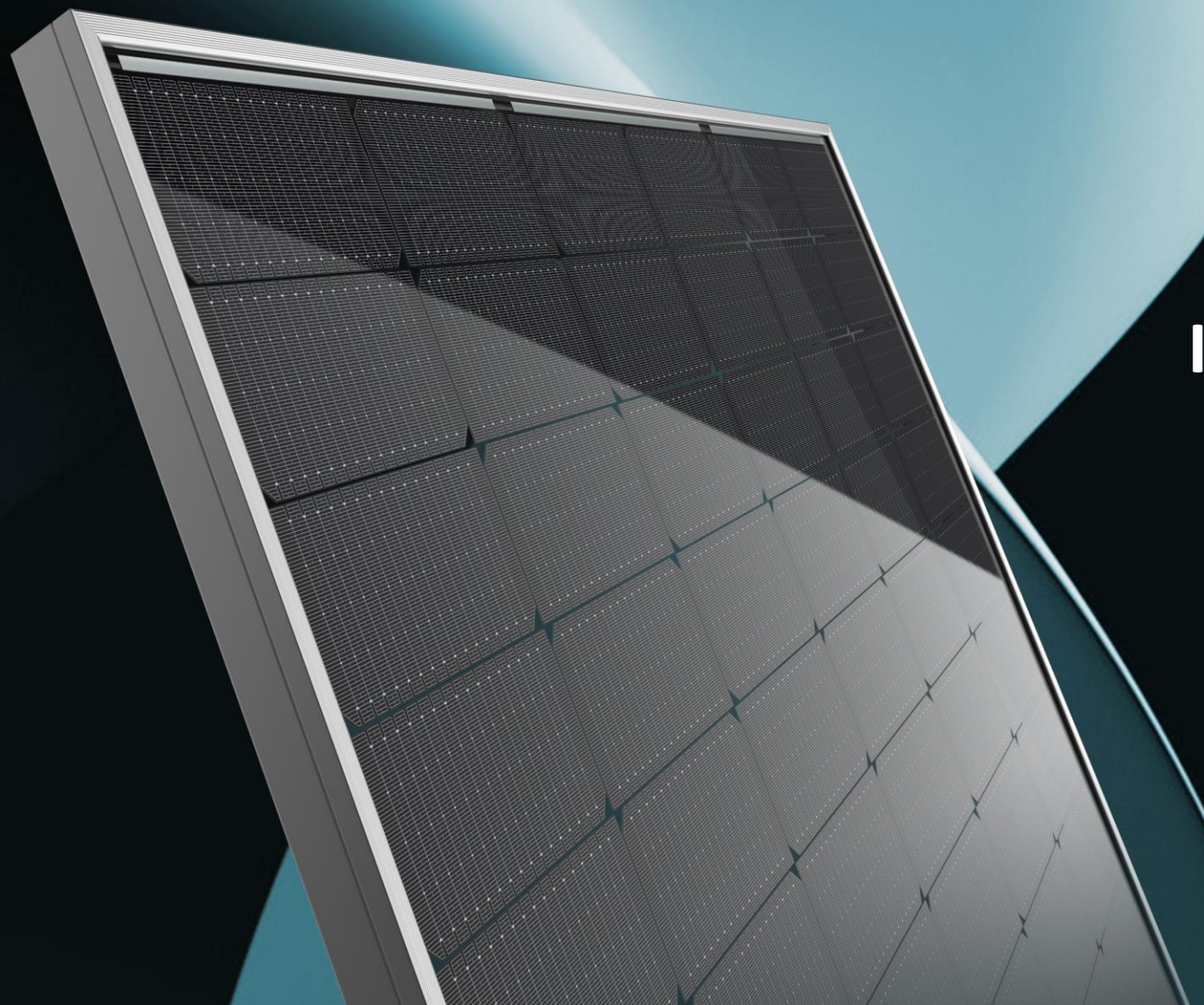


Inside the PV industry's n-type ecosystem and its benefits for individual markets

