Is Module a Module?

How to choose PV module?

- **Efficieny**
- **Price**
- **Brand**
- **What else?**

THE DUPONT PORTFOLIO OF INNOVATIVE MATERIALS FOR SOLAR MODULES

CRYSTALLINE SILICON MODULE

A PHOTOVOLTAIC ENCAPSULANTS
DuPont™ PV5400 Series encapsulant sheeting
DuPont™ PV8600 Series encapsulant sheeting

B PHOTOVOLTAIC METALLIZATIONS
DuPont™ Solamet® photovoltaic metallizations

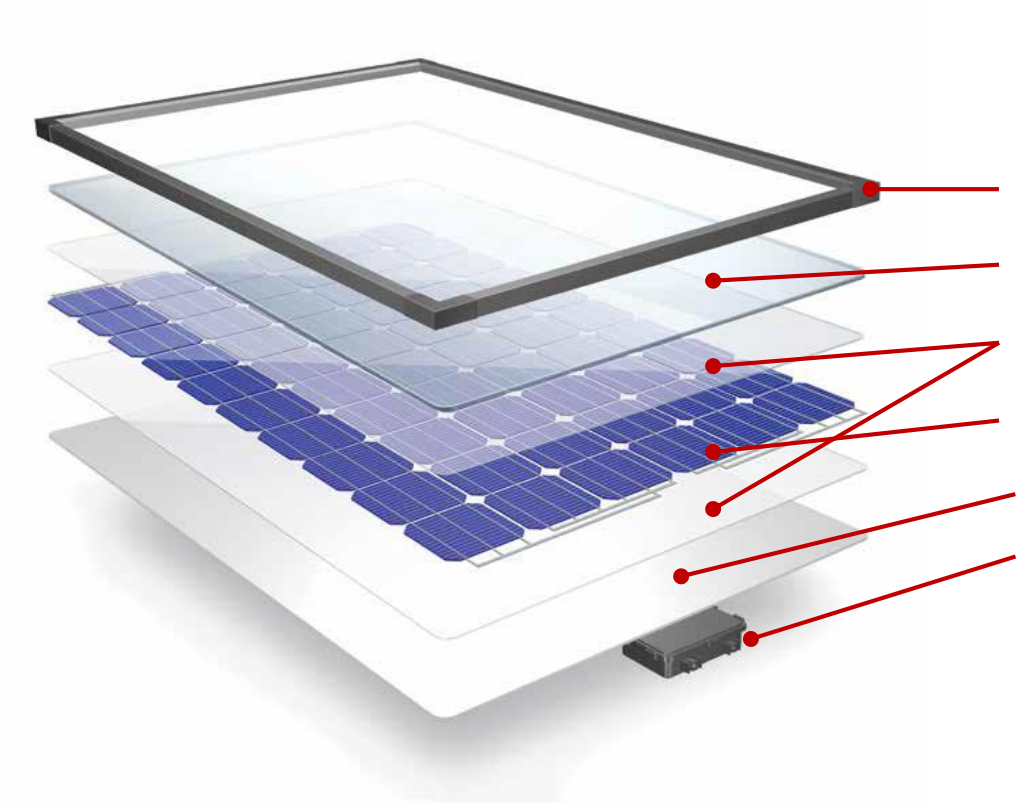
C SILICON DOPING TECHNOLOGIES
DuPont™ Innovalight™ silicon inks

D ELECTRICAL AND STRUCTURAL COMPONENT MATERIALS
DuPont™ Rynite® PET thermoplastic polyester resins
DuPont™ Crastin® PBT polybutylene terephthalate resins

E BACKSHEET MATERIALS
DuPont™ Tedlar® PVF films

Failure Rate By Product Component

Update red numbers



MODULE COMPONENT	% COST	% FAILURE
Al Frame	6%	3%
Glass	4%	2%
Encapsulant	3%	5%
Cell	54%	14%
Backsheet	6%	14%
Junction Box	3%	3%
Processing Cost	21%	

Source: DuPont calculation based on Photon Consulting "Solar Annual 2014“, PVInsights, DuPont field module survey including more than 70 global installations, (700,000+ modules at 150+ MW) in NA, EU and AP
Note: Cost data are calculated to illustrate the overall breakdown and not about specific products

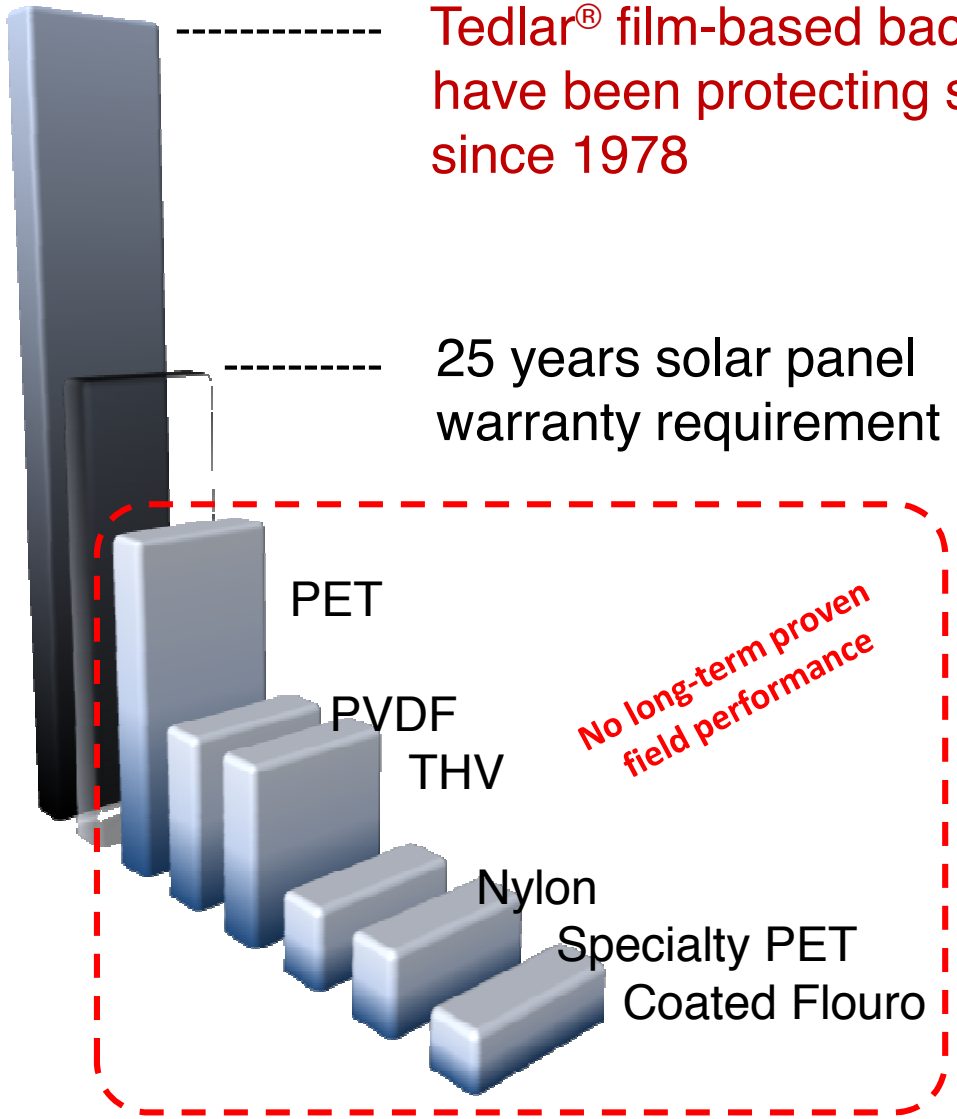
Tedlar® PVF Film Based Backsheets were Selected by NASA After Decade Long Module Reliability Program

Block	Years	Manufacturer	Top Cover	Encapsulant	Backsheet	Number of Modules
I	1975-1976	Sensor Tech	RTV-615	RTV-615	Aluminum	6,750
		Solarex	Sylgard 184	Sylgard 184	NEMA-G10 Board	
		Solar Power	D.C. R4-3117	Sylgard 184	NEMA-G10 Board	
		Spectrolab	Glass	RTV-615	Aluminum	
II	1976-1977	Sensor Tech	RTV-615	RTV-615	Aluminum	5,291
		Solarex	Sylgard 184	Sylgard 184	NEMA-G10 Board	
		Solar Power	D.C. XL-2577	Sylgard 184	GFR Polyester Board	
		Spectrolab	Glass	PVB	Mylar®	
III	1978-1979	Arco Solar	Glass	PVB	Tedlar®	9,961
		Motorola	Glass	D.C 03-6527A	Stainless Steel	
		Sensor Tech	RTV-615	RTV-615	Aluminum	
		Solarex	Sylgard 184	Sylgard 184	NEMA-G10 Board	
		Solar Power	D.C. R4-3117	Sylgard 184	GFR Polyester Board	
IV	1980-1981	Arco Solar	Glass	PVB	Tedlar®/Stainless/Tedlar®	481
		ASEC		PVB	Tedlar®	
		GE Solar		GE SCS2402	MEAD PAN-L-Board	
		Motorola		PVB	Tedlar®/Al/Tedlar®	
		Photowatt		PVB	Tedlar®/Al/Tedlar®	
		Solarex		EVA	Tedlar®	
		Solarex		EVA	Tedlar®	
		Spire		EVA	Mylar®/Al-Coat	
V	1981-1985	Arco Solar	Glass	EVA	Tedlar®/PET/Tedlar®	"10's" of Modules for evaluation
		GE Solar			Tedlar®/PET/Al Tedlar®	
		MSEC			PET/Al/Tedlar®	
		Solarex			PET/PET/Tedlar®	
		Spire			Tedlar®	

- US Department of Energy contracted NASA's Jet Propulsion Lab (JPL) to develop 30 year PV modules
- NASA's JPL conducted 5 rounds of fielded module and lab testing to develop reliable, durable, and safe 30 year PV modules
- Failure rates decreased from 45% in pre-Block V modules to less than 0.1% in Block V Modules
- All of the module designs in the 5th round of experiment adopted Glass/EVA/Tedlar®-based back sheet structure as the standard.

This Program Resulted in Adoption of Glass/EVA/Tedlar® Backsheet as the Safe And Reliable PV Module Construction

DuPont™ Tedlar® PVF Film Has 30+ Years of Proven Field Performance



Source: DuPont, various

Tedlar® PVF-based backsheets in the field

Low power loss and No material degradation

SYSU China 1985
0.4% annual power loss

Nara, Japan, 1983
0.2% annual power loss

Mont Soleil, Switz. 1992
0.3% annual power loss

SUPSI Switzerland 1982
0.4% annual power loss

SMUD USA 1984
0.9% annual power loss

Beijing 1999
0.7% annual power loss

DUPONT™

In China, India, Turkey and some other markets, non-recourse finance is rare and cannot be assumed. From 2Q 2017, we will therefore require additional evidence that a deal is non-recourse (public disclosure or a copy of the agreement with a bank) to include a financing in our database and therefore count it for tiering.

4. Can I share this list on the internet?

No. If you have accessed this through your BloombergNEF subscription, you can share with selected business partners who will not release it further. Pirate copies on the internet may be doctored and are published without BNEF's permission and against our terms and conditions.

Table 1 shows the module makers which, as of 1Q 2023, meet our criteria of supplying projects with non-recourse financing from six different commercial banks in the last two years, as tracked by our database.

Table 1: Photovoltaic module manufacturers meeting BloombergNEF's Tier 1 criteria as of 1Q 2023

Firm/ brand	Annual module capacity, MW/year	Firm/ brand	Annual module capacity, MW/year
ZNShine*	10,000	Leapton Energy	2,000
Yingli*†	11,650	Jolywood*	3,000
Waaree*	9,000	Jinneng/ Jinergy	4,000
VSUN Solar*	3,800	Jinko*†	70,000
Ulica Solar	3,000	Jetion	2,500
Trina*†	60,000	JA Solar*†	51,000
Tongwei	14,000	Heliene*†	950
Suntech	15,000	Hanwha Q-Cells*†	12,400
Sunpro Power	2,000	Hansol Technics	600
Sumec/ Phono Solar*	4,000	Haitai Solar	8,000
Solar-Fabrik	50	First Solar*†	11,200
Sharp	210	Exiom Group	700
Seraphim	7,750	ET Solar Inc*	2,000
Risen Energy*	25,000	Eging*	10,000
Renesola	3,000	DMEGC*	7,500
Recom†	1,200	Chint/ Astronergy*†	22,000
Neo Solar Power/ URE	1,800	Canadian Solar	31,400
Maxeon*	10,100	Boviet Solar*	1,500
Luxen Solar	2,200	Anhui Huasun*	2,700
Longi*†	80,000	AE Solar*	1,600
		Total	**508,810**

*Source: BloombergNEF Note: Methodology here. * denotes a company for which technical due diligence reports are available from PV Evolution Labs, PVEL. Contact Tristan.erion-lorico@pvel.com. † denotes manufacturers upon which RETC has recently conducted or is conducting technical due diligence. Contact info@retc-ca.com for details. Brands are shown in reverse alphabetical order to avoid giving the impression that position in the list is significant. Companies can download the dataset of financings here.*

Historical Scorecard

The table below shows the history of top performance for all manufacturers featured in the 2022 Scorecard. Manufacturers are listed by the number of years they have been designated a Top Performer, in alphabetical order.

