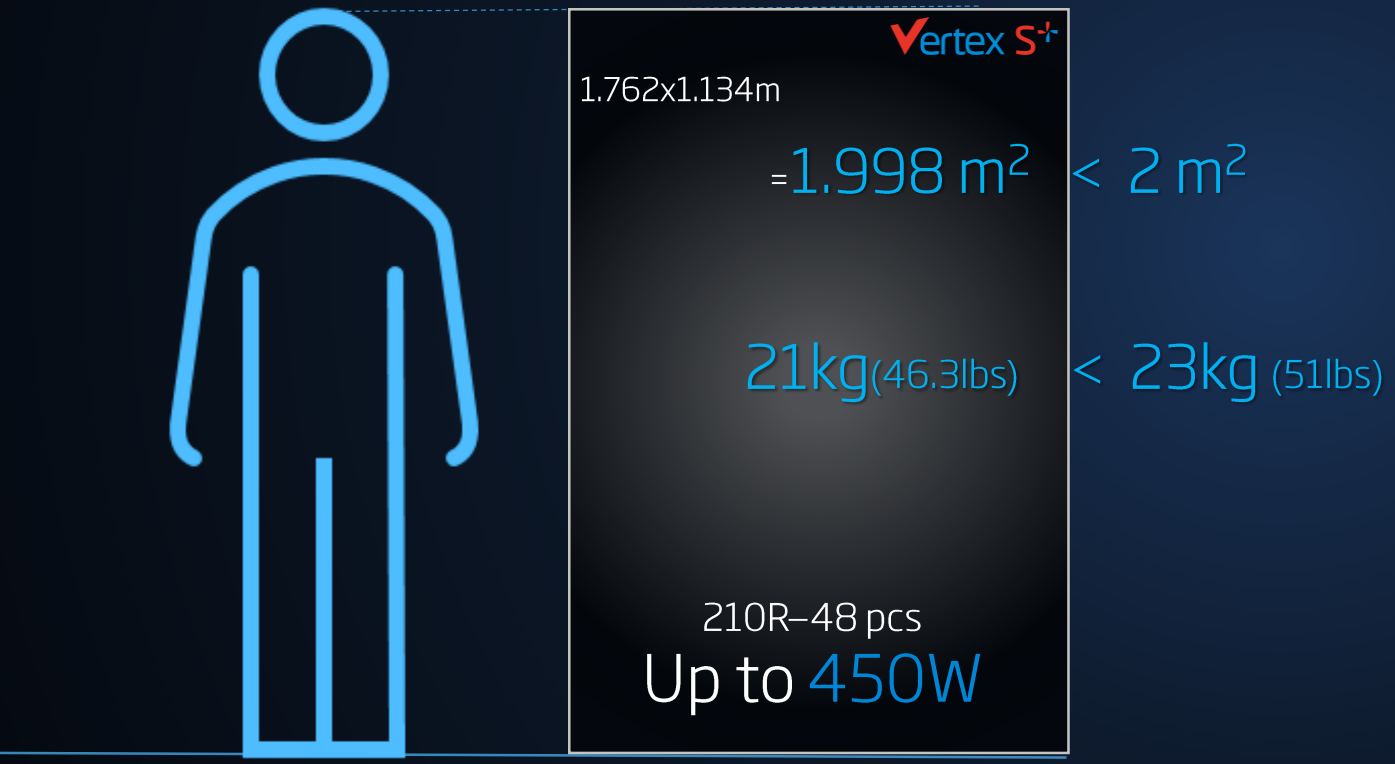
Example project, electricity generation in 25 years

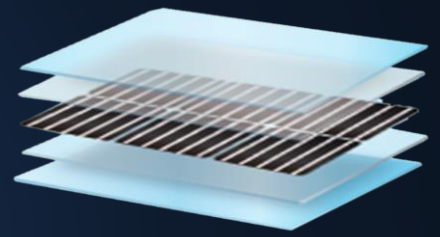


Product Name	Vertex-S+	Vertex-S	182-54pcs N
Module Size(mm)	1762 X 1134 X 30 (Golden size)	1770 X 1096 X 30	1722 X 1134 X 30
Module Area	1.998 m^2	1.940 m^2	1.953 m^2
Module design	210R-48 one-third cut cell 1.6+1.6 dual glass	210-40 one-third cut cell 1.6+1.6 dual glass	182 half cut cell backsheet
Cell technology	i-TOPCon advanced	i-TOPCon plus	182 TOPCon
Module Power	450W (+5.9%)	420W (-1.2%)	425W (BL)
Container space utilization	97%	95%	95.7%
Total power/ container	936PCS = 421200 (+5.9%)	936PCS = 393,120W	936PCS = 397,800 W (BL)

Vertex N i-TOPCon advanced- Vertex S+ roof solar module

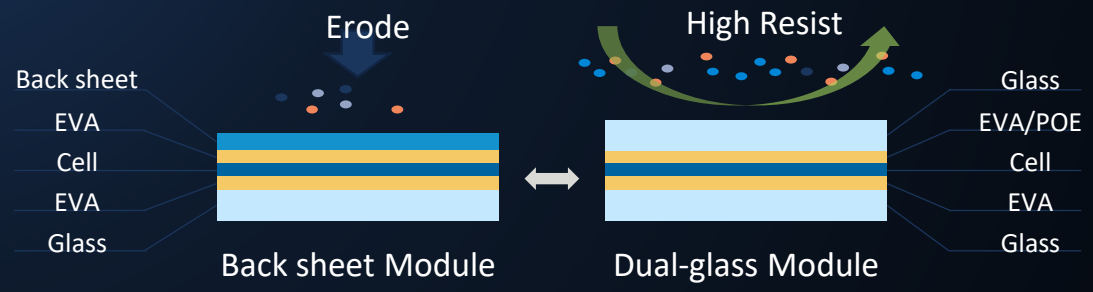
210R -48pcs Golden size :Ultimate small size format design .





Aging Factors in Nature

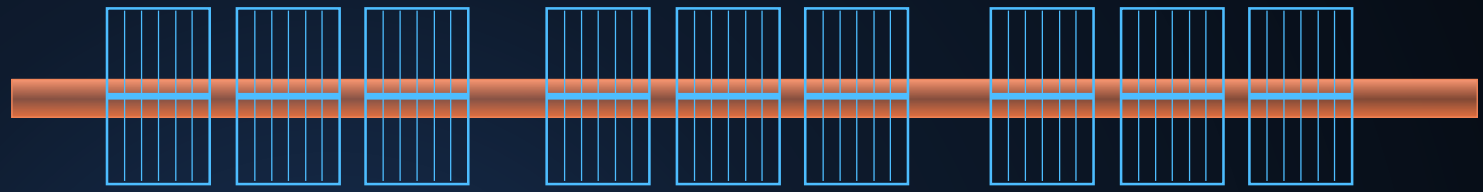
Alkaline · Acidic · High Temperature · High Humidity · UV



Extremely safe, distributor , installer friendly , easy to handle and install

Vertex N i-TOPCon advanced- 210R Utility & C&I module

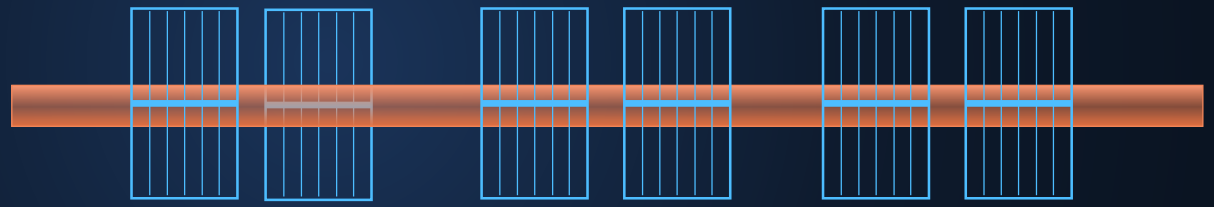
210R-N
605Wp



29 pieces/string , 52.6 kW/Tracker, 1P Tracker Length: ~ 101.0 m

Voc Lower 3.6V, accommodate 2 more pieces , Power+13%/per Tracker

Reference
182N 575Wp



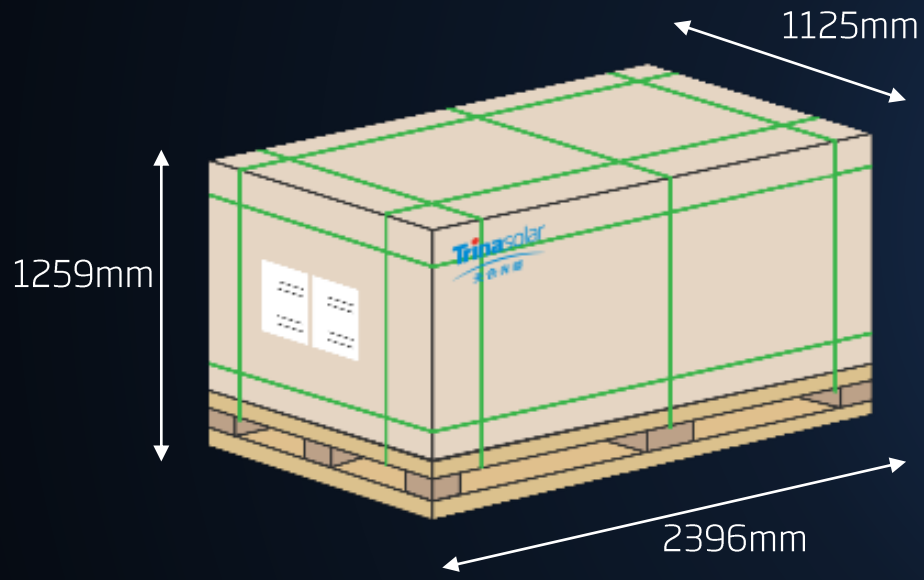
27 pieces./string,46.6 kW/Tracker,1P Tracker length: ~94.2 m

Product Name	Vertex N	182-72pcs N
Module Size(mm)	2384x1134x30（golden size）	2278x1134x30
Module design	210Rx66 half cut Dual glass	182x72 half cut Dual glass
Cell technology	i-TOPCon advanced	182 TOPCon
Module Power output	605W（+5.2%）	575W（BL）
Container space utilization	98.5%	94.5%
Total power/ container	435,600(+5.2%)	414,000