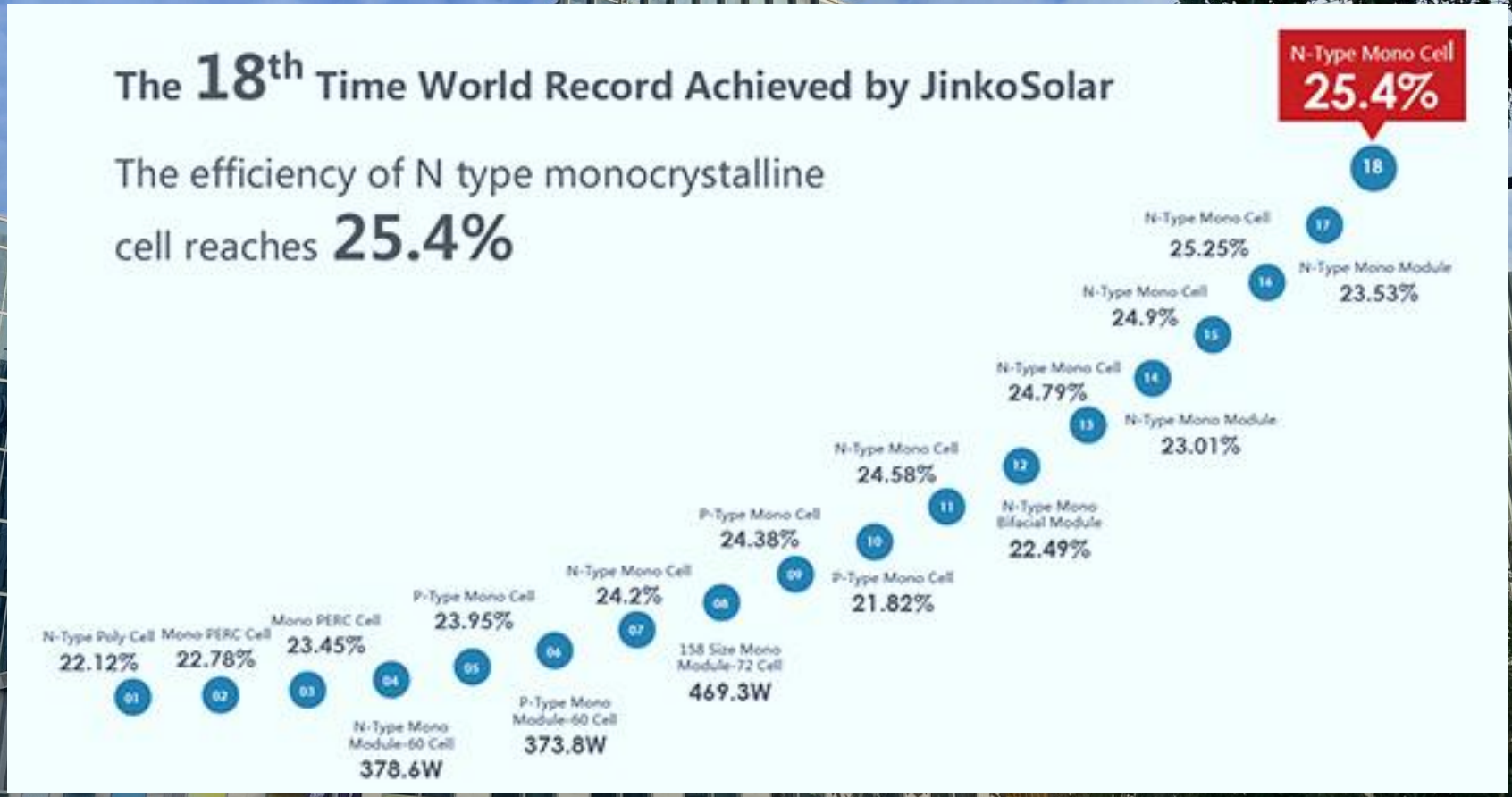
Antonio Ruta

Head of Technical Service LATAM & Italy

Jinko Global Leader in Technological Innovation

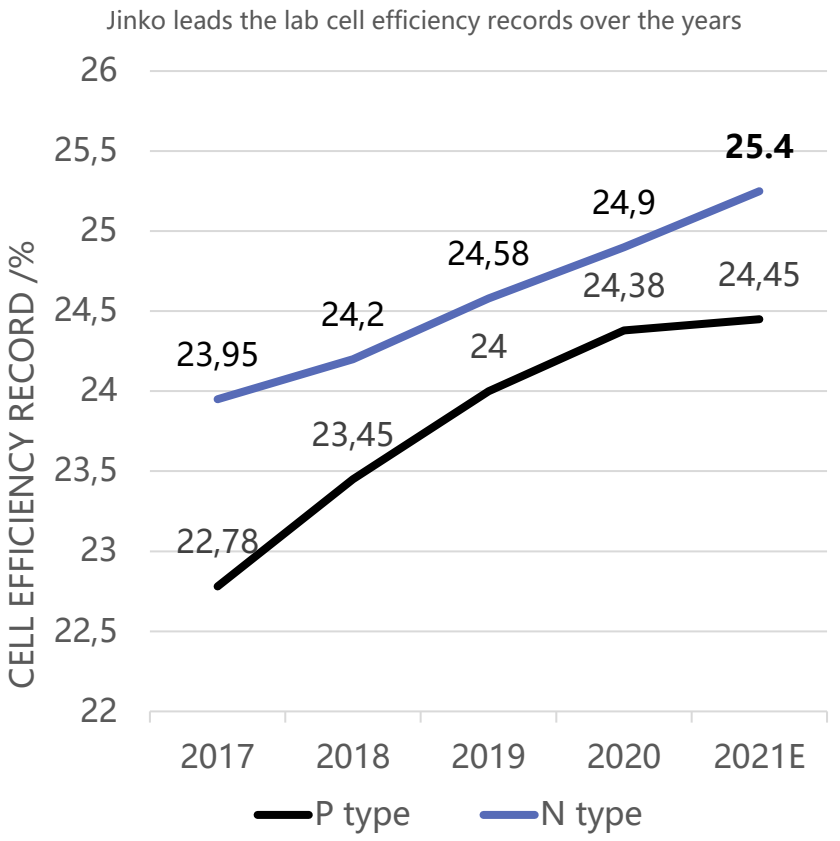
100GW+
Delivered

45GW
Module Capacity

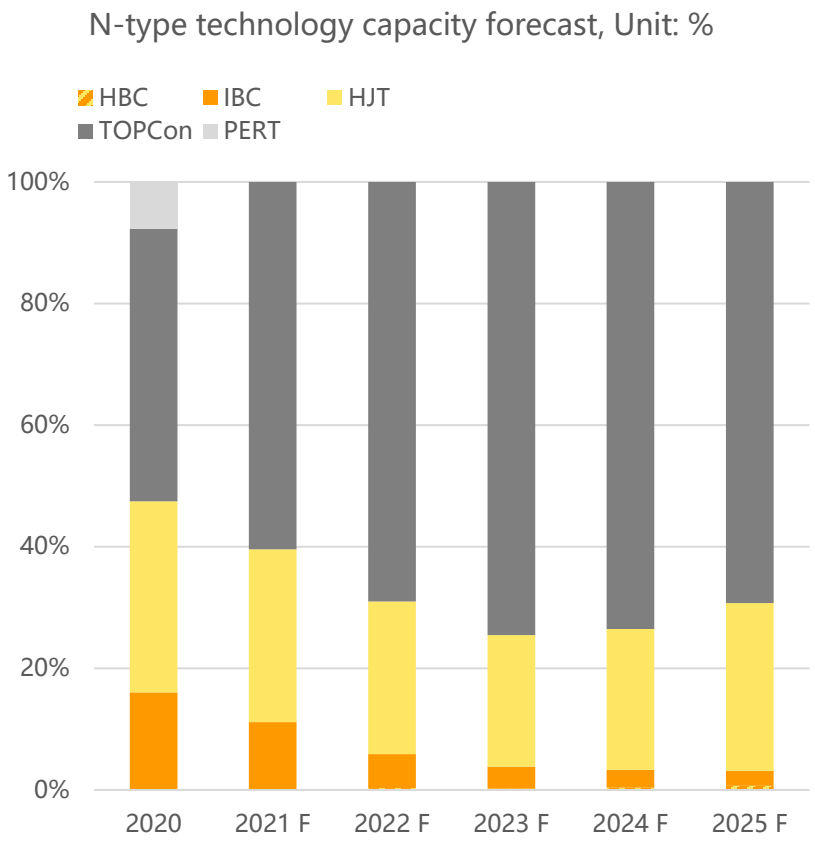


Jinko Solar Co., Ltd.
*Data as of the end of 2021 Q4

The Breakthrough of Cell Efficiency



Data source：Jinko R&D



Data source：PVinfo

24. 5%

Mass Production Efficiency

The application of Hot 2.0 technology has contributed to a new breakthrough in N-type cells, and the efficiency of mass-produced cells can reach 24.50%.