	2022	2021	2020	2019	2018	2017	2016	2014
Jinko	■	■	■	■	■	■	■	■
Trina Solar	■	■	■	■	■	■	■	■
JA Solar	■	■	■	■	■		■	■
Qcells	■	■	■	■	■	■	■	
REC Group	■	■	■	■	■	■	■	
Astronergy	■	■	■		■	■		■
LONGi	■	■	■	■	■	■		
Adani Solar	■	■	■	■	■			
Maxeon/SunPower	■	■	■		■	■		
Phono Solar	■	■		■	■		■	
Seraphim/SEG Solar	■	■	■	■		■		
Suntech	■		■	■	■			■
Vikram Solar	■	■	■	■		■		
Boviet Solar	■	■	■	■				
First Solar	■	■	■		■			
HT-SAAE	■	■	■		■			
ZNShine	■			■				■
Talesun	■	■				■		
DMEGC	■	■						
ET Solar	■	■						
Heliene	■		■					
HHDC/SPIC	■	■						
Risen Energy	■	■						
VSUN	■	■						
Waaree	■							

Jinko Solar

Building **Your Trust** in Solar

No.1 Shipment

for 4 Consecutive Years

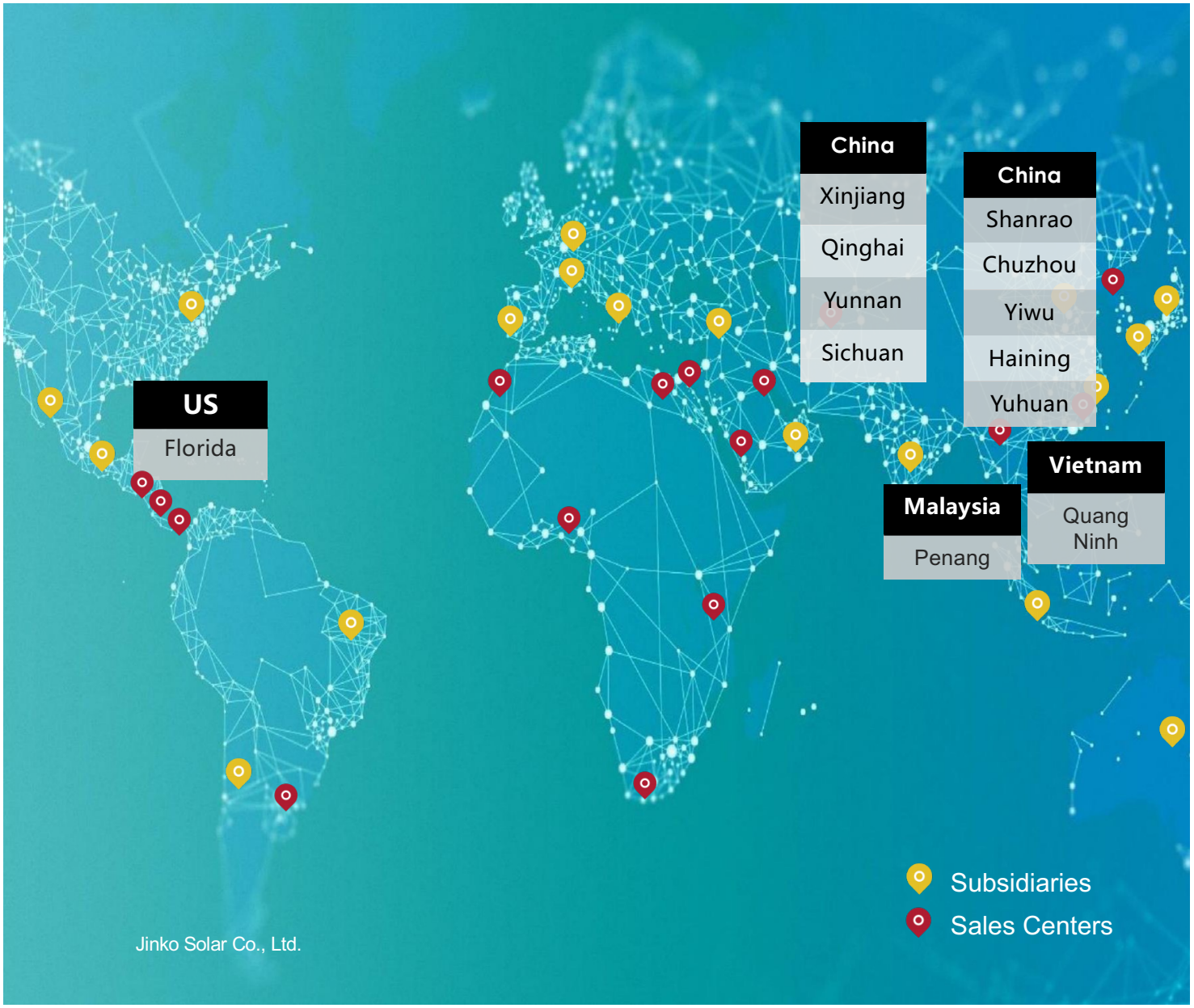
130+GW
Delivered

12%
Market Share

19
World Records

70GW
Module Capacity

*Data as of the end of 2022 Q4



JinkoSolar Global Layout

Providing highly localized solutions

12
Production Facilities

25000+
Employees

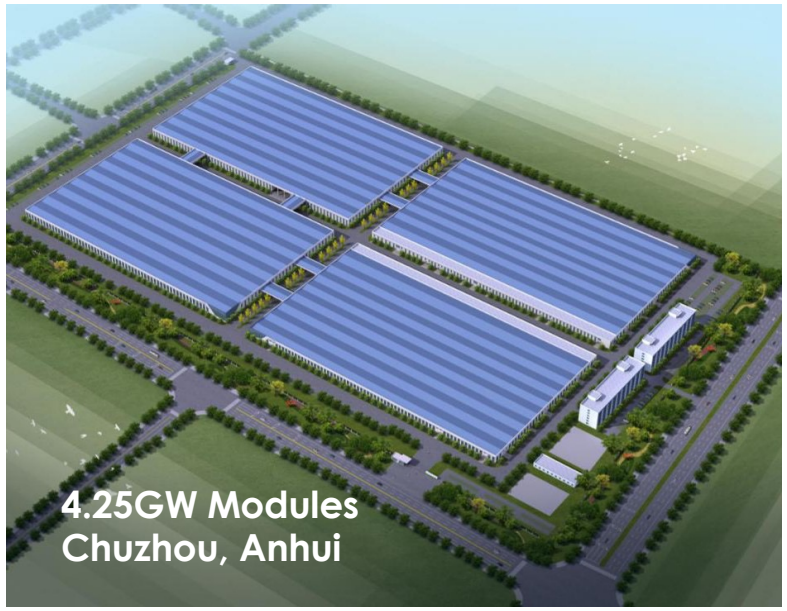
30+
Service Centers

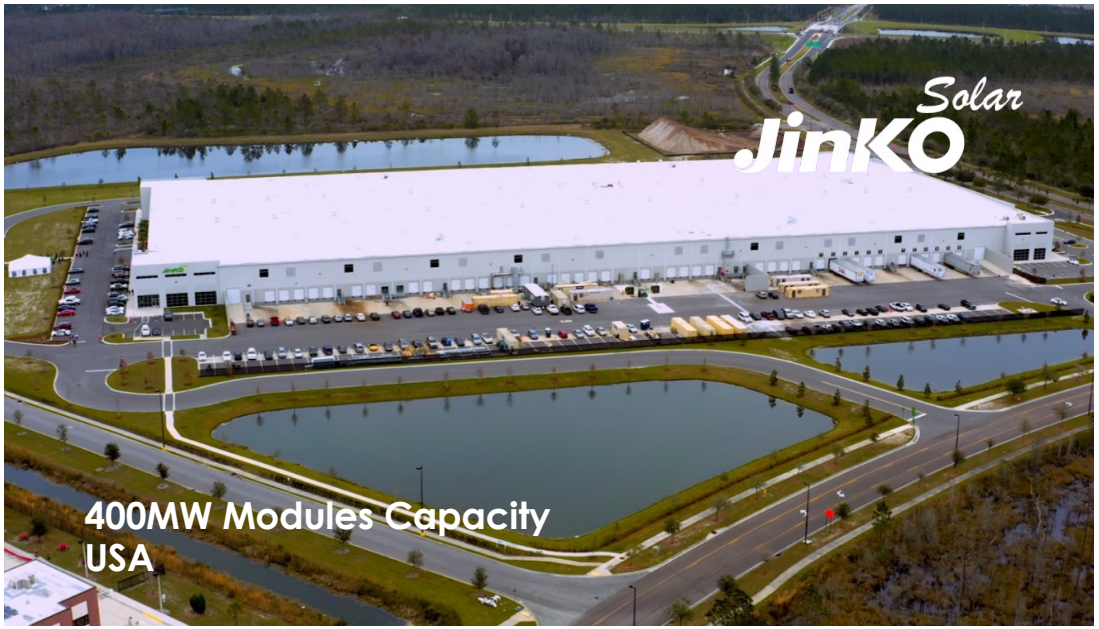
3000+
Customers

160+
Covered Countries

JinkoSolar Domestic Factories High-Efficient Capacity Layout

Jinko Solar Co., Ltd.





JinkoSolar Overseas Factories High-Efficient Capacity Layout

Global Leader in Technological Innovation

Applied for 1632 Patents

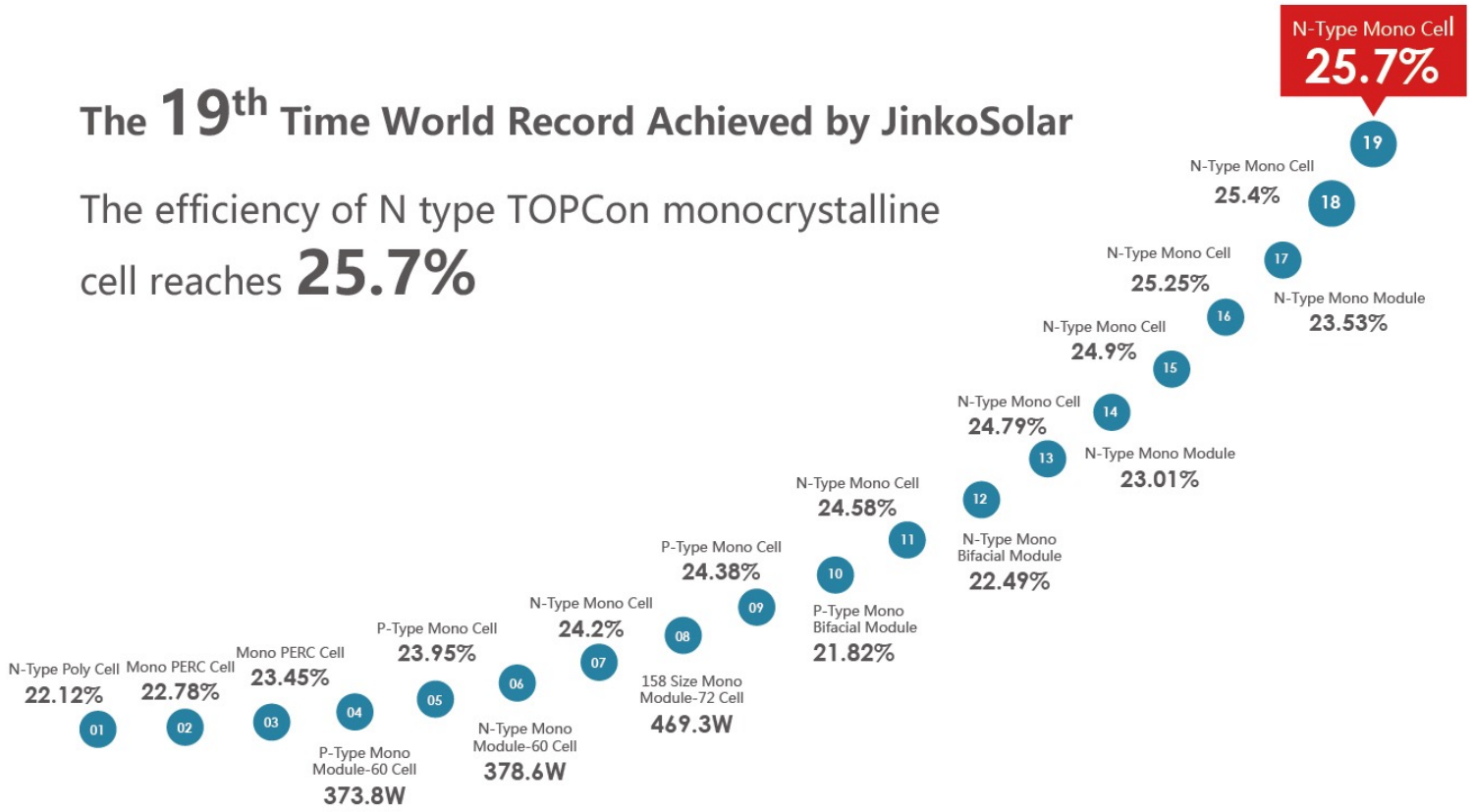
968 Authorized Patents

R&D Team 900+Engineers and Scientists

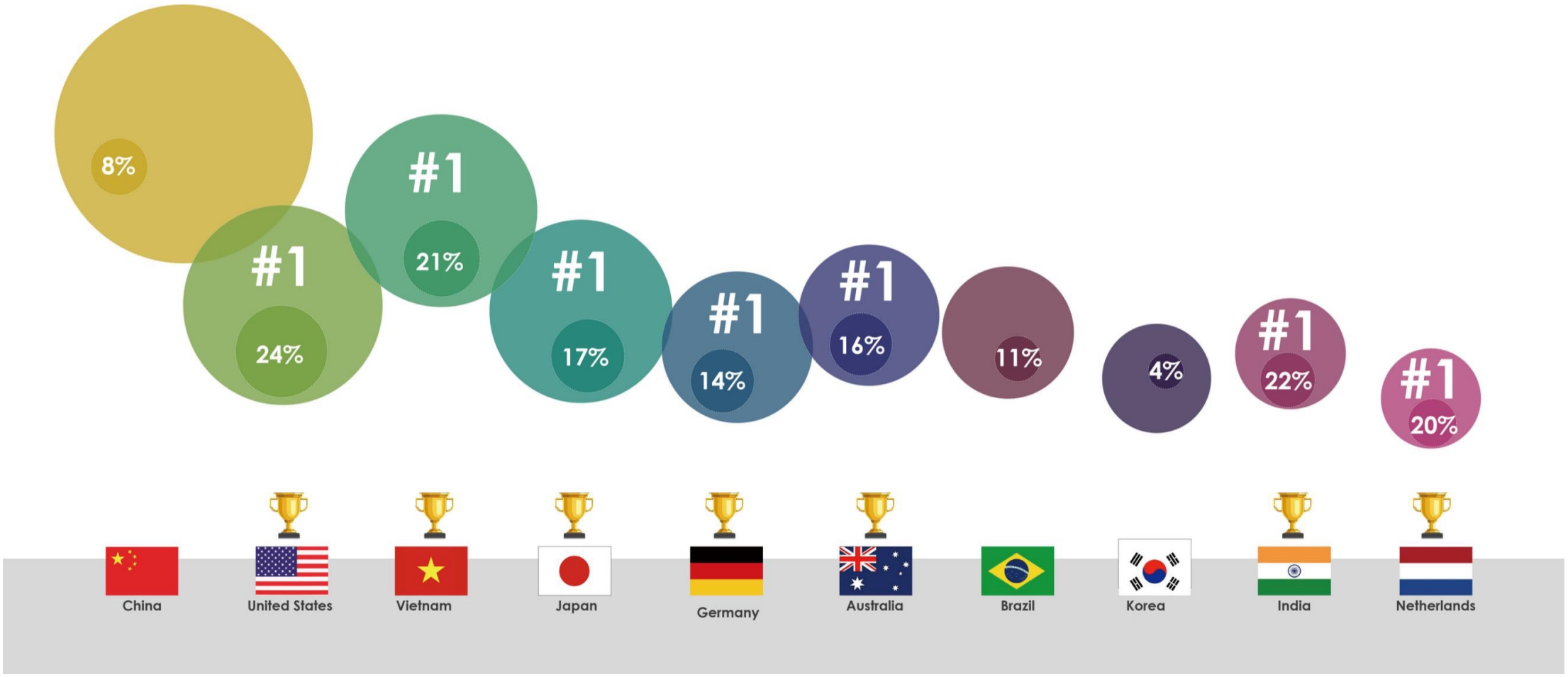
R&D Investments 1.274 Billion (CNY)