Vertex N i-TOPCon advanced- 210R Utility & C&I module

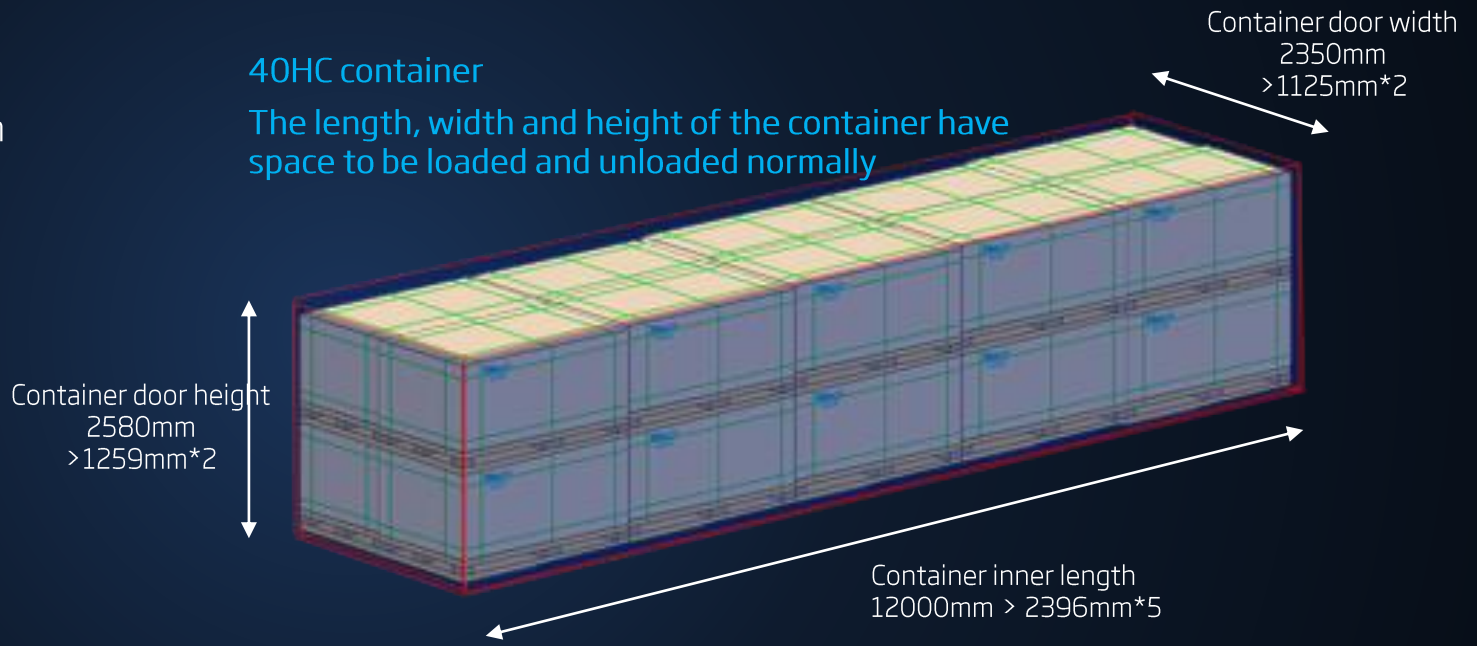
210R -66pcs Golden size:2384*1134mm , Maximize the use of container space

210R module package size (pallet included)



40HC container

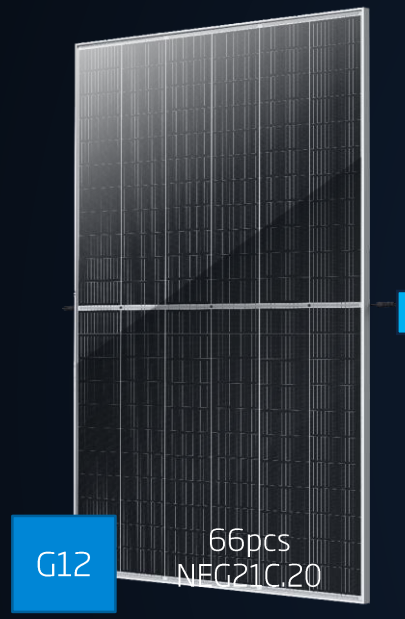
The length, width and height of the container have space to be loaded and unloaded normally



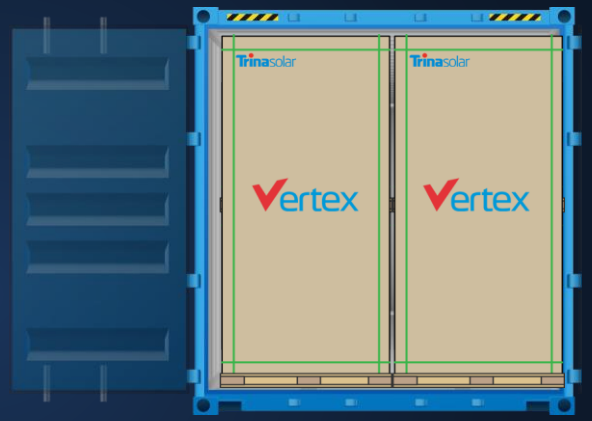
	Module power	Pieces per pallet	Pallets per container	Container space utilization	Power total per container	
182-N	575W	36	20	94.5%	414000W	BL
210R-N	605W	36	20	98.5%	435,600W	+21,600W (+5.2%)

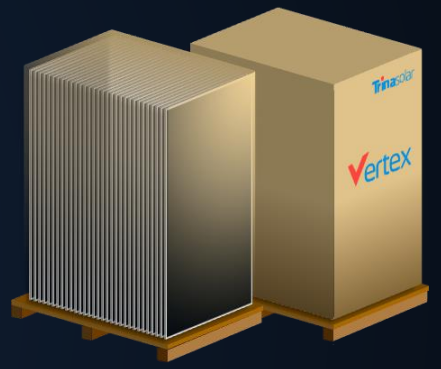
Vertex N i-TOPCon advanced- 210 Utility module

i-TOPCon plus



i-TOPCon advanced





Product Name	Vertex N (2023)	Vertex N (2022)	182-78pcs N
Module Size(mm)	2384x1303x33 (golden size)	2384x1303x33	2465x1134x30
Module design	210-66 half cut cell 2+2 bifacial dual glass	210-66 half cut glass 2+2 bifacial dual glass	182 half cut glass Bificial
Cell technology	i-TOPCon advanced	i-TOPCon plus	182 TOPCon
Module Efficiency	700W (+12.9%)	680W (+10.6%)	620W (BL)
Container space utilization	97.6%	97.6%	81.4%
Total power/ container	594PCS = 415,800(+16.4%)	594PCS = 403920(+13.1%)	576PCS = 357,120(BL)

Vertex N Golden size standardized – take the lead once again

Trinasolar 25TH

2022 Apr. ： release 210R P-type module

Value creation
Based on 210 platform ,Trina launch 210*182 wafer sized module

Customer value orientation：
Innovative 210R（210*182）
Solar module series 430W/580W

Module size：
Small format 1762*1134 430W(210R)
Medium format 2384*1134 580W(210R)
Large format 2384*1303 670W（210）

2022, Nov.： release 210R – N type module

Value deepening：
1. N-i TOPCon + 210R：
Small format module 450W
Medium format module 605W

Shipping capacity +5%
Reduce BOS ,LCOE , maximize ROI

Module size：
Small format 1762*1134 450W(210R)
Medium format 2384*1134 605W(210R)
Large format 2384*1303 700W（210）

2023,Mar.-May： 210R-N golden sized module mass production

Value recognition
1. Customer value orientation：
Reduce BOS and freight cost. Simplify the design difficulty, provide maximum customer value

2. Industry value orientation：
Explore optimal design for industry and peers
Reduce supply difficulties and inventory risks for the industrial chain

Rectangular wafer / golden sized module design value highly recognized by upstream and downstream industry chain partners

Jul.7th,2023： Standardized Module Size from 9 Major Module Manufacturers

Value convergence and size standardized
Nine major module manufacturers agreed on 2382mm*1134mm (400mm/790mm/1400mm)as the size of the new generation of rectangular silicon modules. promote the healthy development of the photovoltaic industry.

Small format 1762*1134 Widely adopted
Medium format 2382*1134 Standardized
Large format 2384*1303 (Standardized in 2021.May)

i-TOPCon advanced 210R:BOS,LCOE assessment

Project Information

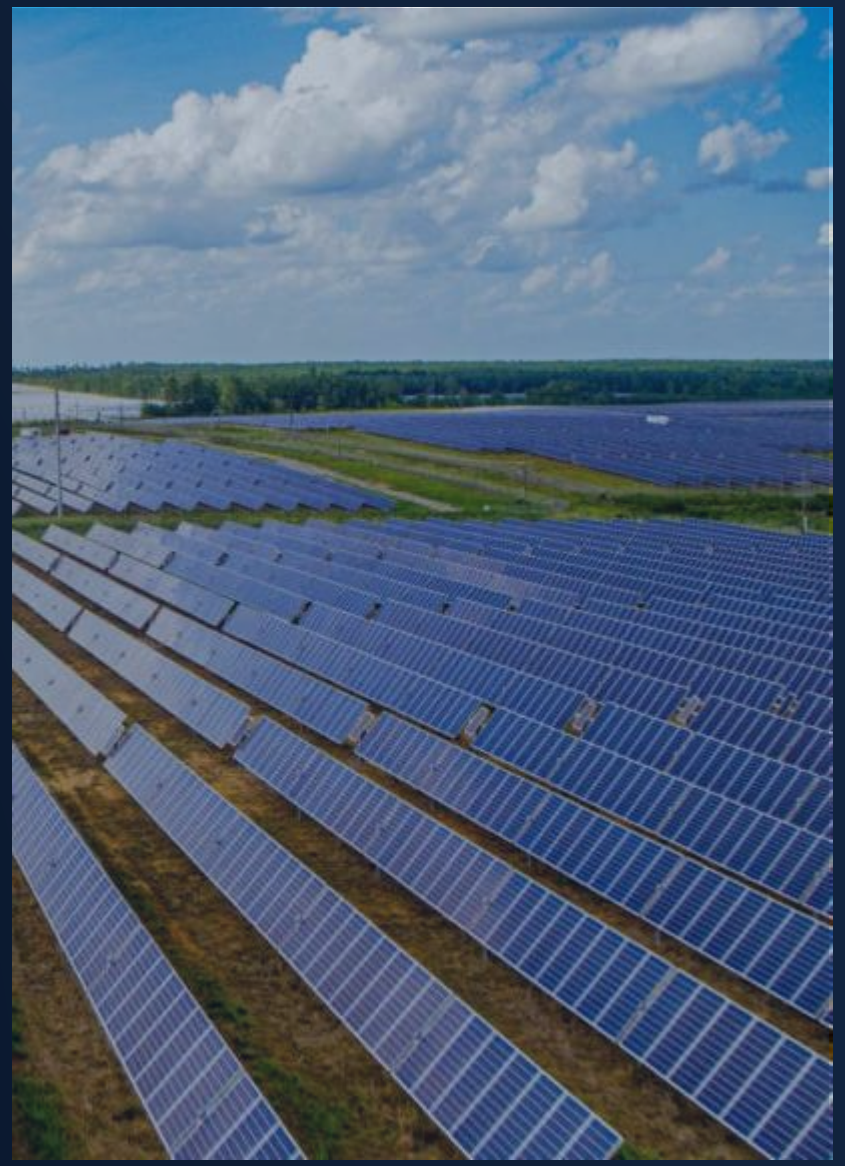
Scenario	Ground-mounted
Location	Dubai, UAE
AC capacity	4 MW (Standard single array)
Type of inverter	Central inverter
Mounting	NX Horizon 1P tracker
Type of module	Bifacial module

PV System Configuration (Standard single array)

Item	Module type	Vertex N NEG19RC.20	Reference 182-N 182N-72pcs
Module	Module power	605W	575W
	Module size (mm)	2384×1134×30	2278×1134×30
	Open circuit voltage	48.7 V	51.27 V
	Short circuit current	15.83 A	14.31 A
Mounting	Installation	NX Horizon 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	18,150W (+13%)	16,100W
	Tracker configuration	1V90 Portrait	1V84 Portrait
	String/tracker	3	3
	String number	279	315
	Tracker units	93	105
	Module number	8370	8820
	GCR (%)	34.50%	34.50%
Capacity	DC capacity (kW)	5063.85	6071.5
	AC capacity (kW)	4000	4000
	DC/AC ratio	1.266	1.268

i-TOPCon advanced 210R:BOS,LCOE assessment

PV module		NEG19RC.20	182N-575W
Structure Part	Torque Tube (kg)	1231.28	1150.18
	Normal pile (kg)	720.99	640.70
	Motor pile (kg)	99.60	95.32
	Purlin (kg)	406.69	380.16
	Slew driver seat (kg)	52.58	48.83
	Tube connector (kg)	33.38	33.38
	Purlin hoop (kg)	64.40	60.20
	Bearing pedestal (kg)	11.40	10.64
	Bearing seat (kg)	50.00	50.00
	Limit baffle (kg)	4.00	4.00
	Control box holder (kg)	2.88	2.88
	Bearing ($/W)	0.002	0.002
	Sub-total price ($/W)	0.0728	0.0759
Motor	Sub-total price ($/W)	0.0084	0.0095
Communication & Control	Control box ($/W)	0.0028	0.0032
	Communication box and cables ($/W)	0.0001	0.0001
	Damper	0.0045	0.0051
	Sub-total price ($/W)	0.0080	0.0090
Total price ($/W)		0.0893	0.0946
Including installation cost $/W		0.1027	0.1087



i-TOPCon advanced 210R:BOS,LCOE assessment

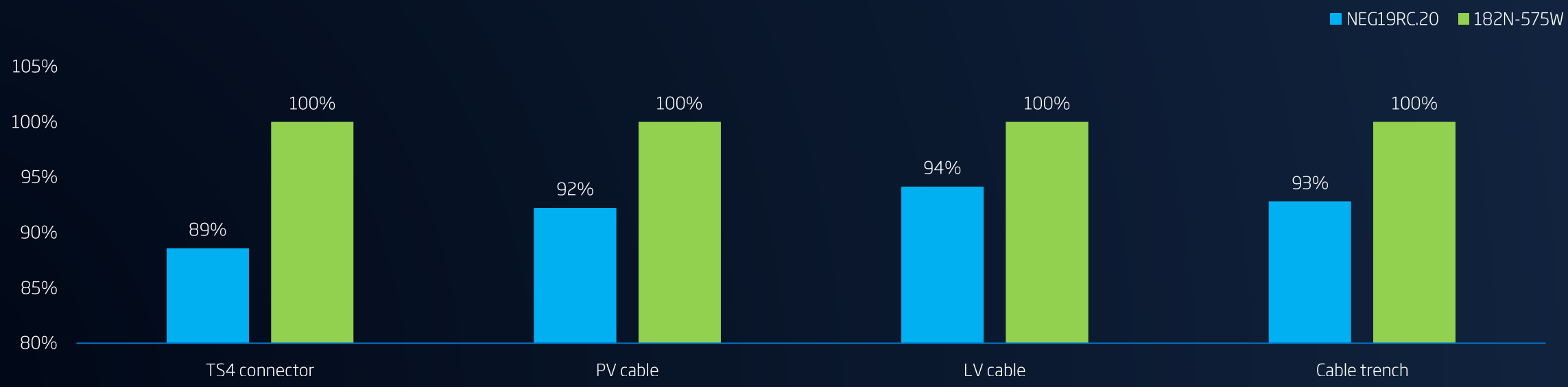
Module type	NEG19RC.20	182N-575W
Combiner box (unit)	18(16 in 1)	18(18 in 1)
TS4 connector (pair)	558	630
PV cable (m)	43367	47028
LV cable (m)	1706	1812
Cable trench (m)	646	696

PV cable

TS4 connector

LV cable trench

LV cable



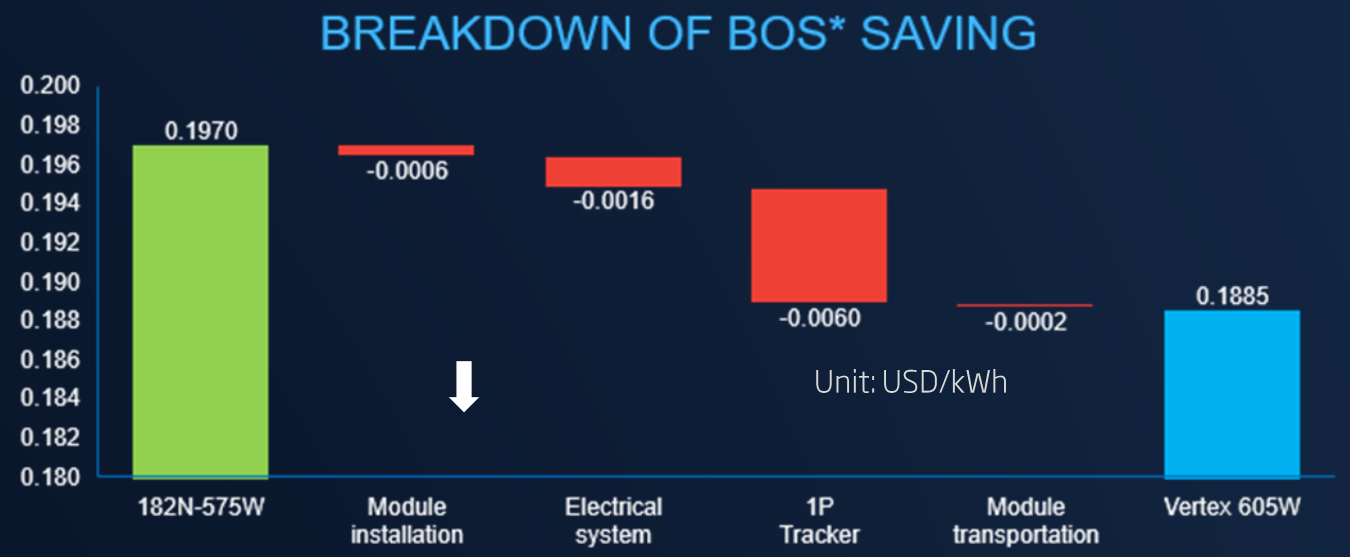
Vertex N i-TOPCon advanced 210R:BOS,LCOE assessment

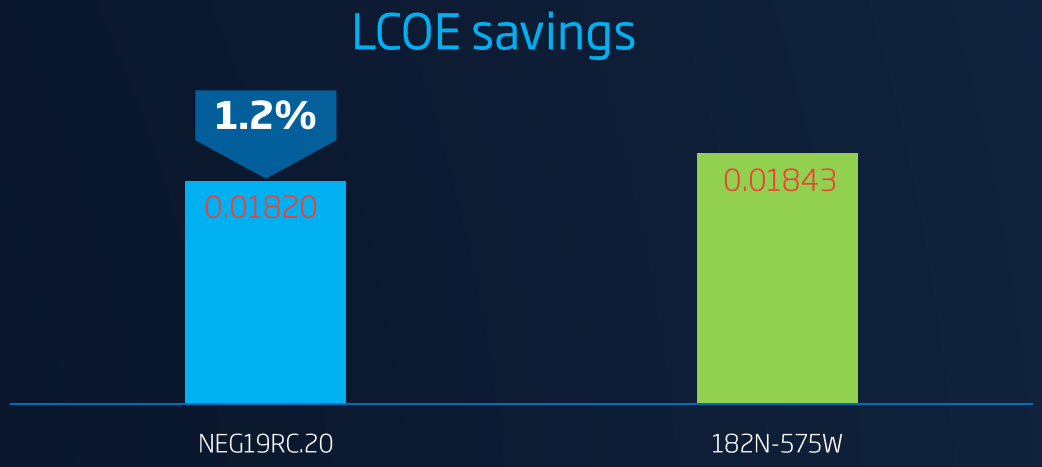
Trinasolar 25

Unit: USD/Wp

Module type	NEG19RC.20	182N-575W
Module installation	0.0116	0.0122
Solar inverter	0.0439	0.0439
Combiner box	0.0039	0.0039
TS4 connector	0.0003	0.0003
PV cable	0.0097	0.0105
LV cable	0.0103	0.0109
Cable trench	0.0023	0.0025
Electrical system	0.0704	0.0720
1P Tracker	0.1027	0.1087
Module transportation	0.0039	0.0041
Total BOS*	0.1885	0.1970
BOS saving	-0.0085	Baseline

*includes only the components which make difference with different modules.