The 19th Time World Record Achieved by JinkoSolar

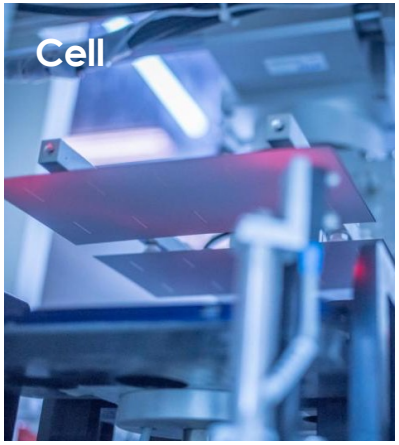
The efficiency of N type TOPCon monocrystalline cell reaches **25.7%**

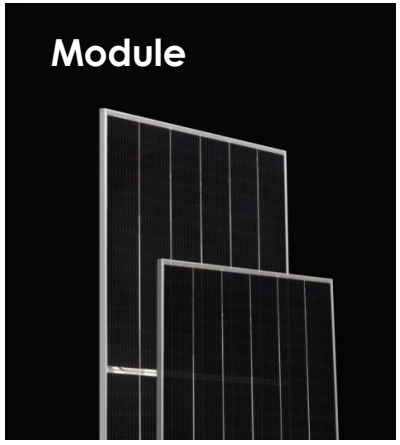


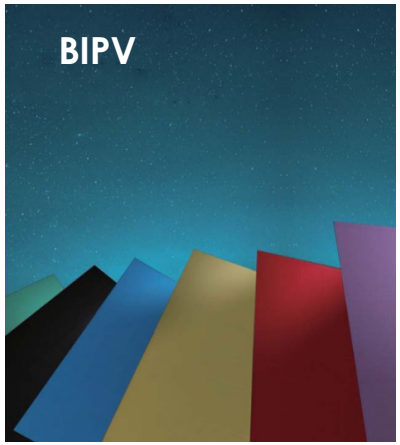
JinkoSolar Market Share Rankings in the Top Ten PV Markets, 2020



Our Core Businesses







Solar Business

We are continuously expanding the production capacity of silicon wafers, cells and modules to create a vertically integrated PV industrial chain

Our Solutions

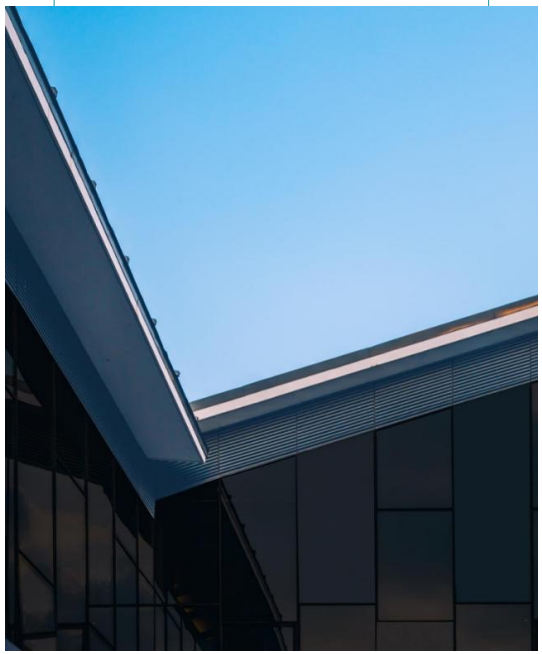
BIPV+BAPV to foster the development of green buildings

Solar+ Solutions and Energy Storage

Solutions - Solar+

Solar+ESS

Solar+Building



Solar+Pumping

Solar+Communication

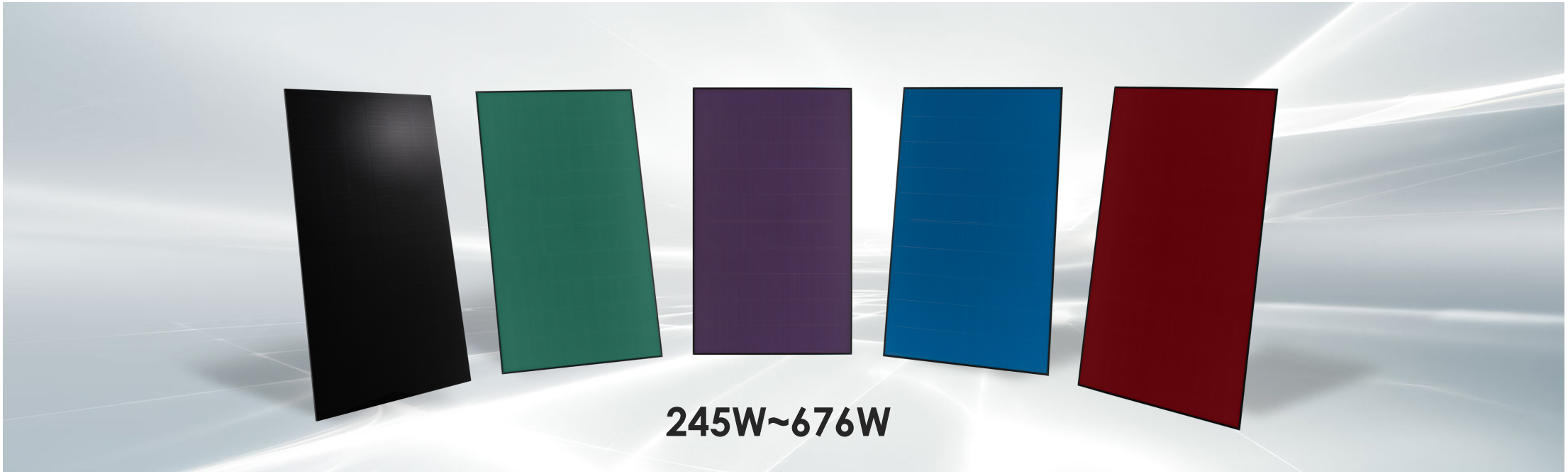
Our Solutions - Energy Storage Products

Residential Storage System
(1kWh-50kWh)

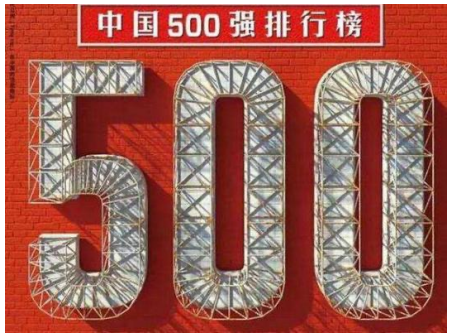
C&I Storage System
(50kWh-1MWh)

Utility Storage System
(≥1MWh)

Our Solutions - BIPV



Comprehensive power coverage | Diversified colors | Optimized transmittance | Full customization



Awards

- Ranked 325 in China's Fortune 500 in 2020, on the list for six consecutive years
- In 2020, ranked 144 of China's top 500 private enterprises in the All-China Federation of Industry and Commerce, on the list for seven consecutive years
- In 2020, ranked 10th in the "Top 500 Global New Energy Companies, and has been on the list for ten consecutive years
- 2020 HR Asia Best Employer
- 2020 "21st Century Business Herald" and "Excellent Board of Directors of Listed Companies"
- In 2019 won the Rushlight Natural Energy Award and Solar Energy Award
- 2019 Panel Technology Award
- 2019 Integrated Marketing Innovation Award
- 2018 World Brand Awards
- 2018 "The Asset" Best Corporate Governance Award-Gold Award
- 2018 Boston "Top 100 Global Challengers"
- Co-chair of the B20 Germany 2021 Climate and Energy Efficiency (ECRE) Taskforce
- 2016 Fortune's 16th fastest growing company in the world
- Member of B20 Hangzhou 2016 Infrastructure Taskforce
- 2015 Paris Climate Summit "Today's Change Award"
- Vice Chairman of the G20 China Business Council

.....

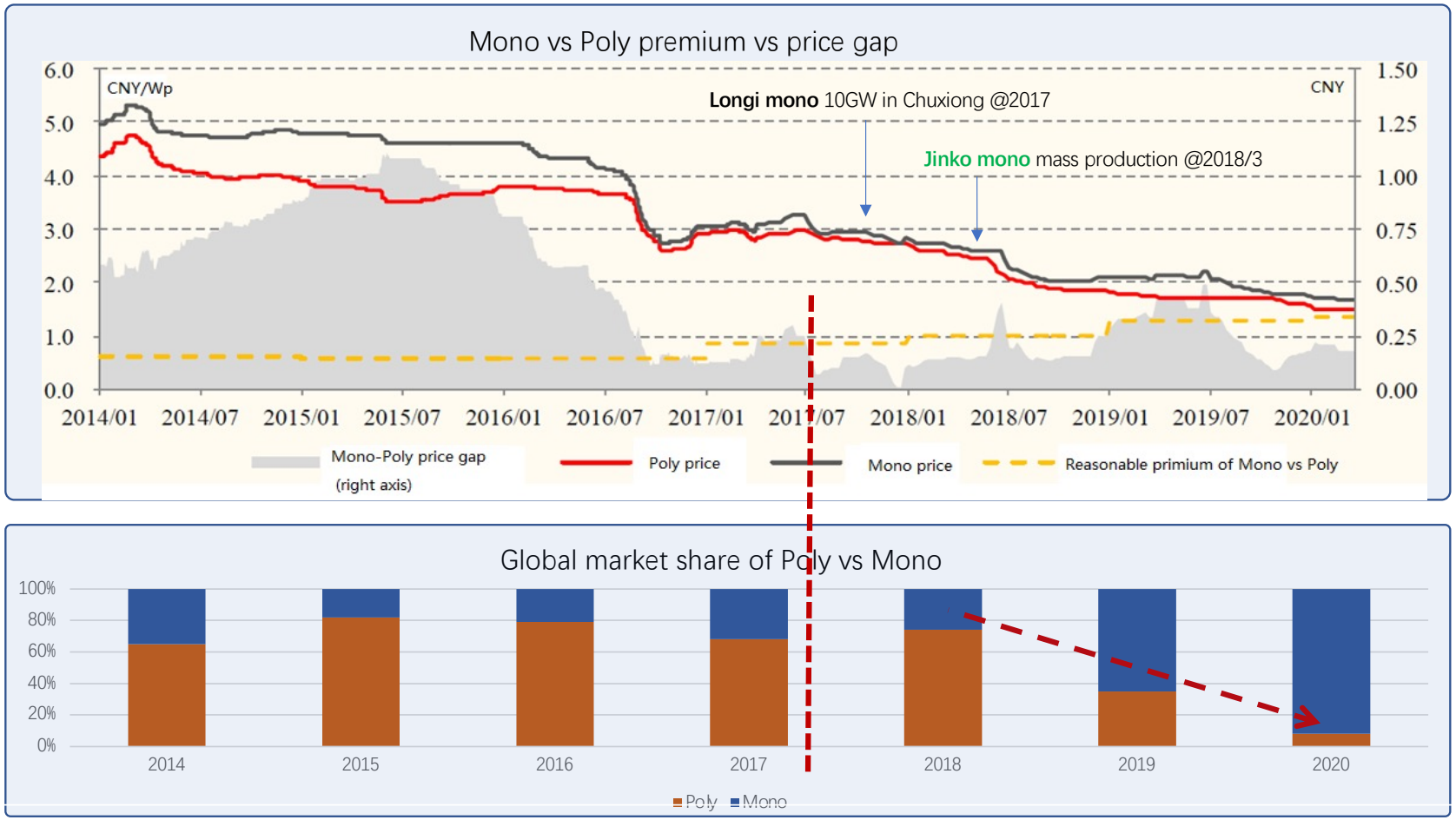

RE 100
JinkoSolar was the first module supplier to join the RE 100, committing to power 100% of its operations with renewable energy by 2025
JinkoSolar Holding Co., Ltd.
jinkosolar.com

N-type TOPcon

The next BIG THING after PERC

Jinkosolar Technical Dept.

The past and future: Mono-vs-Poly and N-vs-P



1. Longi led the story of Mono replacing Poly; It took 2-3 years for Mono to dominate the market after Mono vs Poly premium > price gap.
2. The story of N replacing P is very comparable with Mono-vs-Poly. Now the premium of N vs P is larger than its price gap. N might dominate the market gradually in next 2-3 years.
3. JinKO is leading the N replacing P story, like what Longi did in mono replacing poly story.

Background of N-type Technology

24. 5%

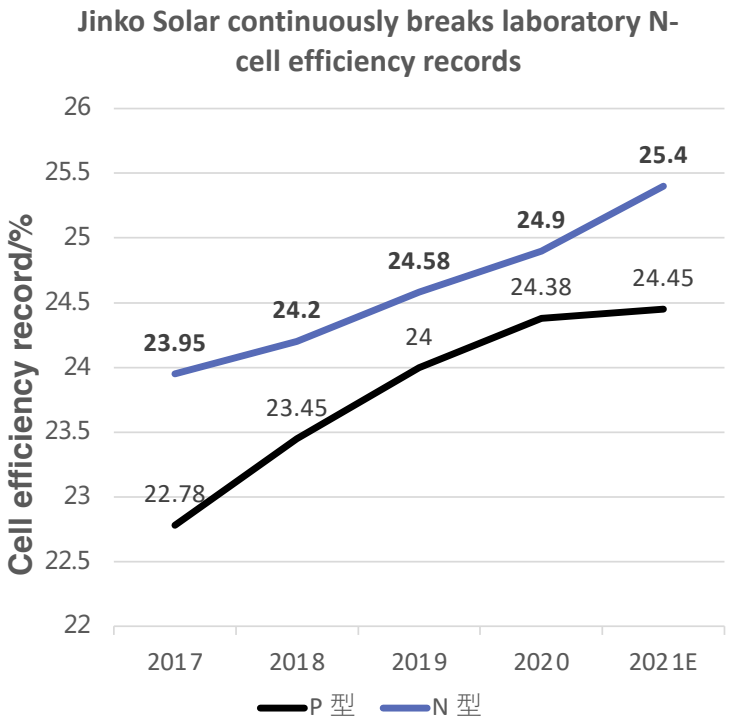
Mass Production Efficiency

The application of Topcon technology has contributed to a new breakthrough of cells efficiency, in mass-production, the cells efficiency can reach 24.50%.

28.70%

Higher Efficiency Limits

Topcon cells have higher efficiency limit (28.2%~28.7%), much higher than that of PERC cells .