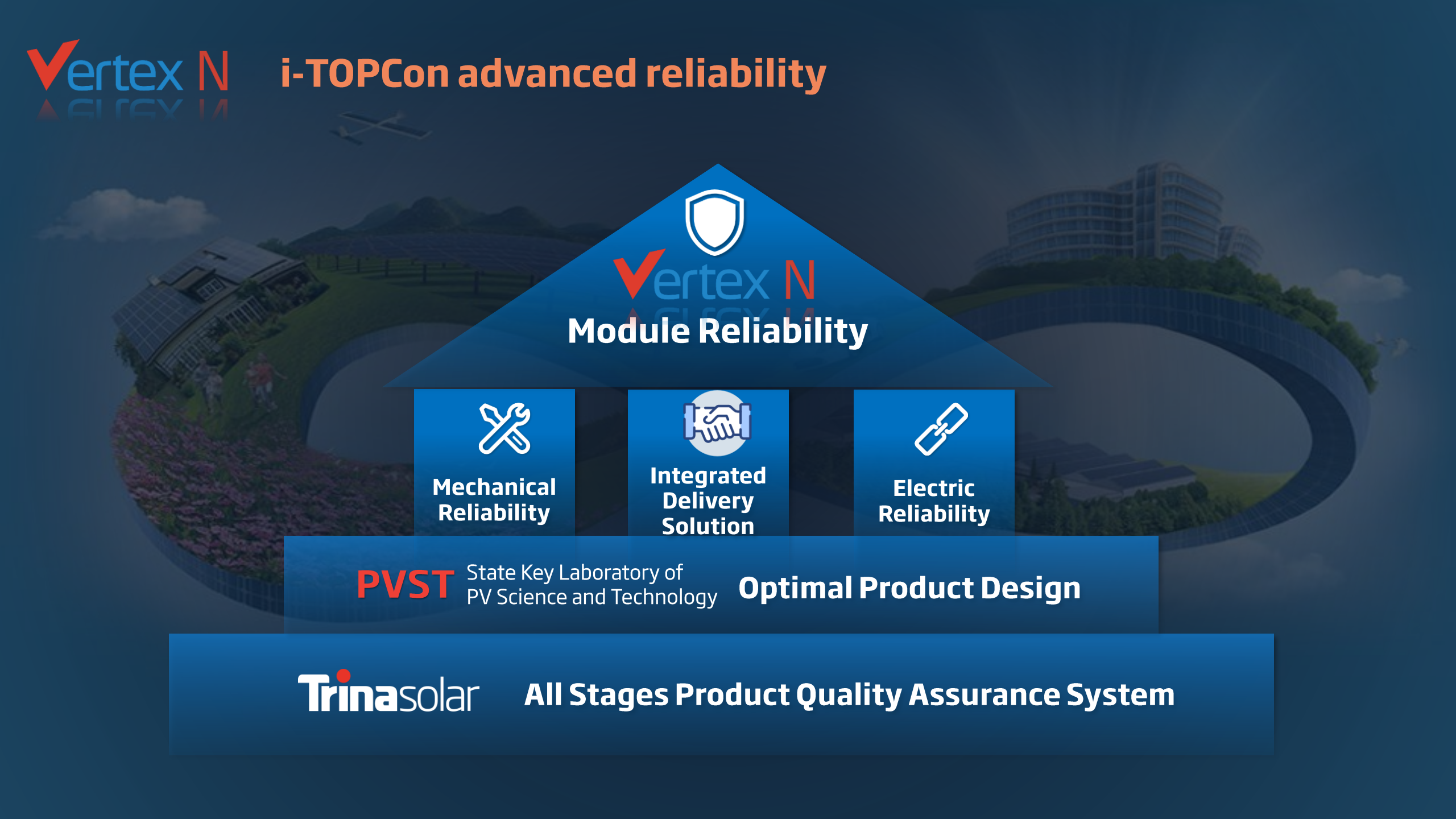




The result shows that the Vertex NEG19RC.20-605W module performs better, with a saving of 0.85 $ct in CAPEX and 1.2% in LCOE than 182N-575W.

Catalog

Vertex N i-TOPCon advanced reliability



Vertex N Module Reliability

- **Mechanical Reliability**
- **Integrated Delivery Solution**
- **Electric Reliability**

PVST State Key Laboratory of PV Science and Technology — **Optimal Product Design**

Trinasolar — **All Stages Product Quality Assurance System**

Vertex N i-TOPCon advanced reliability

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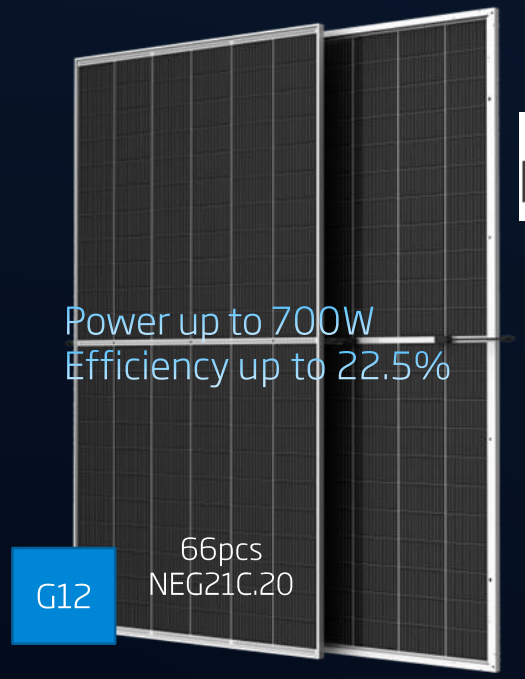


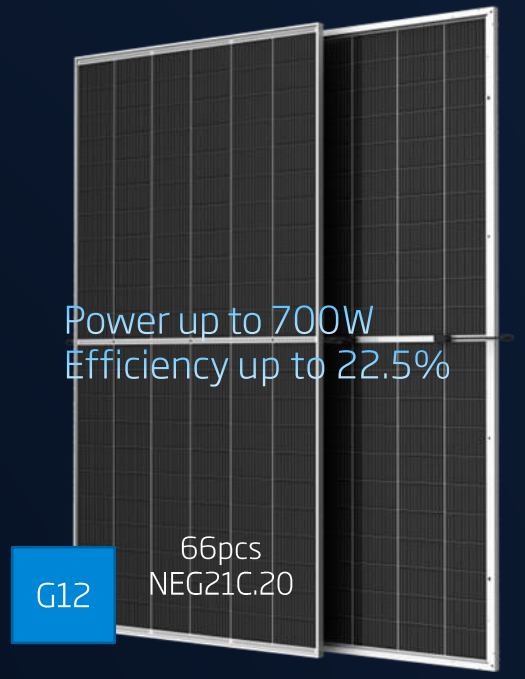
Power up to 700W
Efficiency up to 22.5%

G12

66pcs
NEG21C.20

RETC

- TC600
- DH2000
- SML+DML+ TC50+HF30
- LeTID
- PID 192



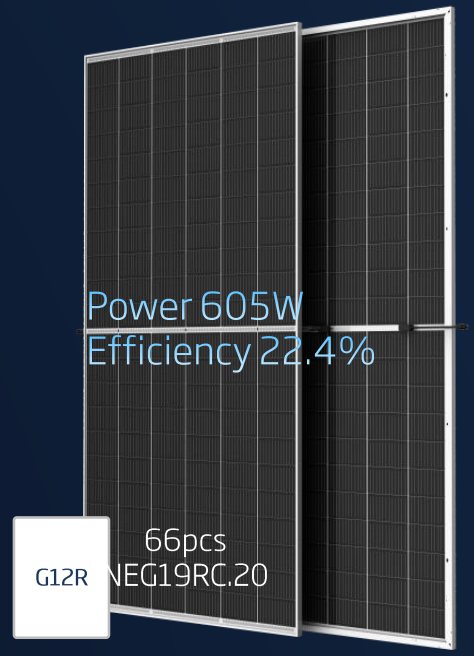
Power up to 700W
Efficiency up to 22.5%

G12

66pcs
NEG21C.20

鉴衡认证 CHINA GENERAL CERTIFICATION

- DH200+ (UV60+TC50+ hf10)*3 +UV6.5
- SML+DML+ TC50+HF10
- TC600
- DH2000



Power 605W
Efficiency 22.4%

G12R

66pcs
NEG19RC.20

PVEL member of group kiwa

- TC600
- DH2000
- PID -192h
- LeTID
- MSS

*SML+DML+ TC 50+ HF 10

Trina i-TOPCon advanced products passed various extended reliability tests(TC, DH, Letid, PID, UV, compound mechanical tests) in reputable 3rd party labs.

Manufacturing capacity of Trina

2023 module capacity

95 GW

2023 cell capacity

75 GW

i-TOPCon 40GW

2023 Si ingot capacity

50 GW

数据截至2022年12月31日

THANKS!

Vertex N

Reliability Analysis of Trina Solar's N-type Modules

Cherif Kedir | July 13, 2023

Presented by

cherif@retc-ca.com

Cherif Kedir

President & CEO

Cherif is a solar industry veteran of 17+ years with experience extending from product development, product engineering, yield enhancement, performance enhancement, test site development, reliability and durability testing, bankability, to certification testing. He also has an extensive 15-year background in Semiconductors, specifically with product engineering, testing, and failure analysis.

RETC

Since 2009, downstream manufacturers, developers, independent engineers, and financiers have trusted RETC to test and vet their modules, inverters, energy storage systems, and racking products.

- Complete Design Review & Support
- Pre-Certification Support
- Certification Testing
- Best-in-Class Turnaround Time
- World Renown Bankability Testing Data
- IE Flexibility
- Global Partnerships
- Close Relationships with Developers/Banks

A2LA ACCREDITED Testing Laboratory 3038.01

A2LA ISO / IEC 17025 Accreditation

IECEE CB SCHEME

IEC CBTL
(Certifying Body Test Laboratory)

UL

UL DAP
(Data Acceptance Program)

ETL C LISTED US

Intertek RTL
(Recognized Test Laboratory)

TÜVRheinland

TUV Rheinland Partner Laboratory

VDE

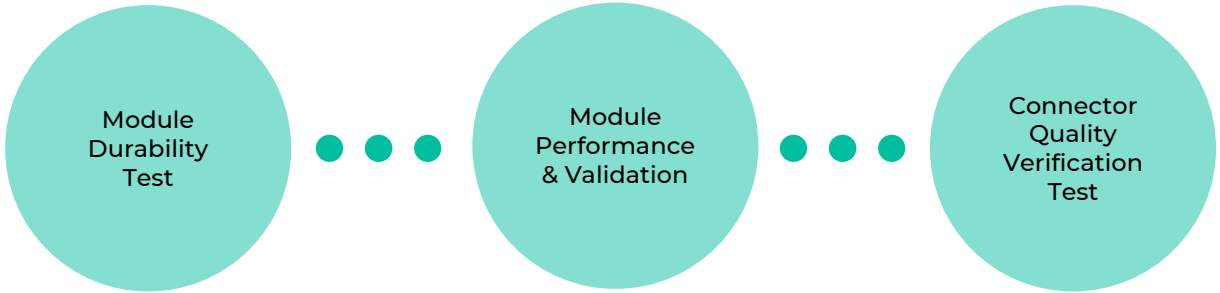
VDE Qualified Test Laboratory

CALIFORNIA SOLAR + STORAGE ASSOCIATION

CALSSA Membership

WHY USE THE **THRESHER TEST?**

How is it performed?