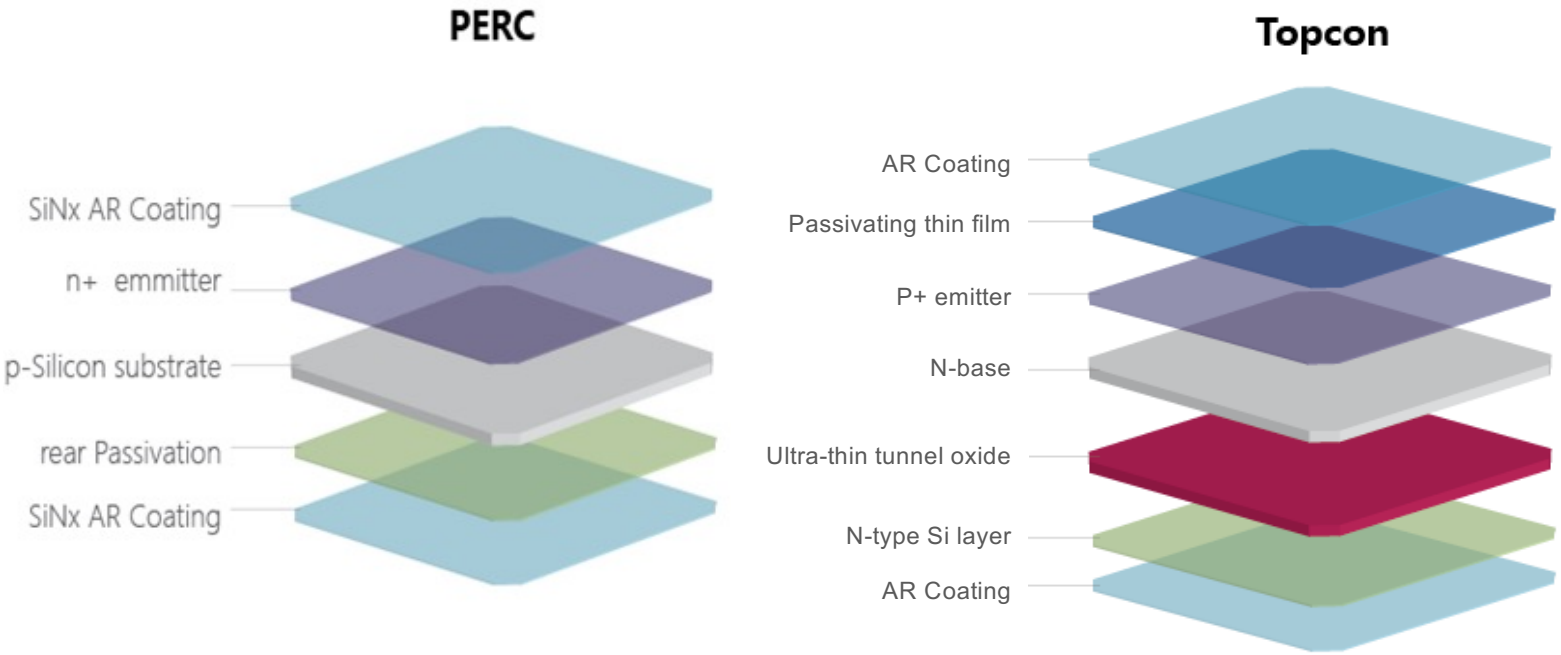
Source：Jinko public data

$S_{10,e\&h,max}$	$f_{e,max}$ [%]	Electron-selective contacts													
$f_{h,max}$ [%]	$\eta_{e\&h,max}$ [%]	P-diffused n^+ [57]		a-Si:H(i) /a-Si:H(n) [58]		th-SiO_x/ poly-Si(n^+) PECVD [84]		th-SiO_x/ poly-Si(n^+) LPCVD [59]		chem-SiO_x/ poly-Si(n^+) LPCVD [60]		SiO_x/TiO_2 [133]		MgO_x [134]	
Hole-selective contacts	Al-doped p^+ [61]	11.7	56	12.8	64	12.6	23	12.9	6.4	13.0	0.12	12.5	12	11.9	4.1
		3.5	24.5	1.3	26.8	1.2	26.9	1.2	27.1	1.1	27.1	1.6	26.3	2.9	24.9
	a-Si:H(i) /a-Si:H(p) [58]	11.8	51	13.2	76	13.3	18	13.5	6.6	13.5	0.90	12.8	9.7	12.0	3.6
		464	24.7	152	27.5	144	27.7	134	27.9	133	28.0	190	26.8	379	25.1
	chem-SiO_x/ poly-Si (p^+) [85]	11.9	47	13.6	64	13.8	15	14.2	5.8	14.2	0.8	13.1	8.2	12.1	3.3
		21	24.9	6.4	28.1	6.1	28.3	5.8	28.7	5.7	28.7	8.0	27.3	17	25.4
	chem-SiO_x/ Si:C (p^+) [88]	11.9	47	13.5	66	13.7	16	14.0	5.8	14.1	0.8	13.0	8.4	12.1	3.3
		37	24.9	11	28.0	11	28.2	10	28.5	10	28.6	14	27.2	30	25.3
	a-Si:H(i)/ MoO_x [128]	11.7	59	12.6	107	12.7	26	12.8	9.4	12.8	1.3	12.4	13	11.8	4.4
		242	24.4	95.9	26.5	91.5	26.6	85.6	26.8	84.9	26.8	115	26.0	203	24.7
	MoO_x [139]	11.6	67	12.3	139	12.4	34	12.4	12	12.4	1.8	12.2	16	11.7	5.0
		14	24.1	6.2	25.9	6.0	26.0	5.7	26.1	5.6	26.1	7.2	25.5	12	24.4
	PEDOT :PSS [132]	11.6	65	12.4	133	12.4	32	12.5	12	12.5	1.7	12.2	16	11.7	4.9
		47	24.1	21	26.0	20	26.1	19	26.2	19	26.2	25	25.6	40	24.5

PERC Cell efficiency limit

TOPCon Cell efficiency limit

Source: Surface passivation of crystalline silicon solar cells: Present and future, Jan Schmidta, Robby Peibst, Rolf Brendela,2019, PV silicon Conference



TOPCon

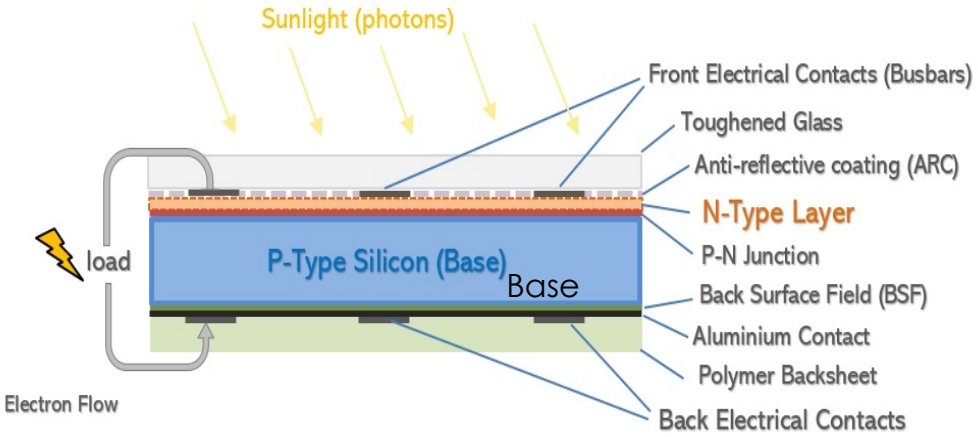
Higher boron atomic activation rate

Less impurities

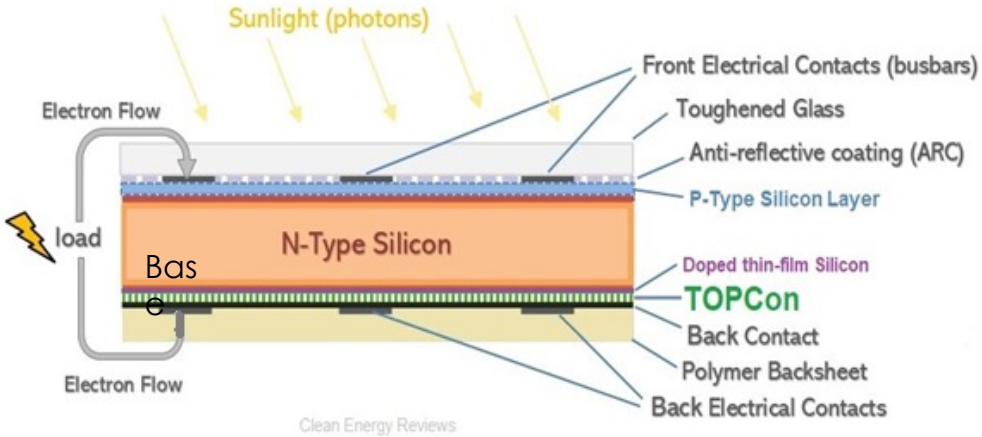
Better thickness uniformity

Better carrier conductivity

P-Type



N-Type TOPCon



P Layer (Silicon doped with Boron) **–** Deficiency of electrons area, abundance of electon holes
P-N junction – depletion region created when P and N layers are in contact
N Layer (Silicon doped with Phosphorous) – Abundance of electrons, few electon holes

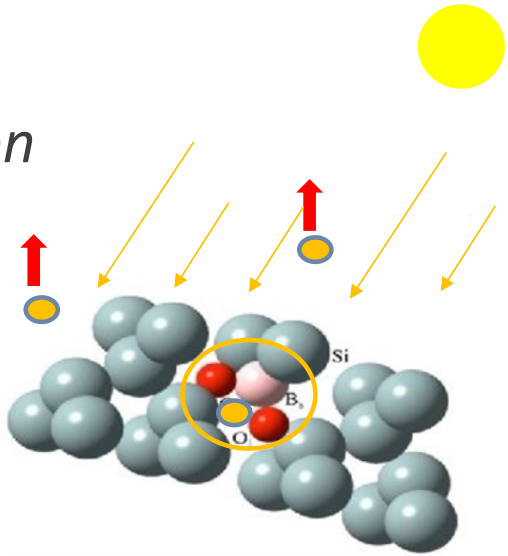
Due to the very nature and material composition N-type cells offer higher performance through having a greater tolerance to impurities and lower defects which increases overall efficiency. In addition N-type cells have greater temperature tolerance compared to both mono and multi P-type cells. More importantly **n-type cells do not suffer from the issues of LID** (light induced degradation) due to the boron-oxygen defects which are a common issue with P-type cells doped with Boron.

LID Defect – Light Induce Degradation

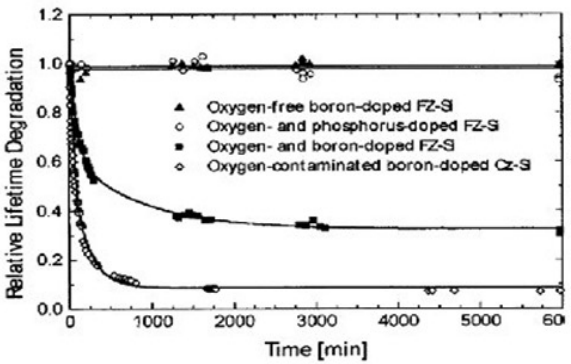
Light Induced Degradation

LID (Light Induced Degradation) is a loss of performances arising in the very first hours of exposition to the sun, with Crystalline modules. LID occurs when oxygen impurities in the silicon wafer react with the doped Boron in the first few hours/weeks of illumination of the cell. When exposed to light, Oxygen atoms diffuse through the silicon lattice and bonds with Boron atoms (present in P-type cells). Bo-oxygen complexes generate their own energy levels in the silicon lattice and can capture electrons and holes. This will reduce the efficiency of the module plate because electrons and holes are the two factors that determine the PV effect that occurs when the module receives sunlight.

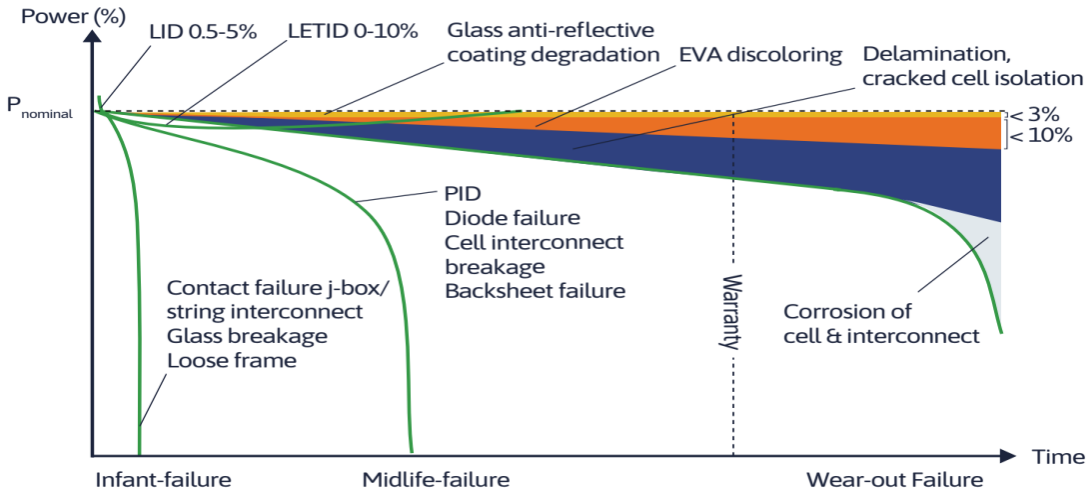
LID can cause 1~1.5% loss on current class P (Mono PERC) modules.



Schmidt and Bothe, Phys Rev B 69, 024107 (2004)



Glunz *et al*, 2nd World PVSC, Vienna (1998)



Source: IEA PVPS 2014; LETID and backsheet failure added by PVEL, 2019

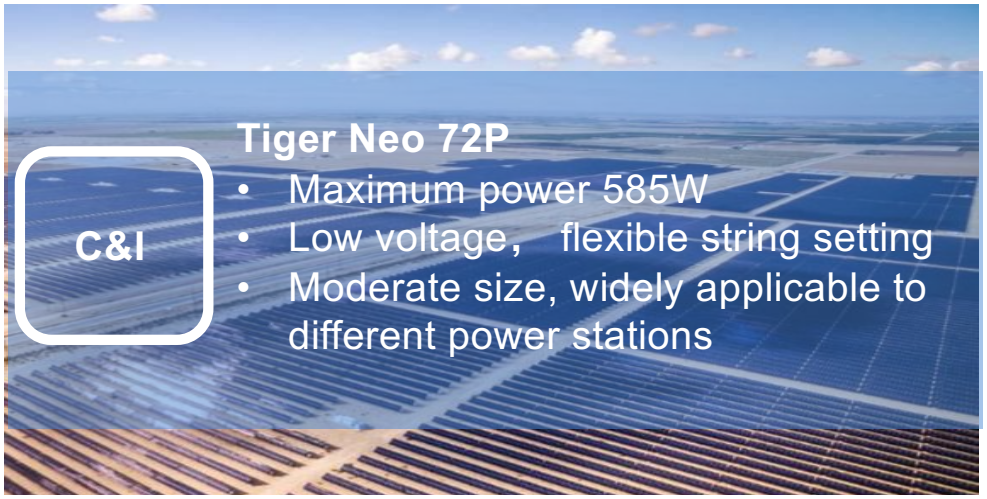
Outstanding applicability to multiple application scenarios

Utility

Tiger Neo 78P
- Maximum power 625W
- Lowest LCOE in certain senario

Tiger Neo 60P/54P
- Maximum power 480W/430W
- Compatible with residential Roofing and C&I
- High eff. module for DG market

DG

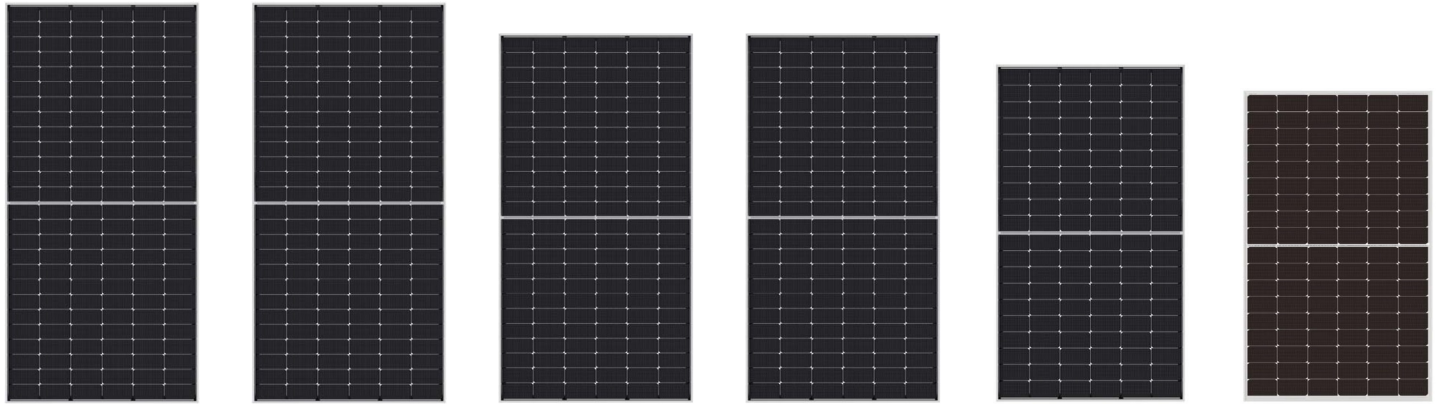


C&I

Tiger Neo 72P
- Maximum power 585W
- Low voltage， flexible string setting
- Moderate size, widely applicable to different power stations

Tiger Neo

- N-type M10/182mm wafer
- TOPCON technology
- Higher efficiency
- Lower degradation
- Higher bifaciality



JKMxxxN-78HL4-(V)	JKMxxxN-78HL4-BDV	JKMxxxN-72HL4-(V)	JKMxxxN-72HL4-BDV	JKMxxxN-60HL4-(V)	JKMxxxN-54HL4-(V)
615-630 W	610-615 W	570-585 W	555-565 W	470-480 W	410-420 W
2465*1134 mm	2465*1134 mm	2278*1134 mm	2278*1134 mm	1903*1134mm	1722*1134mm
78P	78P	72P	72P	60P	54P
Mono-facial	Bifacial	Mono-facial	Bifacial	Mono-facial	Mono-facial

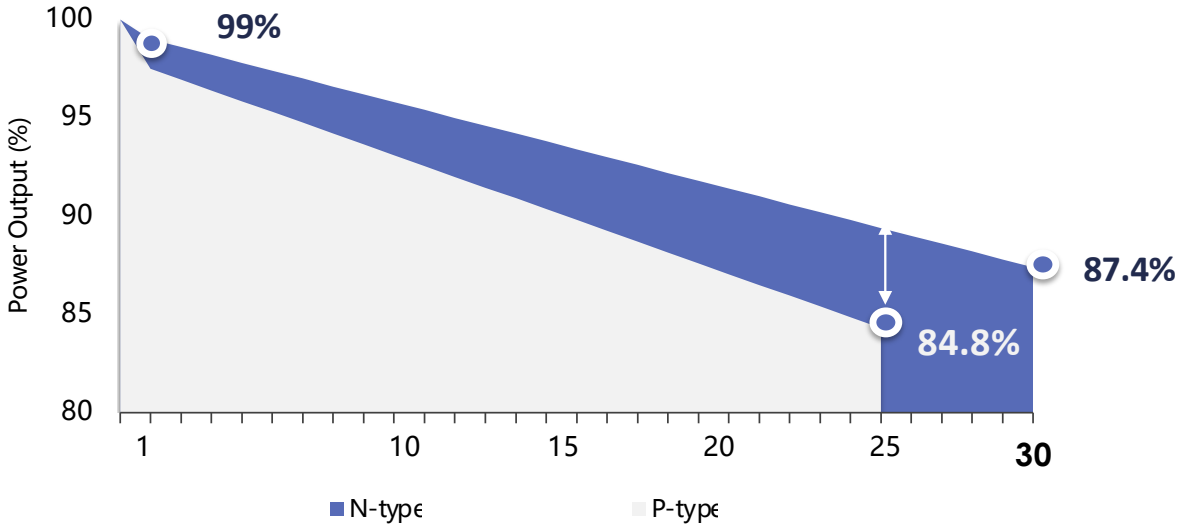
Product Advantage I
Optimized Degradation
Advanced Warranty

The power warranty could achieve 30 years compared with traditional P-type module. The first year degradation is lower than 1% which means the power output could remain over 87.4% compare with the 1st year

30 years Power Warranty

≤ 1%
First year degradation

-0.4%
Linear degradation



Product Advantage Ⅱ

Optimized Temperature Coefficients

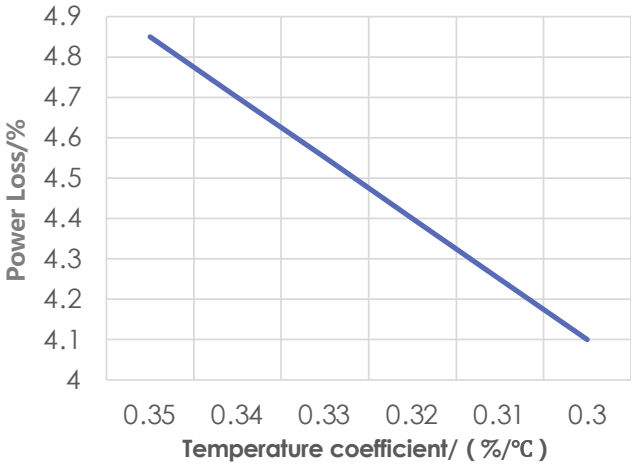
-0.29%/ ℃

In mono PERC (P type): -0.35%/ ℃

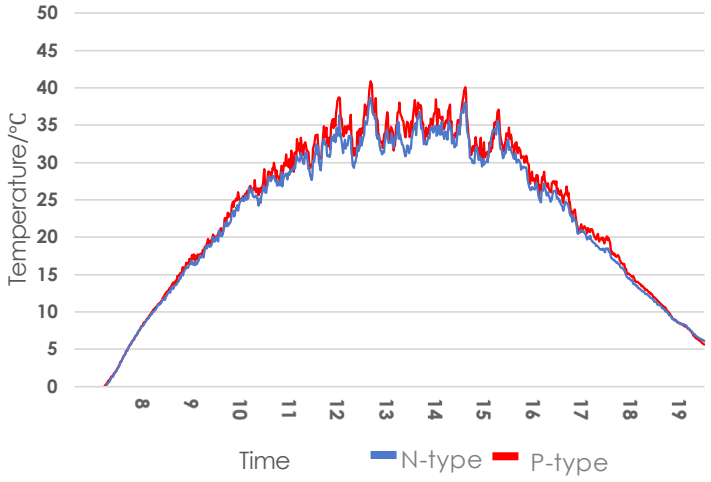
	Pmax	cell's temp. at site	ΔT	γ	ΔP (W)	Preal
P type	600 Wp	65°C	40°C	-0.35%/ °C	-84	516 W
N type	600 Wp	65°C	40°C	**-0.30%/ °C**	-72	**528 W**

- Tiger Neo's power output will increase with the better **temperature coefficient** (**0.75% higher** compared with PERC)
- Under the same external environment, Tiger Neo's **operating temperature** is lower (**>1 %** compared with the same specification P type)
- Under high temperature condition, the advantage will further expanded **(~2% higher**)

Power Loss influenced by temp. coefficient



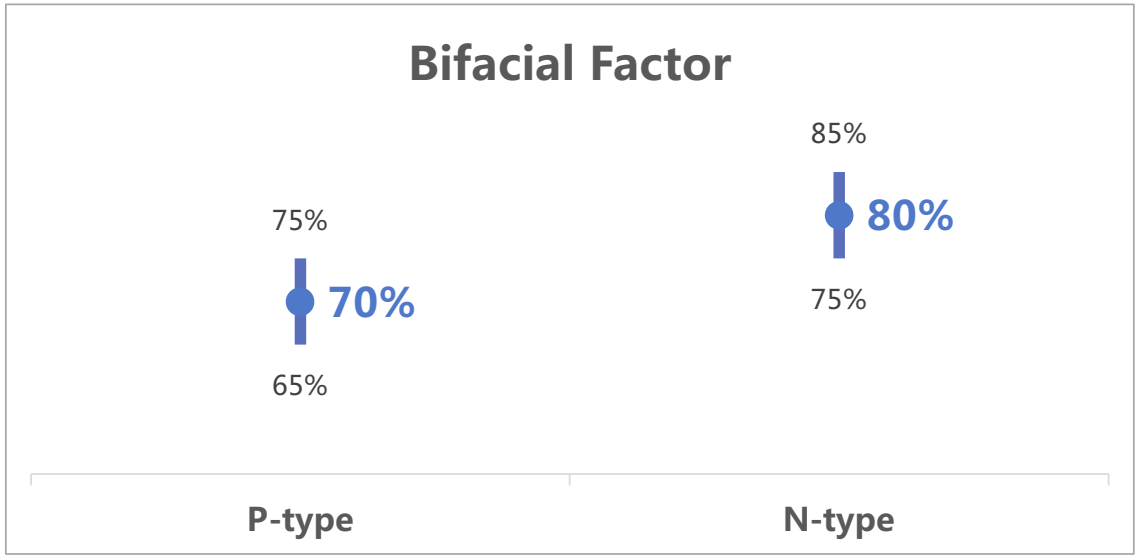
Real-time operating temperature



Product Advantage Ⅲ

Bifacial factor 85%

High bifacial factor of N-type can bring power generation gain ~ **2.03%**



P total Power =P Front* (1+BSI * Bifi)

*Bifi： module bifacial factor
*BSI： bifacial stress environmental irradiation coefficient 13.5%
(Depends on actual irradiation and ground reflectance)

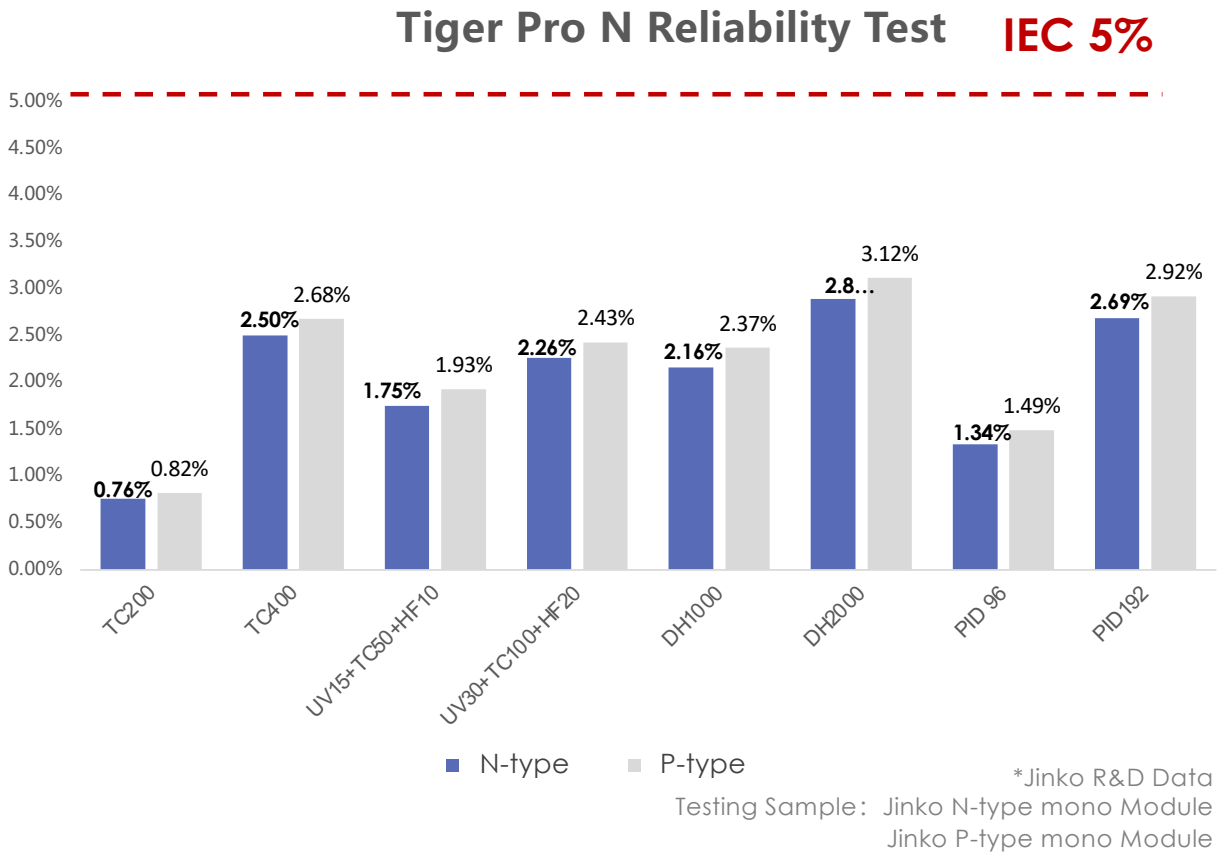
Generation gain due to bifacial factor increase.

PERC: BSI*Bifi (70%) ≈**9.45%**

TOPCon: BSI*Bifi (85%) ≈ **11.48%**

Product Advantage IV
Enhanced Reliability

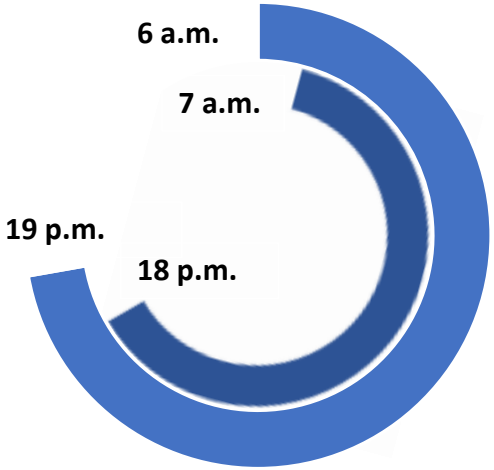
The N-type modules have better indicators than normal IEC standard and performs excellent during test process.