The Thresher Test

A series of tests designed to put PV modules through a rigorous durability vetting protocol:

- Provide detailed info on long-term safety and power output
- Identify modules with truly differentiated long-term reliability and performance advantages

THRESHER TEST FLOW

PAN File with AOI/IAM

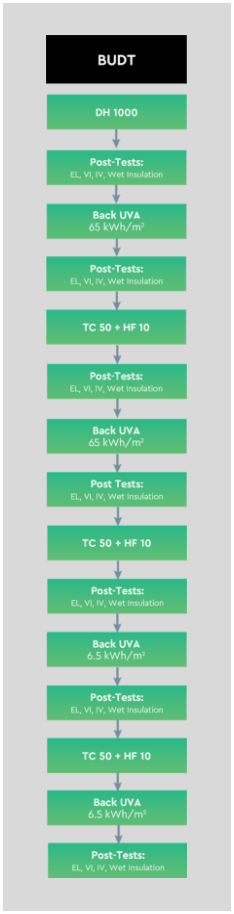
per IEC61853-1/-2, includes .pan file extrapolations +/-5% of tested bin

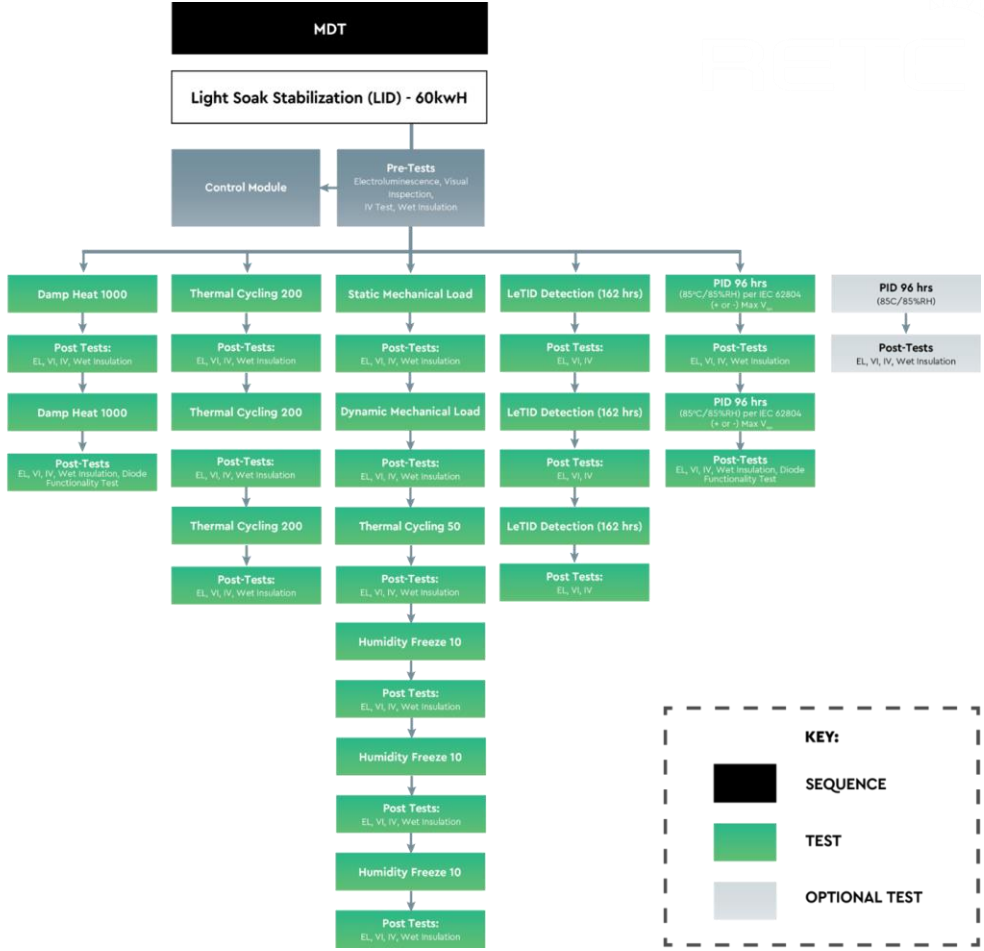
Hail Durability Test (HDT)

Ultraviolet Exposure (UV)

Light & Elevated Temperature-Induced Degradation (LeTID)

CEC Certification



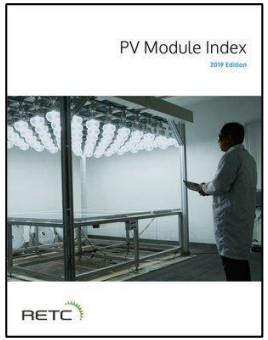


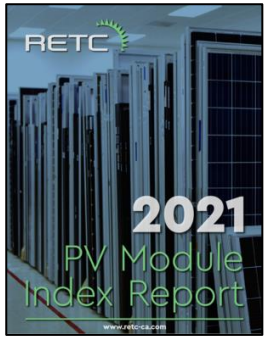
PV MODULE INDEX
OVERVIEW & RESULTS

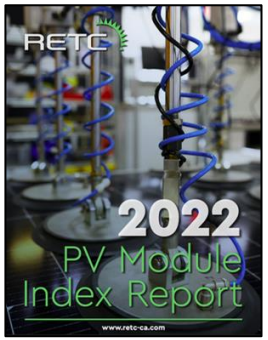
About the PVMI

The PVMI is a yearly compilation of **reliability**, **performance**, and **quality** indices generated by RETC with leading PV module manufacturers.

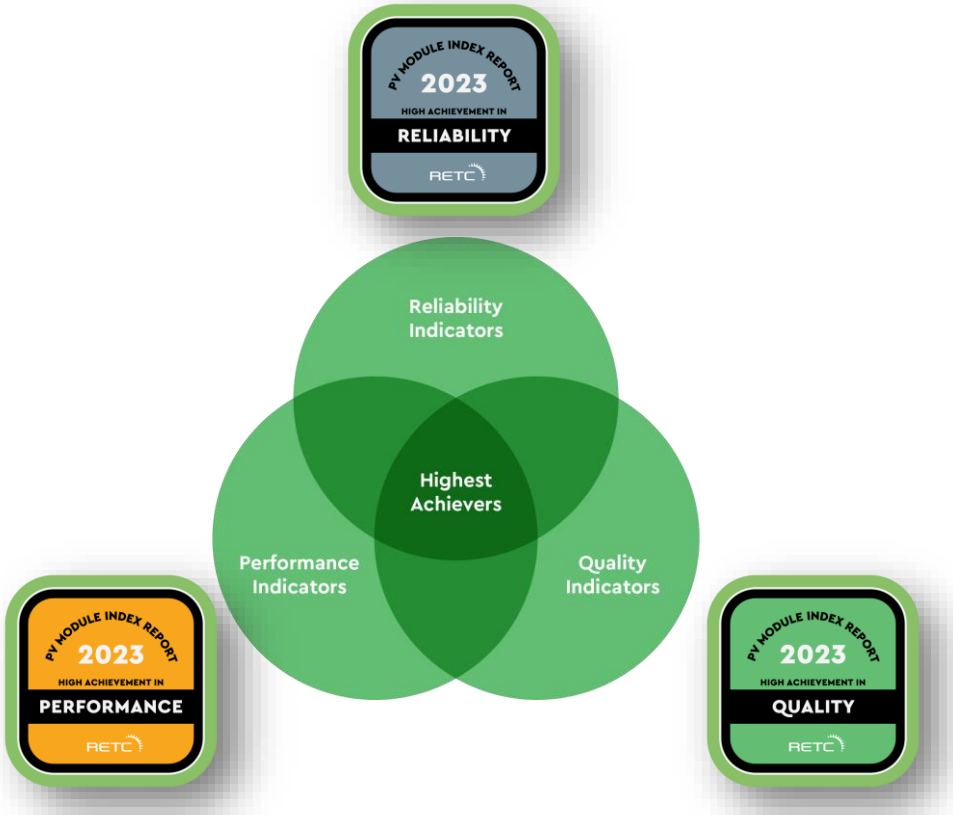
- Creating a report that is free and accessible to all
- Providing specific, data-backed findings
- Reporting noteworthy performance and trends
- Objectively highlighting PV manufacturers' accomplishments and showing who is best at manufacturing product in the industry