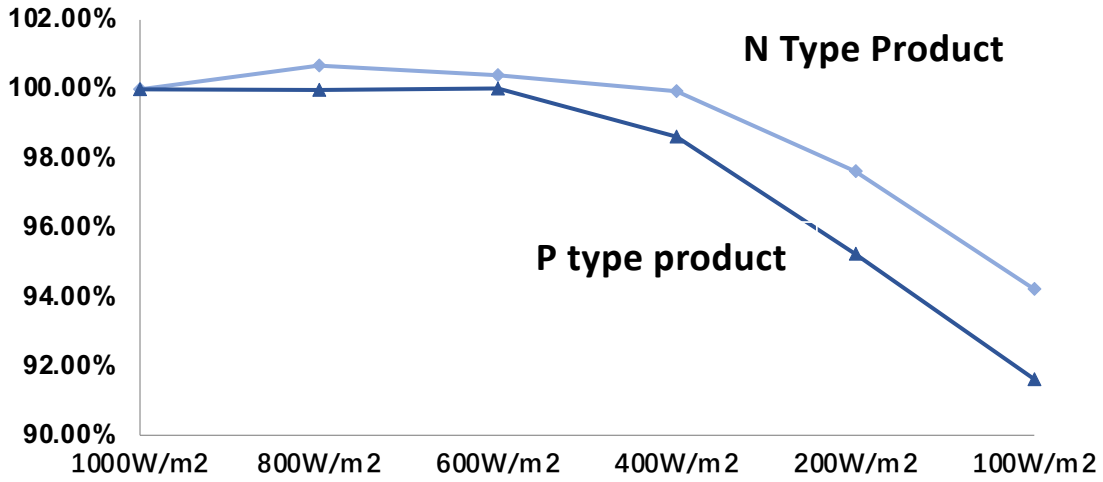
*Jinko R&D Data
Testing Sample: Jinko N-type mono Module
Jinko P-type mono Module

Product Advantage V
Better low light performance

N-type cell, higher internal resistance, longer minority carriers life, naturally better low light response

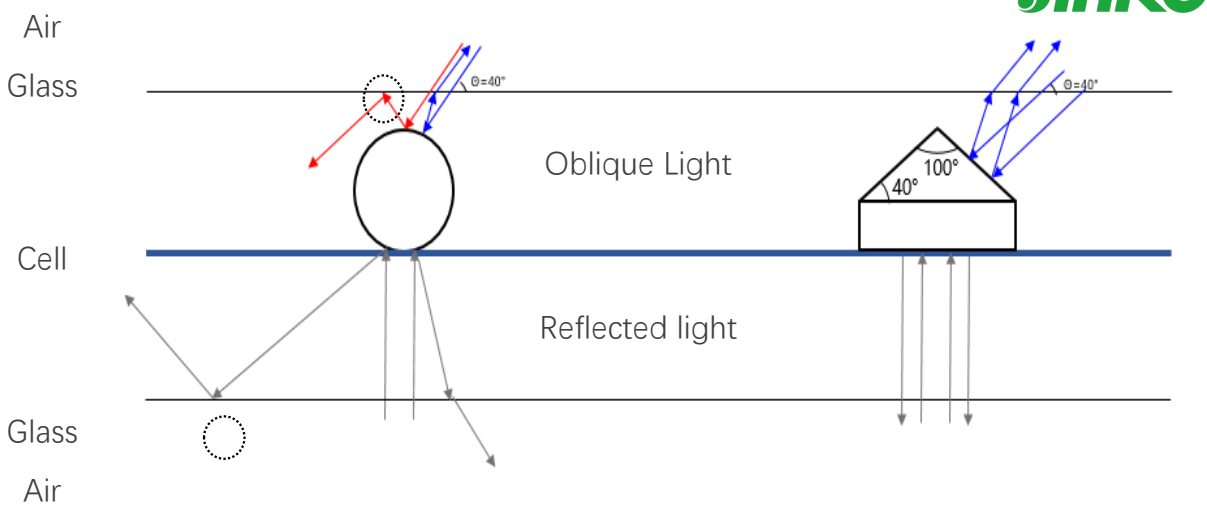


- Compared with traditional PERC modules, N-type TOPCon modules have a better response to low light, extend the power generation period by about 1H in the morning and evening.
- Low light coefficient, especially the performance below 600W/m2, N-type products > P-type products



Product Advantage VI
High efficient use of light

The use of circular ribbon effectively increases the total reflection of oblique light and the absorption of rear reflected light further improvement of bifacial factor



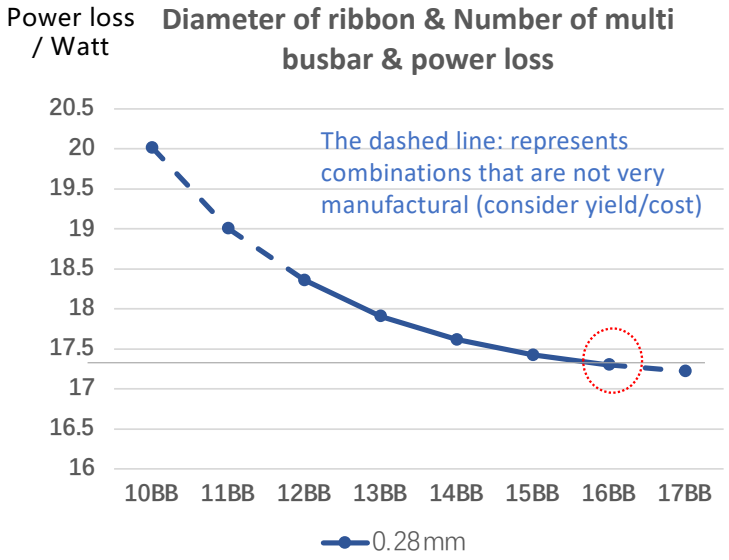
Tilt irradiation	Triangular ribbon	Circular ribbon
Integrated light utilization	**43.33%**	**54.44%**

Rear Reflected light	Triangular ribbon	Circular ribbon P-type	Circular ribbon N-type
Bifacial factor	**67.8%**	**70%**	**85%**

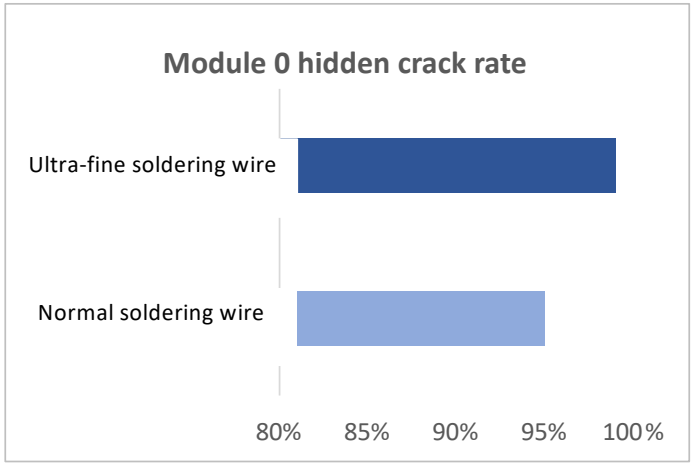
Product Advantage Ⅶ

Better busbar matching

Jinko SMBB technology，effectively improves current collection capability, reduces the risk of hidden cell cracks and improves power performance

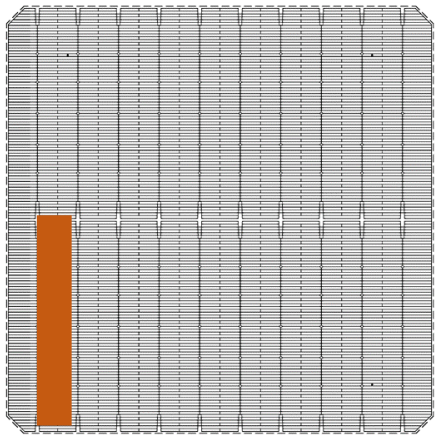


Electrical Analysis ：Busbar increases by 1, internal resistance decreases by ~ 4%, corresponding power increases by 0.18%.

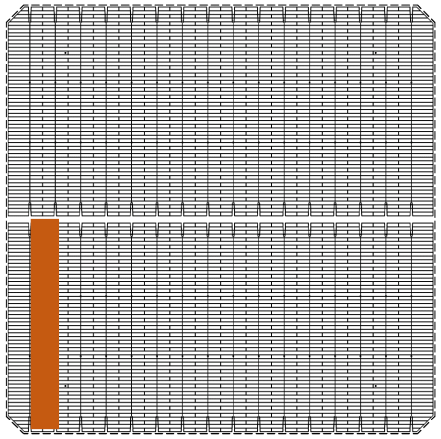


Ultra-fine soldering wire improves product quality, 0 hidden crack rate increases by 5%~10%.

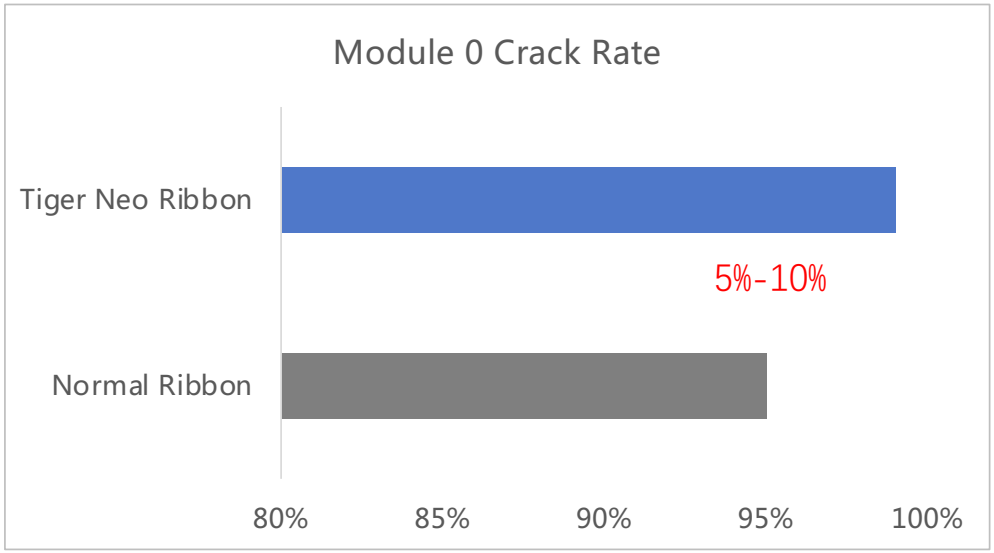
Jinko High Quality TOPCon Cell



Normal10BB Cell



TOPcon 16BB Cell



Tiger Neo Superfine wire increases the 0 crack rate

- Jinko N-type TOPCon cell adopts higher quality silicon material, and the yield of the cell with impurity metal content (vanadium, iron and nickel, etc.) is optimized.
- Unlike N-type TOPCon cells, the traditional PERC cell process will carry out laser grooving on the back, which means N-type cell has a more stable structure, and the overall load level of the module is better.

Content summary: P-type Mono PERC vs N-type TOPCon key differentiates

Aspects	P-type Mono PERC	N-type TOPCon	Comments
Panel efficiency (as of Q2/2022)	~21%	**~ 22%**	*Technically, N-type TOPCon panels produce 20~25Wp higher than P type PERC – on the same panel's area*
LID (light induce degradation)	< 2% (usually set as 1.5~1.7%)	**< 0.5%**	*N type has significantly lower LID defect compared to P type, thus enhance panels performance and reliability in longterm*
Temperature coefficient of Pmax	-0.35%/°C	**-0.29%/°C**	*N-type modules have particularly outstanding power generation in high temperature environments*
Busbar design	9 or 10 busbars	**16 busbars**	*New busbar system on N-type effectively improves current collection capability, reduces the risk of hidden cell cracks and improves power performance*
1st year degradation	2%	**1%**	*N-type TOPcon technical advantages allowed manufacturers committing higher performance warranty to solar users*
Linear degradation (from 2nd year)	0.55%/year	**0.4%/year**	
Performance warranty (year)	25	**30**	
Bifacial factor (on Bifacial panels)	65%~75% (70% as standard)	**75%~85% (80% as standard)**	*Higher bifacial factor of N-type can bring power generation gain add up to 2.03%*

Improved Energy Generation

over 3%

1

Optimized Temperature Coefficients

The advanced N-type HOT2.0 technology brings better temperature coefficients from -0.35% (P-type) to -0.29% (N-type)

2

Higher Bifacial Gain

N-type modules have higher bifacial factor : 70% (P-type) up to 85% (N-type), significantly optimizing power generation capacity.

3

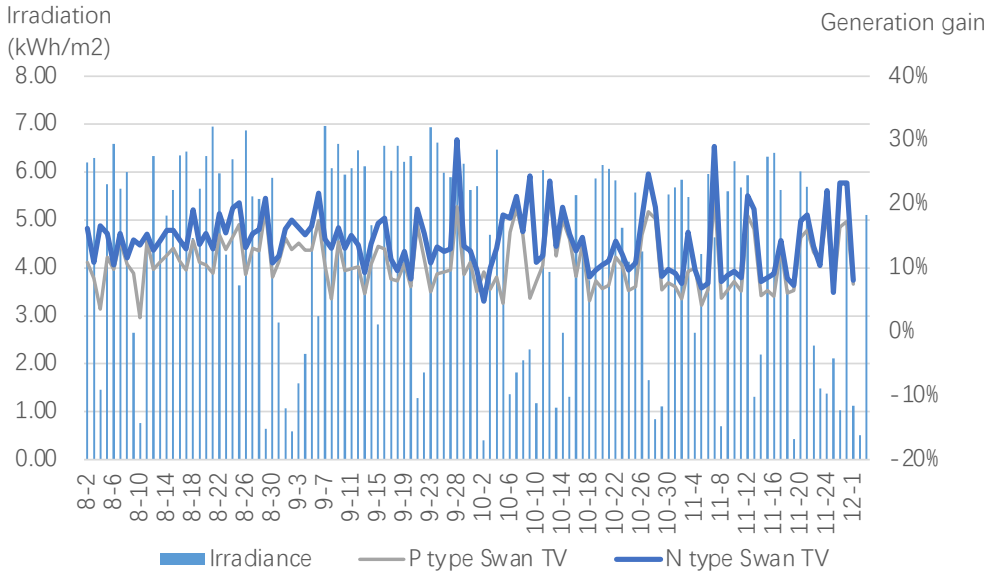
Lower LID / LETID

Low B content in N-type c-Si doped with P （significantly lower LETID from 0.9~1.2% (P-type) to 0.4% (N-type) and improved LID < 0.5% ）

N type Module Field Test – Compared to P type

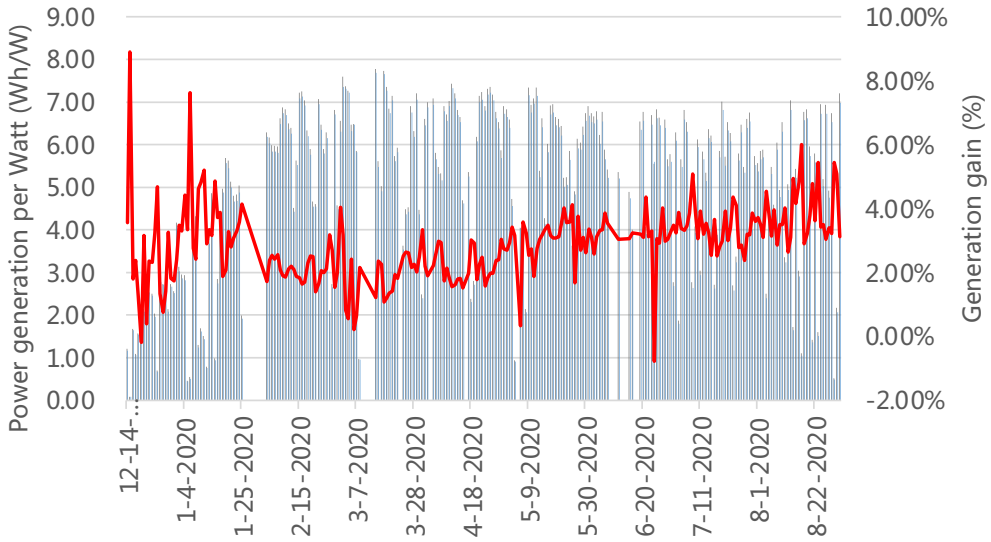
Compared with 158N and 163N, 182N module adopts a more advanced N-type technology of TOPCon instead of PERC, thus bringing a higher generation gain.

- Location: Haining, China
- Ground type: concrete
- Installation: fixed, 0.7m
- Test period: 2019.8.2~2019.12.2



158mm - N-type showed 2.95% more generation gain than P-type.

- Location: Ningxia, China
- Ground type: gravel
- Installation: fixed, 1m
- Test period: 2019/12~2020/9



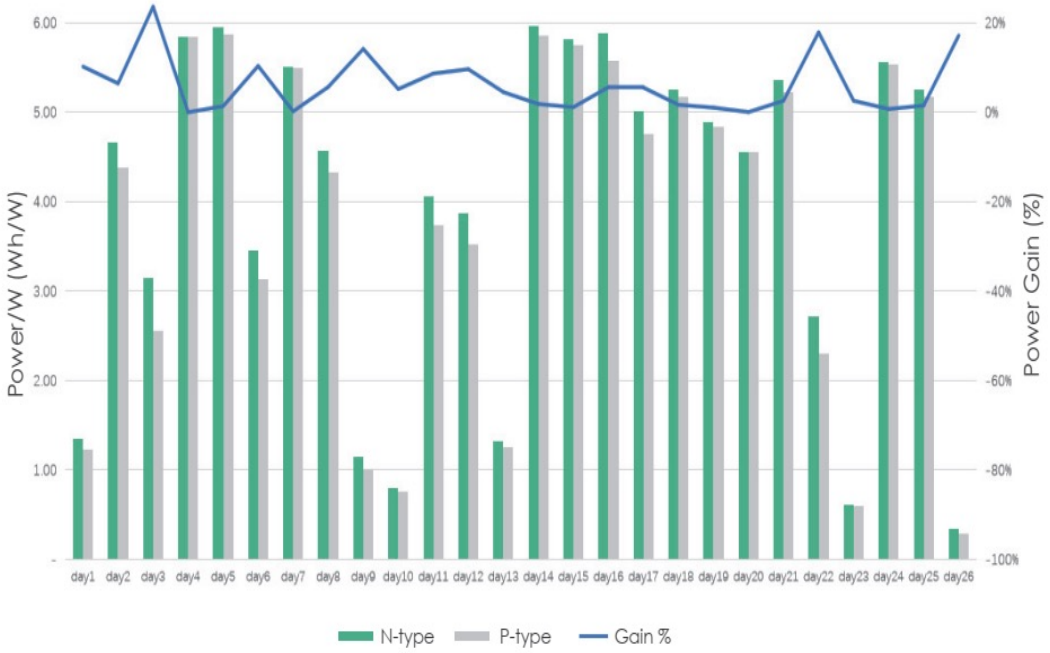
158mm - N-type showed 2.89% more generation gain than P-type.

N type Module Field Test – Compared to P type

The N-type TOPCon modules have shown an average 4.2% higher performance compared with PERC modules. It is also conclude that output power of modules increases linearly with the increase of solar irradiance

- Location: Liaocheng Shandong province, Eastern region of China
- Ground type: Metal roof
- Installation: fixed tilt 30° on rooftop
- Test period: August to September 2021

	N-type	P-type
Technology	TOPCon	PERC
System Capacity	30kW	34.44kW
Pmax(W)	475	455
Efficiency(%)	21.2%	20.9%
Power/W (Wh/W)	+4.2%	Base line



N type Module Field Test – Compared to P type

Monitored from 7:00am to 5:00pm, generation gain of N-type TOPCon module has an average of 4.56% over PERC bifacial module, including 6.05% and 10.26% more electricity yield during the time from 7:00 am to 8:00 am and from 16:00 pm to 17:00 pm respectively. This proved better low-light performance of N-type TOPCon module in comparison to PERC.

- Location: Hainan-CN (18°10'-20°18 N,108°37′-111°03′ E)
- Ground type: Concrete
- Installation: fixed, 0.5m ~ tilt 34° -Bifacial panels
- Test period: August to September 2021

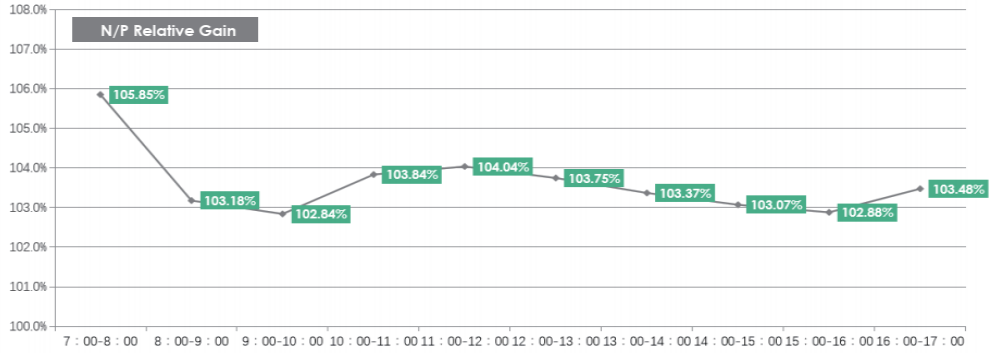


Figure 3. Daily energy yield on a sunny day in Hainan project

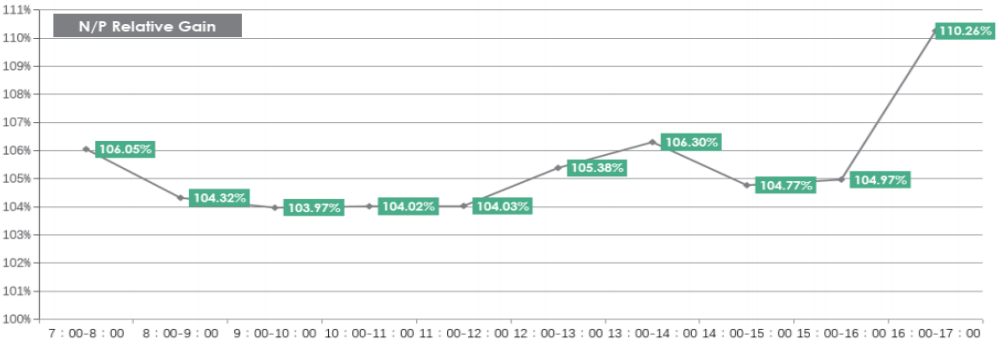


Figure 4. Daily energy yield on a cloudy day in Hainan project

N type Module Field Test – Compared to P type

In the tropical climate on the east north coast of Queensland Australia, Jinkosolar' s N-type bifacial can reach power gain ranging from 4.3-5.5% higher than PERC modules on the white paint surface condition

- Location: Blue Sun project in Queensland – Australia (1.5MW)
- Ground type: White painted steel roof
- Installation: fixed tilt Bifacial panels (cell type 163mm)
- Recorded period: January to December 2020

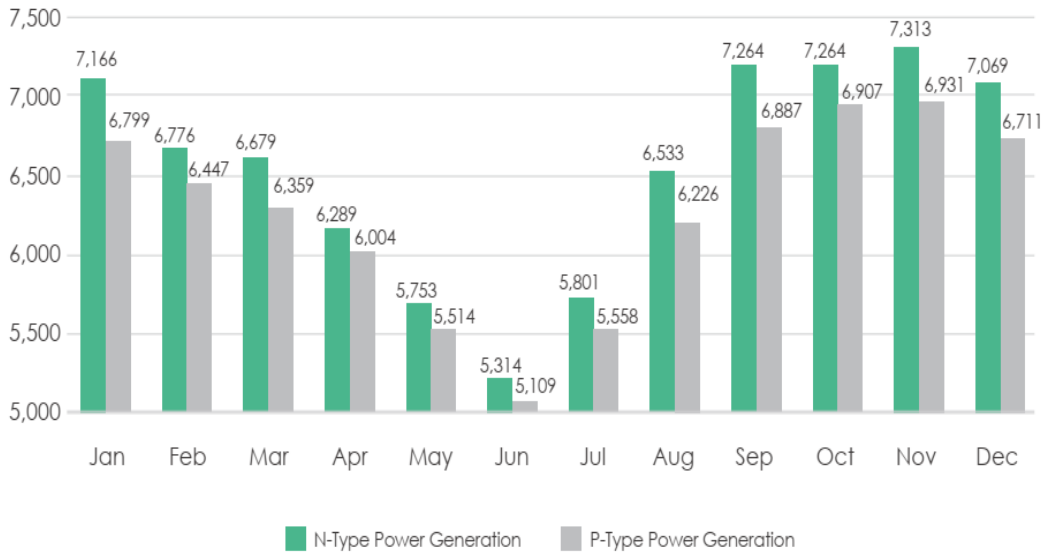


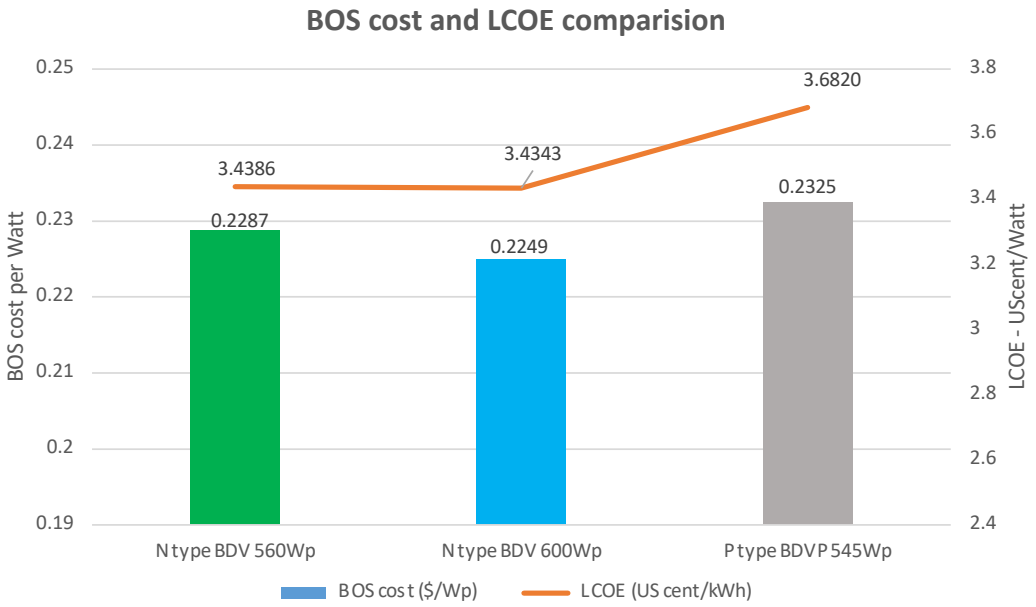
Table 1. Power generation performance of two type modules

Energy Yield comparison – Reference projects

2. Ground mounted bifacial system 35.6MWp_ Suphanburi Thailand

Financial Model-35.6MW(DC)

INPUTS			
Parameters & System Configuration	**N type BDV 560Wp**	**N type BDV 600Wp**	**P type BDVP 545Wp**
Project (35.59MWp-30MWAC)			
Module Price (USD cents/W)	**27.50**	**27.50**	**27.00**
Power(W/module)	**560**	**600**	**545**
Efficiency(%)	**21.68%**	**21.46%**	**21.10%**
Warranty (years)	30	30	25
First year degradation (%)	1	1	2
Linear degradation (%)	0.4	0.4	0.45
Module Thickness (mm)	30	30	30
Module Length(mm)	2278	2465	2278
Module Width(mm)	1134	1134	1134
Moudule/40‘ container	720	576	720
Albedo(30 %)			
Bifacial Factor (%)	80	80	70
First year produce energy (MWh)	**57,295**	57,057	55,238
Number of Modules per string	28	26	28
Number of total inverters	150	150	150
Unit inverter power (kWac)	200	200	200
System Voltage(V)	1,500	1,500	1,500
Quantity of module	**63,560**	**59,306**	**65,296**
Quantity of strings	2,270	2,281	2,332
BOS cost (USD/Wp)	**0.2287**	**0.2249**	**0.2325**
EPC USD per watt	0.5458	0.5419	0.5489
PPA/Fit (**0.045** USD/KWh)			
LCOE (US cent/kWh)	**3.4386**	**3.4343**	**3.6820**
Equity IRR	**10.70%**	**10.74%**	**9.50%**
Project IRR	**6.92%**	**6.94%**	**6.16%**



	182N-72HC	182N-78HC	182P-72HC
Power (W)	560	600	545
- Δ LCOE (%)	▼ -6.6 %	▼ -6.7 %	-
- Δ BOS (%)	▼ -1.66%	▼ -3.38%	-

System Design—the combination of inverters

Residential inverter

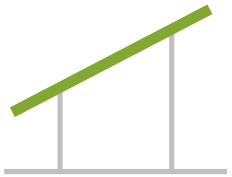
Isc 14.18A

Voc 55.40V

100kW inverter

System Design—the combination of mounting system

Fixed mounting system

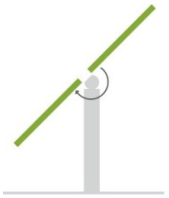


1P Tracker

NEXTracker A Flex Company

ARRAY TECHNOLOGIES

2P Tracker



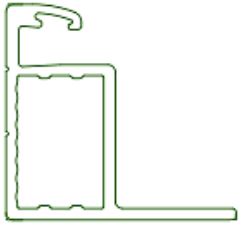
Arctech Solar

Soltec

High mechanical strength design

Enhanced frame design

- Thicker material
- Thicker cavity



Multiple installation modes

- Bolts installation
- Clamp installation

2400Pa

5400Pa

Mechanical ability against strong wind

The dynamic load test used in a wind tunnel to recreate wind speeds of up to 60m per second, while the static load test simulated bearing capabilities under a snow load equivalent to pressures of -2400 Pascal (Pa).
Testing results prove 182 module types has stronger mechanical strength against wind load, thus significantly improve the reliability and durability in high wind speed scenario

182 module types Static load test	210 module types Static load test
Structural rigidity 1.3 times higher reduced risk of module damage during consistent wind speeds	Greater vibration amplititude during the wind tunnel test lead to **heavier Micro crack**
Monofacial panel Deformation of **43.5mm**	Monofacial Deformation of **67 mm**
Bifacial panel Deformation of **38.5mm**	Bifacial panel Deformation of **63mm**