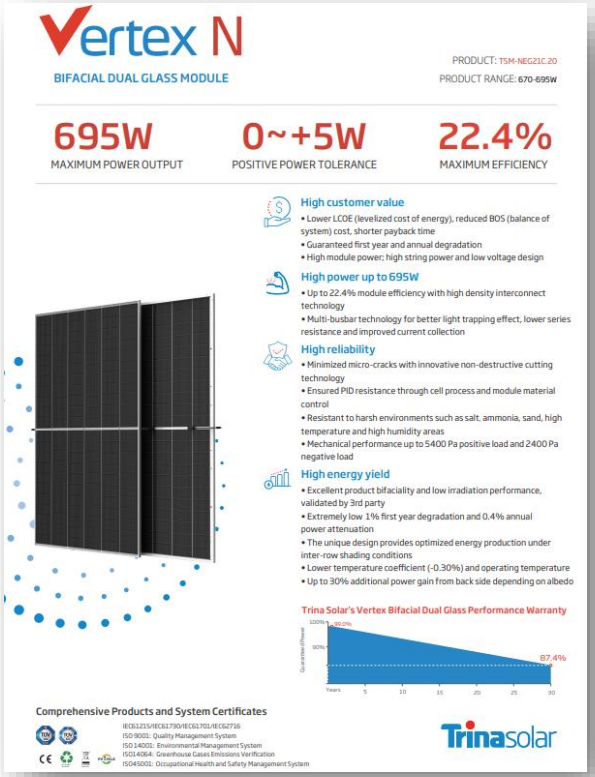


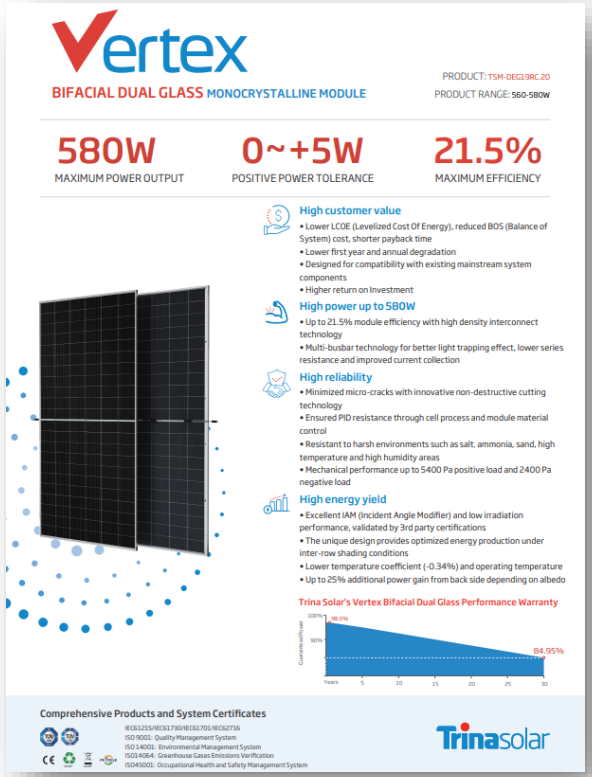
PVMI Differentiation



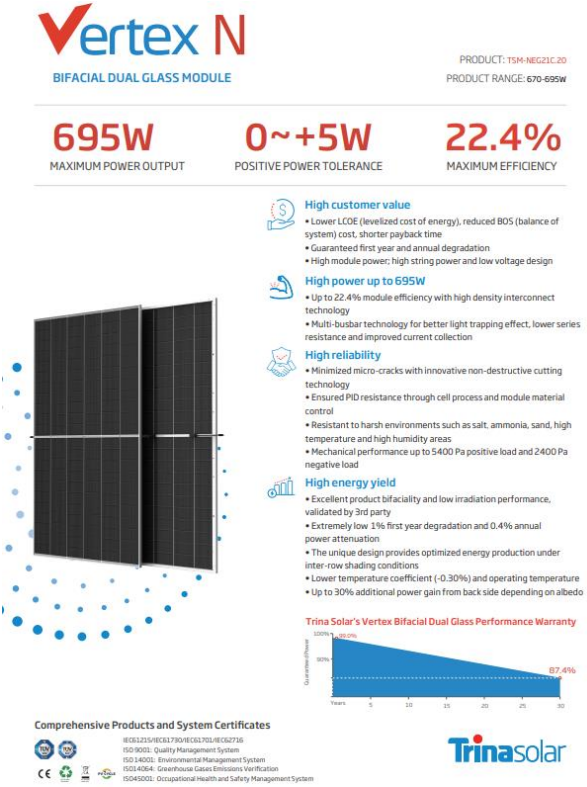
- Validated bill of materials manufactured under supervision
- Quality Audit and process assessment
- Comprehensive reliability testing
- Comprehensive Performance Testing
- PVMI High Achievers must demonstrate best in class ranking in all categories

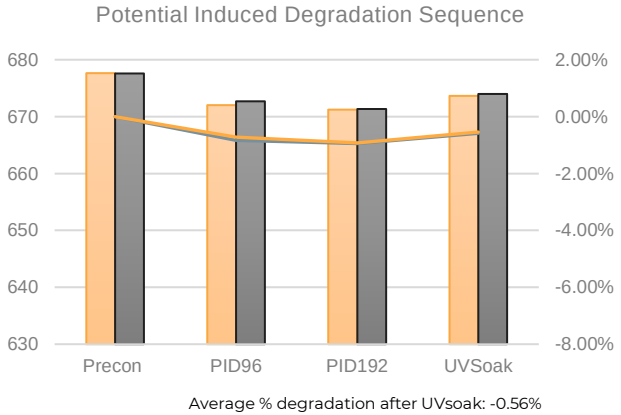
Trinasolar in the RETC PVMI



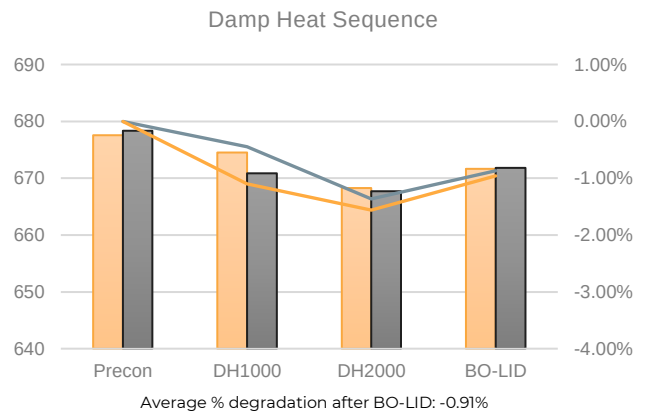


Thresher Test Results - TSM-NEG21C.20

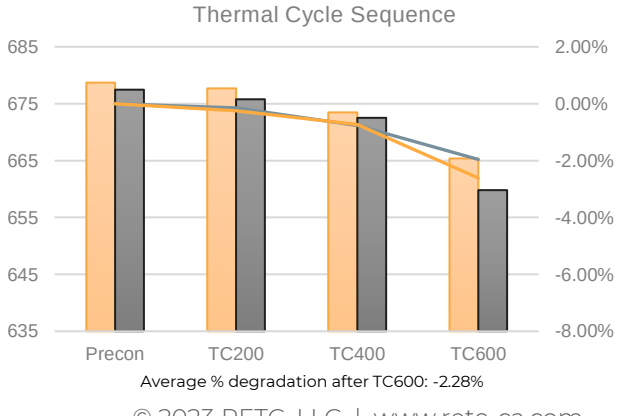




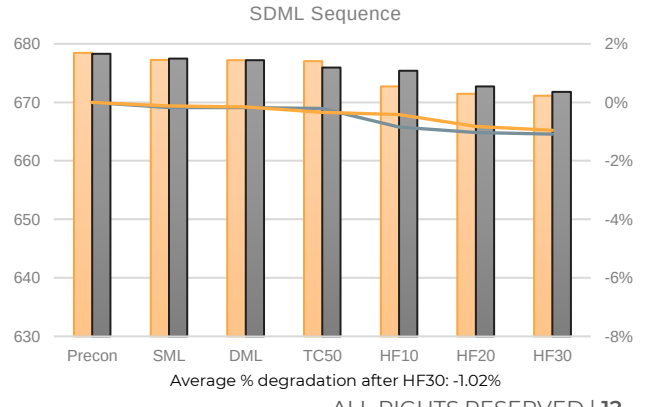
Average % degradation after UVsoak: -0.56%



Average % degradation after BO-LID: -0.91%



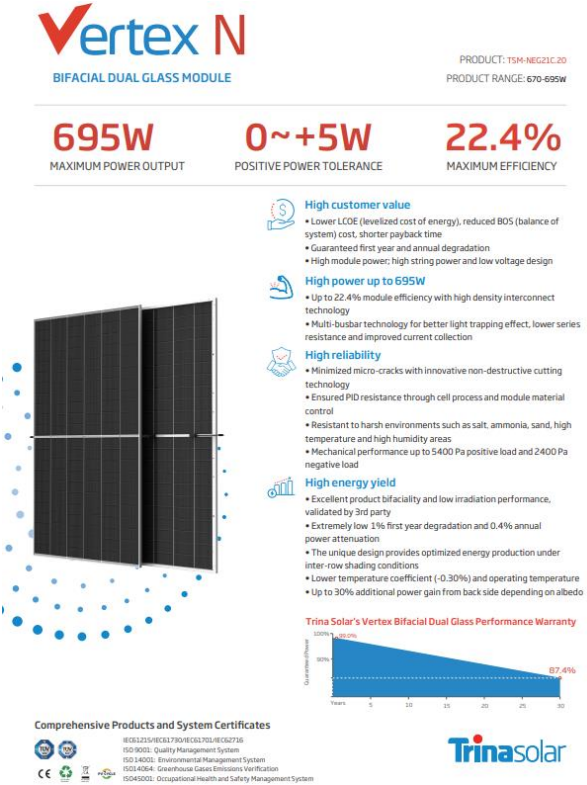
Average % degradation after TC600: -2.28%

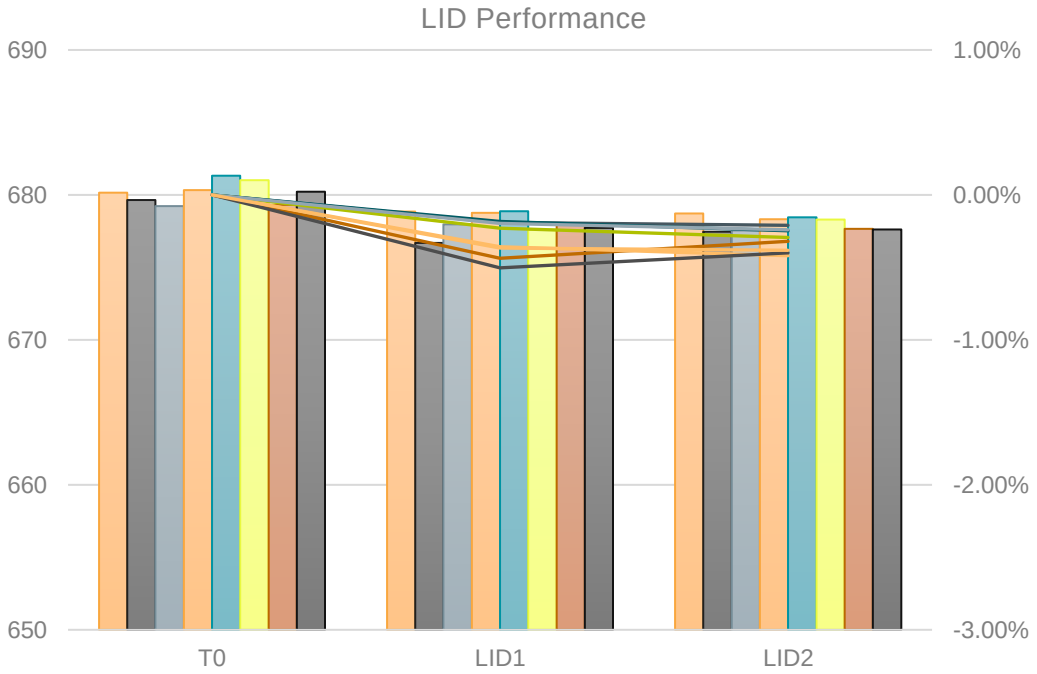


Average % degradation after HF30: -1.02%

RETC

Thresher Test Results - TSM-NEG21C.20





Average % degradation after post-LID2: -0.31%

Thresher Test Results - TSM-565DEG19RC.20

Vertex

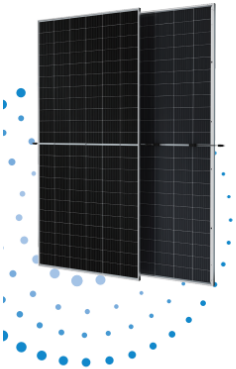
BIFACIAL DUAL GLASS MONOCRYSTALLINE MODULE

PRODUCT: TSM-DEG19RC.20
PRODUCT RANGE: 560-580W

580W MAXIMUM POWER OUTPUT

0~+5W POSITIVE POWER TOLERANCE

21.5% MAXIMUM EFFICIENCY



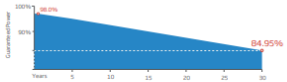
High customer value
- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance of System) cost, shorter payback time
- Lower first year and annual degradation
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power up to 580W
- Up to 21.5% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