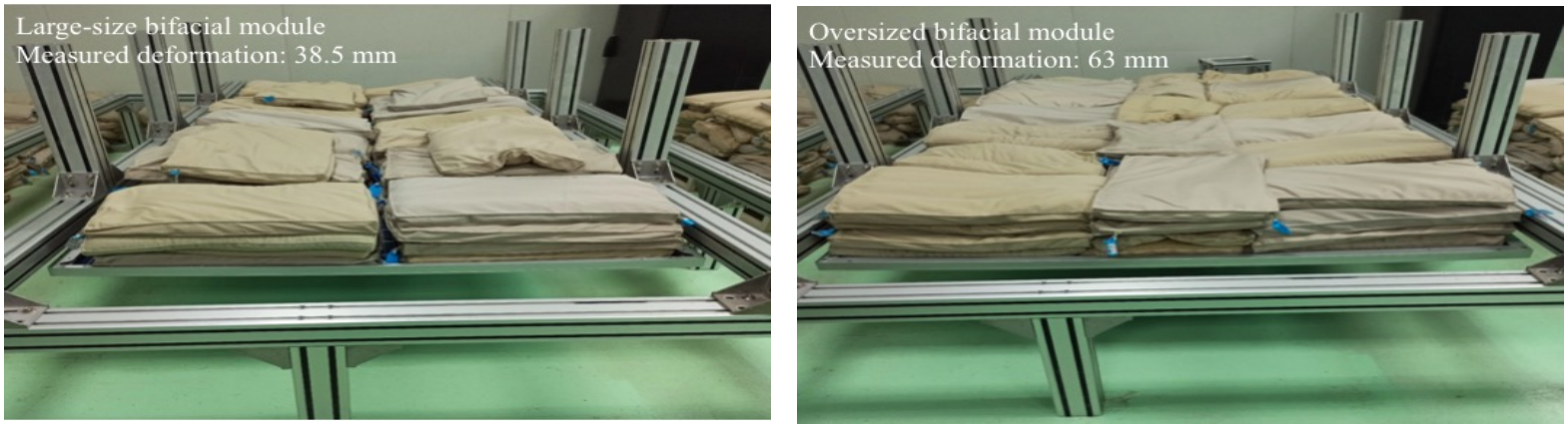


Fig. 1: Static load testing of large-size (182) and oversized (210) bifacial panels

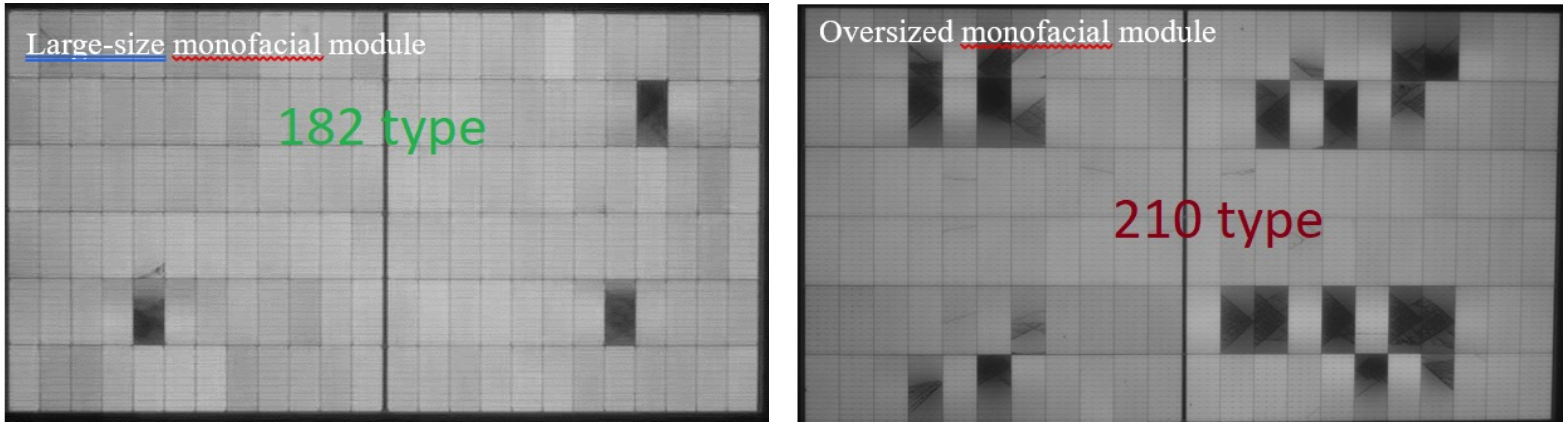
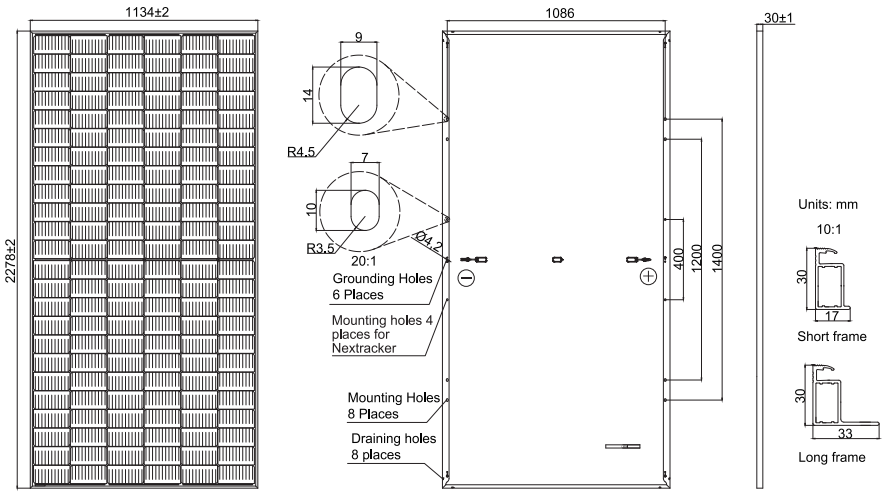


Fig. 2: EL Comparison of large-size (182) and oversized (210) monofacial modules at -2400Pa

JA SOLAR

JAM72S30 530-555/MR Series

MECHANICAL DIAGRAMS



Remark: customized frame color and cable length available upon request

SPECIFICATIONS

Cell	Mono
Weight	27.3kg
Dimensions	2278±2mm×1134±2mm×30±1mm
Cable Cross Section Size	4mm² (IEC), 12 AWG(UL)
No. of cells	144(6×24)
Junction Box	IP68, 3 diodes
Connector	QC 4.10-351/ MC4-EVO2A
Cable Length (Including Connector)	Portrait: 200mm(+)/300mm(-); Landscape: 1300mm(+)/1300mm(-)
Packaging Configuration	36pcs/Pallet 720pcs/40HQ Container

ELECTRICAL PARAMETERS AT STC

TYPE	JAM72S30 -530/MR	JAM72S30 -535/MR	JAM72S30 -540/MR	JAM72S30 -545/MR	JAM72S30 -550/MR	JAM72S30 -555/MR
Rated Maximum Power(Pmax) [W]	530	535	540	545	550	555
Open Circuit Voltage(Voc) [V]	49.30	49.45	49.60	49.75	49.90	50.02
Maximum Power Voltage(Vmp) [V]	41.31	41.47	41.64	41.80	41.96	42.11
Short Circuit Current(Isc) [A]	13.72	13.79	13.86	13.93	14.00	14.07
Maximum Power Current(Imp) [A]	12.83	12.90	12.97	13.04	13.11	13.18
Module Efficiency [%]	20.5	20.7	20.9	21.1	21.3	21.5
Power Tolerance	0~+5W					
Temperature Coefficient of Isc(α_Isc)	+0.045%/°C					
Temperature Coefficient of Voc(β_Voc)	-0.275%/°C					
Temperature Coefficient of Pmax(γ_Pmp)	-0.350%/°C					
STC	Irradiance 1000W/m², cell temperature 25°C, AM1.5G					

Remark: Electrical data in this catalog do not refer to a single module and they are not part of the offer.They only serve for comparison among different module types.

ELECTRICAL PARAMETERS AT NOCT

TYPE	JAM72S30 -530/MR	JAM72S30 -535/MR	JAM72S30 -540/MR	JAM72S30 -545/MR	JAM72S30 -550/MR	JAM72S30 -555/MR
Rated Max Power(Pmax) [W]	401	405	408	412	416	420
Open Circuit Voltage(Voc) [V]	46.18	46.31	46.43	46.55	46.68	46.85
Max Power Voltage(Vmp) [V]	38.57	38.78	38.99	39.20	39.43	39.66
Short Circuit Current(Isc) [A]	11.01	11.05	11.09	11.13	11.17	11.21
Max Power Current(Imp) [A]	10.39	10.43	10.47	10.51	10.55	10.59
NOCT	Irradiance 800W/m², ambient temperature 20°C,wind speed 1m/s, AM1.5G					

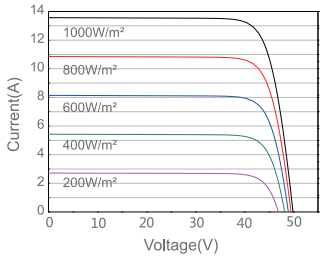
OPERATING CONDITIONS

Maximum System Voltage	1000V/1500V DC
Operating Temperature	-40℃~+85℃
Maximum Series Fuse Rating	25A
Maximum Static Load,Front* Maximum Static Load,Back*	5400Pa(112lb/ft²) 2400Pa(50lb/ft²)
NOCT	45±2℃
Safety Class	Class Ⅱ
Fire Performance	UL Type 1

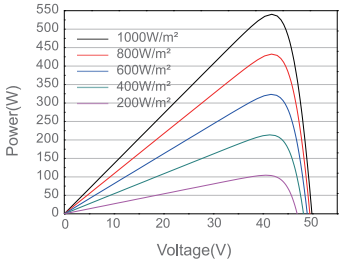
*For Nextracker installations, maximum static load please take compatibility approve letter between JA Solar and Nextraker for reference.

CHARACTERISTICS

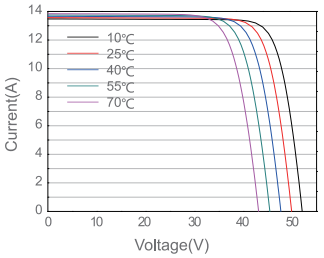
Current-Voltage Curve JAM72S30-540/MR



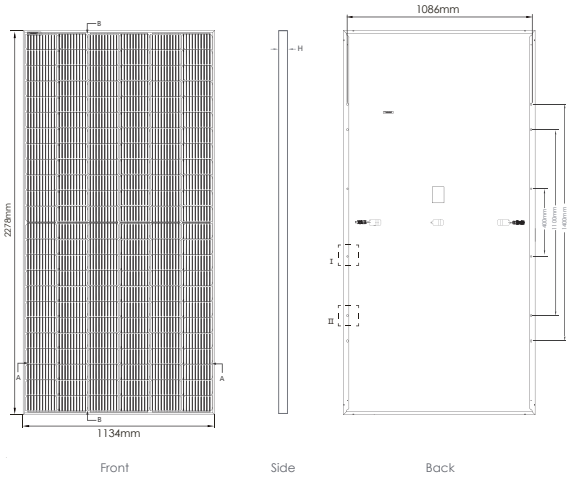
Power-Voltage Curve JAM72S30-540/MR

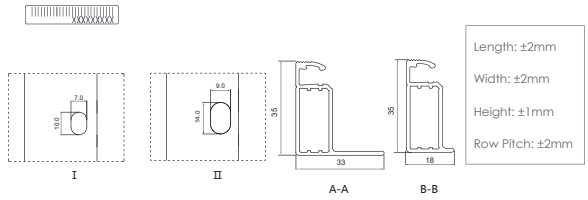


Current-Voltage Curve JAM72S30-540/MR



Engineering Drawings



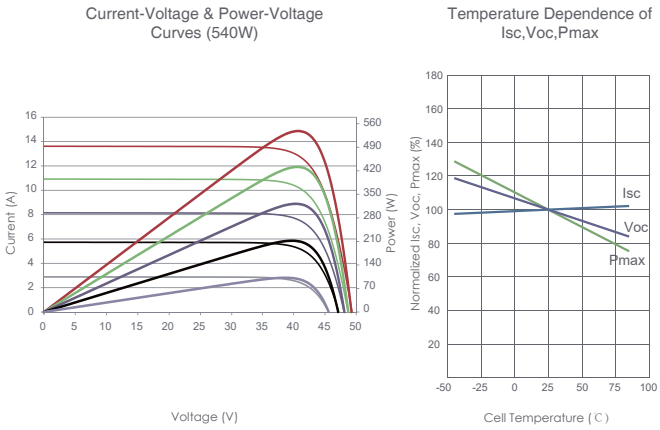


Packaging Configuration

(Two pallets = One stack)

31pcs/pallets, 62pcs/stack, 620pcs/ 40'HQ Container

Electrical Performance & Temperature Dependence



Mechanical Characteristics

Cell Type	P type Mono-crystalline
No. of cells	144 (6×24)
Dimensions	2278×1134×35mm (89.53×44.65×1.38 inch)
Weight	28 kg (61.73 lbs)
Front Glass	3.2mm,Anti-Reflection Coating, High Transmission, Low Iron, Tempered Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP68 Rated
Output Cables	TUV 1×4.0mm² (+): 400mm , (-): 200mm or Customized Length

SPECIFICATIONS

Module Type	JKM540M-72HL4 JKM540M-72HL4-V		JKM545M-72HL4 JKM545M-72HL4-V		JKM550M-72HL4 JKM550M-72HL4-V		JKM555M-72HL4 JKM555M-72HL4-V		JKM560M-72HL4 JKM560M-72HL4-V	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax)	540Wp	402Wp	545Wp	405Wp	550Wp	409Wp	555Wp	413Wp	560Wp	417Wp
Maximum Power Voltage (Vmp)	40.70V	38.08V	40.80V	38.25V	40.90V	38.42V	40.99V	38.59V	41.09V	38.69V
Maximum Power Current (Imp)	13.27A	10.55A	13.36A	10.60A	13.45A	10.65A	13.54A	10.70A	13.63A	10.77A
Open-circuit Voltage (Voc)	49.42V	46.65V	49.52V	46.74V	49.62V	46.84V	49.72V	46.93V	49.82V	47.02V
Short-circuit Current (Isc)	13.85A	11.19A	13.94A	11.26A	14.03A	11.33A	14.12A	11.40A	14.21A	11.48A
Module Efficiency STC (%)	20.90%		21.10%		21.29%		21.48%		21.68%	
Operating Temperature(℃)	-40℃~+85℃									
Maximum system voltage	1000/1500VDC (IEC)									
Maximum series fuse rating	25A									
Power tolerance	0~+3%									
Temperature coefficients of Pmax	-0.35%/℃									
Temperature coefficients of Voc	-0.28%/℃									
Temperature coefficients of Isc	0.048%/℃									
Nominal operating cell temperature (NOCT)	45±2℃									

*STC: Irradiance 1000W/m² Cell Temperature 25℃ AM=1.5

NOCT: Irradiance 800W/m² Ambient Temperature 20℃ AM=1.5 Wind Speed 1m/s

Thanks !