High reliability
- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield
- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions
- Lower temperature coefficient (-0.34%) and operating temperature
- Up to 25% additional power gain from back side depending on albedo

Trina Solar's Vertex Bifacial Dual Glass Performance Warranty

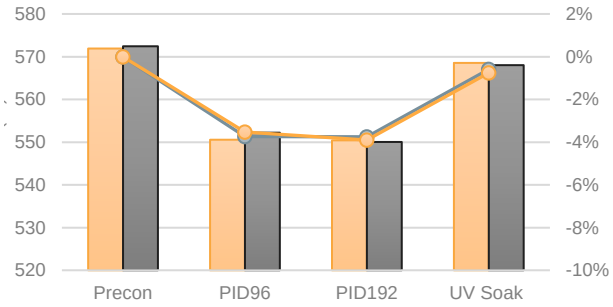


Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

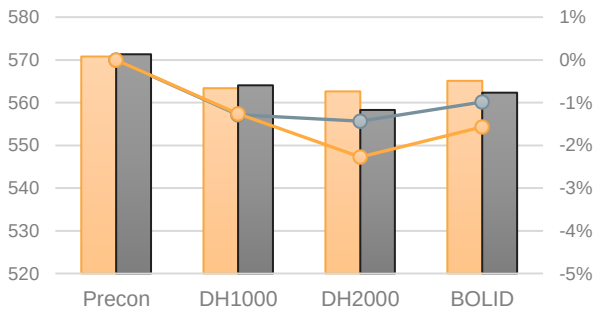
Trinasolar

PID Sequence



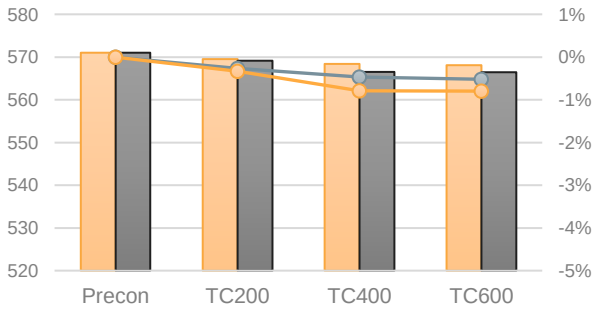
Average % degradation after PID+UV Soak: -0.68%

DH Sequence



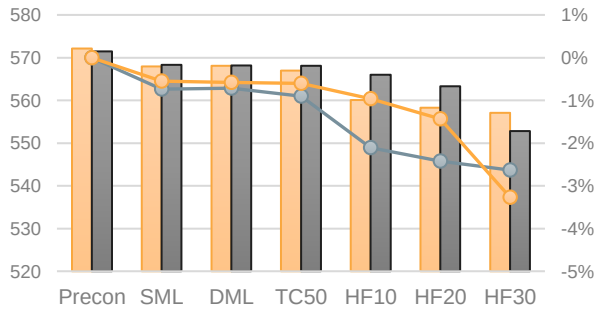
Average % degradation after BOLID: -1.28%

TC Sequence



Average % degradation after TC600: -0.66%

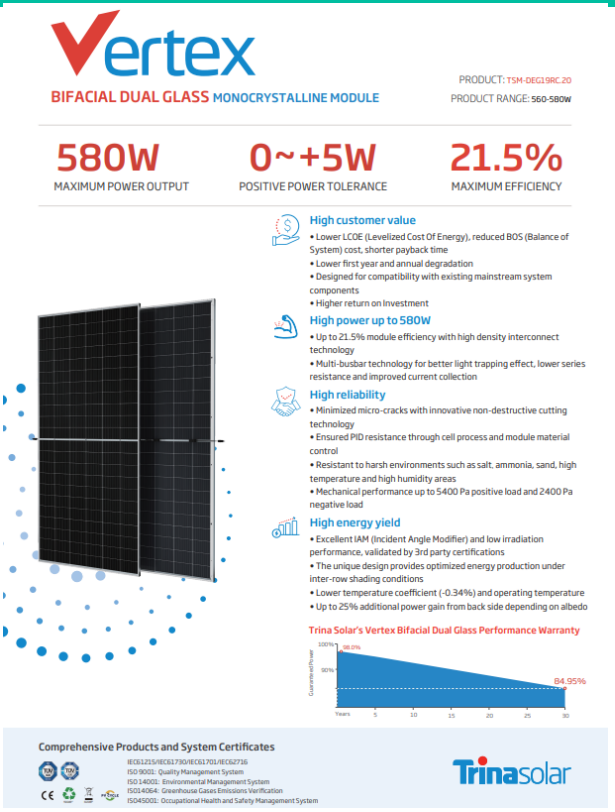
SDML Sequence

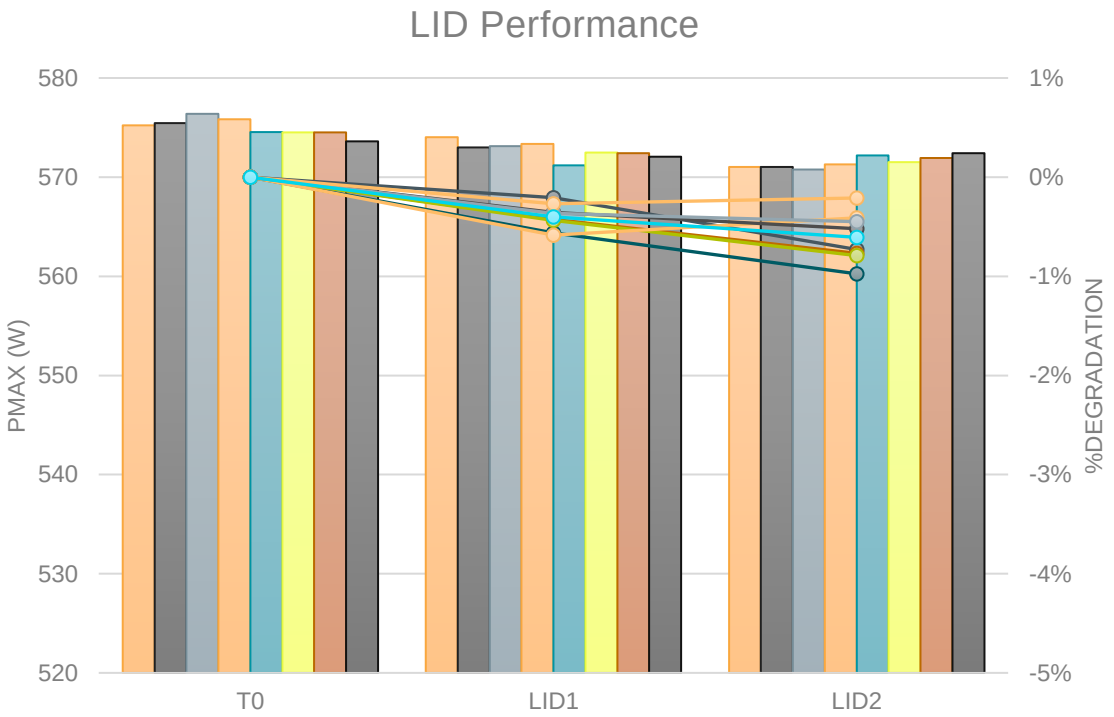


Average % degradation after HF30: -2.95%

RETC

Thresher Test Results - TSM-565DEG19RC.20





Average % degradation after LID1: -0.40%; after LID2: -0.61%

Trina is a **2023 Overall High Achiever**

Trinasolar

HIGH ACHIEVEMENT IN QUALITY

HIGH ACHIEVEMENT IN PERFORMANCE

LeTID Resistance • Module Efficiency • PTC

HIGH ACHIEVEMENT IN RELIABILITY

Damp Heat (DH2000) • SDML/TC50/HF30 • Thermal Cycle (TC600)

FOR MORE INFO

www.retc-ca.com • info@retc-ca.com

Performance Advantages of Topcon PV modules

Jason You

2023-07-13

CONTENTS

1.

Introduction of IEC 61853 series of standards

Scope and object

Photovoltaic (PV) modules are typically rated at STC (25 °C cell temperature, 1 000 $W \cdot m^{-2}$ irradiance, and air mass (AM) 1.5 global (G) spectrum). However, the PV modules in the field operate over a range of temperatures, irradiance, and spectra. The object of IEC 61853 is to accurately predict the energy production of the modules under various field conditions.

IEC 61853-1	Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating	Edition 1.0	2011
IEC 61853-2	Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements	Edition 1.0	2016
IEC 61853-3	Photovoltaic (PV) module performance testing and energy rating - Part 3: Energy rating of PV modules	Edition 1.0	2018
IEC 61853-4	Photovoltaic (PV) module performance testing and energy rating - Part 4: Standard reference climatic profiles	Edition 1.0	2018

PAN file

IEC 61853-1

Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating **Edition 1.0** **2011**

Irradiance	Spectrum		Module temperature		
$W \cdot m^{-2}$		15 °C	25 °C	50 °C	75 °C
1 100	AM1,5	NA			
1 000	AM1,5				
800	AM1,5				
600	AM1,5				
400	AM1,5				NA
200	AM1,5			NA	NA
100	AM1,5			NA	NA

IEC 61853-2

Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements **Edition 1.0** **2016**

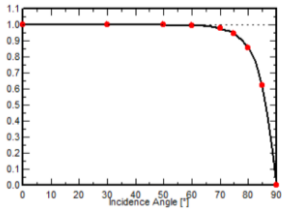
Spectral responsivity measurement

Follow the procedure in IEC 60904-8, using the short circuit condition, 25℃ device temperature and an appropriate bias light.

Measurement of incidence angle effects

$$\tau(\theta) = I_{sc}(\theta)/(\cos(\theta)\, I_{sc}(0))$$

$$\pi(\theta) = \frac{1 - \exp\frac{-\cos(\theta)}{a_r}}{1 - \exp\frac{-1}{a_r}}$$



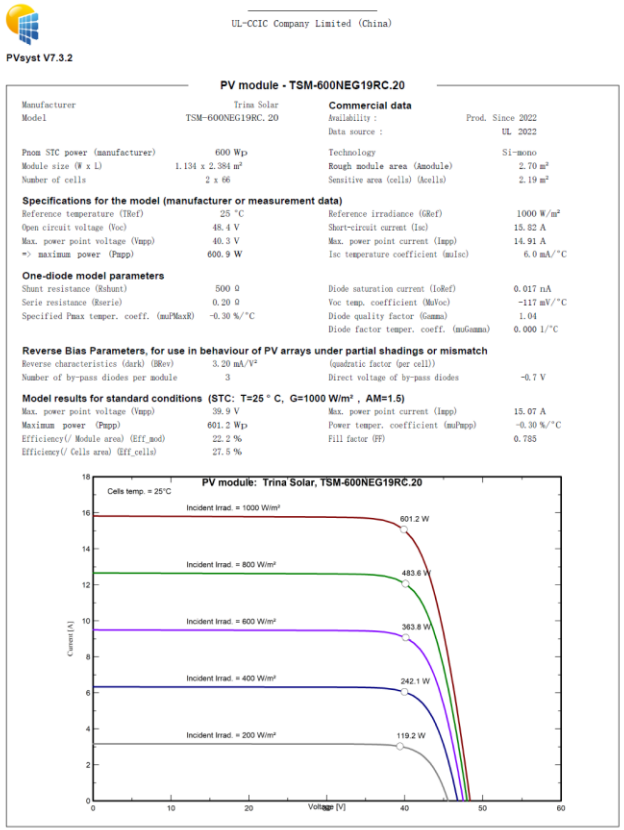
Determination of operating temperature

$$T_m - T_{amb} = G / (u_0 + u_1 v)$$

NMOT

PAN file

The PAN file is created using PVsyst, with the PV module's basic information, nominal STC parameters, measurement data of different irradiance and different temperature, Temperature coefficient, IAM, etc.



PVsyst V7.3.2

UL-CCIC Company Limited (China)

PV module - TSM-600NEG19RC.20

Manufacturer	Trina Solar	**Commercial data**	
Model	TSM-600NEG19RC. 20	Availability :	Prod. Since 2022
		Data source :	UL 2022
Pnom STC power (manufacturer)	600 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.384 m²	Rough module area (Amodule)	2.70 m²
Number of cells	2 x 66	Sensitive area (cells) (Acells)	2.19 m²

Specifications for the model (manufacturer or measurement data)

Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m²
Open circuit voltage (Voc)	48.4 V	Short-circuit current (Isc)	15.82 A
Max. power point voltage (Vmpp)	40.3 V	Max. power point current (Impp)	14.91 A
=> maximum power (Pmpp)	600.9 W	Isc temperature coefficient (muIsc)	6.0 mA/°C

One-diode model parameters

Shunt resistance (Rshunt)	500 Ω	Diode saturation current (IoRef)	0.017 nA
Serie resistance (Rserie)	0.20 Ω	Voc temp. coefficient (MuVoc)	-117 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.30 %/°C	Diode quality factor (Gamma)	1.04
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch

Reverse characteristics (dark) (BRev)	3.20 mA/V²	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V

Model results for standard conditions (STC: T=25 °C, G=1000 W/m² , AM=1.5)

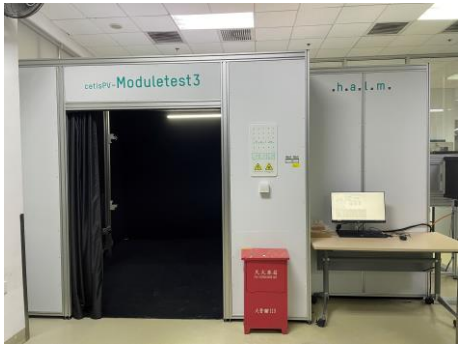
Max. power point voltage (Vmpp)	39.9 V	Max. power point current (Impp)	15.07 A
Maximum power (Pmpp)	601.2 Wp	Power temper. coefficient (muPmpp)	-0.30 %/°C
Efficiency(/ Module area) (Eff_mod)	22.2 %	Fill factor (FF)	0.785
Efficiency(/ Cells area) (Eff_cells)	27.5 %		

2.

Key control points of PAN file testing

Test equipment for PAN file in UL

1. High-precision test simulator, meets the A+ standard.
2. Independent ambient temperature control system, controls the ambient temperature at 25 within ± 0.5 ℃.
3. Multi-point temperature measurement of components, real-time monitoring of uniformity. The temperature uniformity of the module is controlled within 2℃.
4. IAM testing supports full-size samples, and high-precision angle measurement equipment can reach 0.01°.



Key control points

The following control points are considered for the accuracy of the test results:

- Factors that affect the accuracy of device measurement, such as voltage, current, power.
- The accuracy of irradiance, such as spectra, uniformity, stability, etc.
- Influence factors of WPVS calibration measurement, spectral matching, etc.
- Coplanar deviation of the measured sample and WPVS.
- Factors that affect the accuracy of sample temperature measurement.
- The inhomogeneity of sample temperature.
- The temperature differences between the inside cell and substrate of the sample.
- Test repeatability by different person.
- Influencing factors of angle measurement (for IAM).

3.

Performance advantages of TOPCon modules

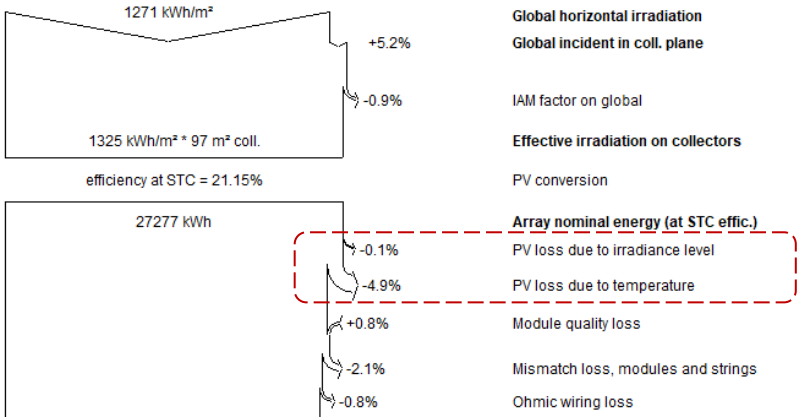
Performance advantages of test results

Temperature coefficients of Pmax [%/°C]

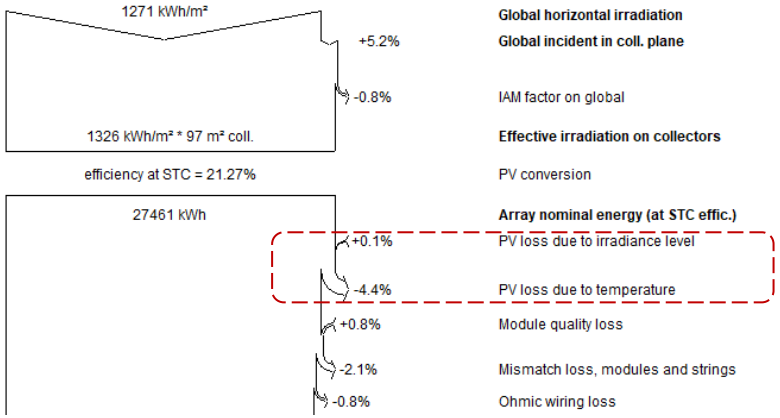
Efficiency of Low irradiance

Performance advantages in PVsyst simulation

- System Loss in a demo project, all settings are same except for PAN file of PV module.



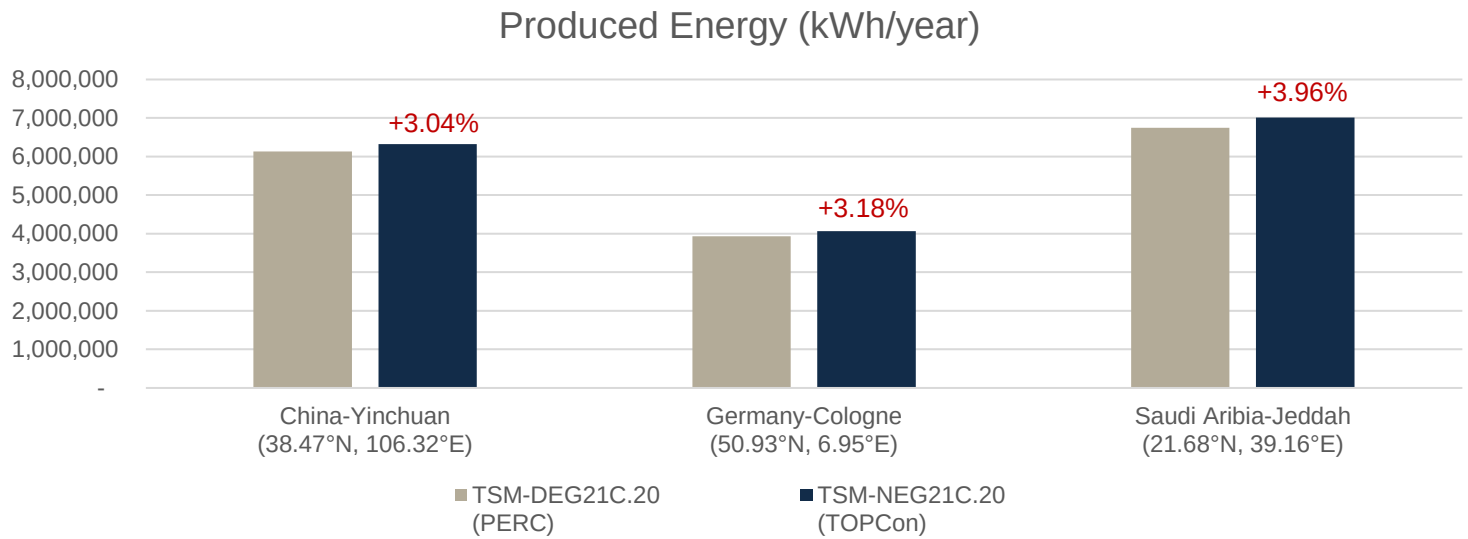
TSM-DEG19RC.20 (PERC)



TSM-NEG19RC.20 (TOPCon)

Performance advantages in PVsyst simulation

- Produced Energy (kWh/year) for 3.1 MW demo projects in different locations.



Thank you

Jason.you@ul.com

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Reliability analysis of n-type modules
Q&A

13 July 2023
10:00 am – 11:00 am | EDT, New York City
11:00 am – 12:00 pm | BRT, São Paulo
4:00 pm – 5:00 pm | CEST, Berlin, Madrid

Anne Fischer
Senior Editor
pv magazine USA

Rocky Li
Product Manager
Trina Solar

Cherif Kedir
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Tuesday, 25 July 2023
1:00 pm – 2:00 pm EDT, New York City
7:00 pm – 8:00 pm CEST, Berlin, Paris, Madrid

The IRA domestic content bonus and its implications on developers and manufacturers

Monday, 31 July 2023
2:00 pm – 3:00 pm CEST, Berlin, Paris, Madrid
4:00 pm – 5:00 pm Dubai

How liquid cooled ESS helps achieving a lower LCOS for utility-scale applications

Many more to come!

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Anne Fischer
Senior Editor
pv magazine USA

Thank you for joining today!