28.70%

Higher Efficiency Limits

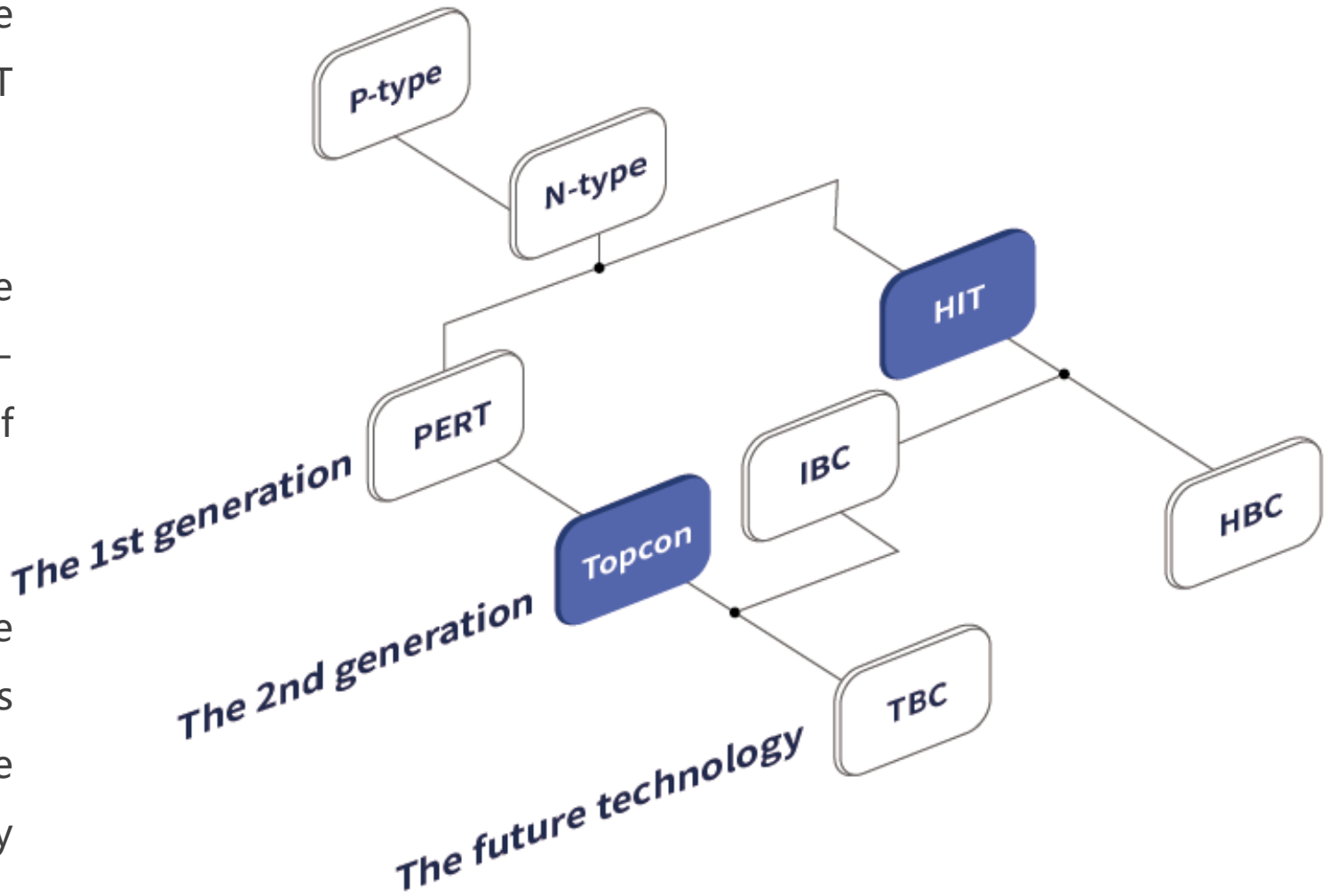
Topcon cells have higher efficiency limit (28.2%~28.7%), much better than PERC cells .

N-type Cell——The Technical Classification

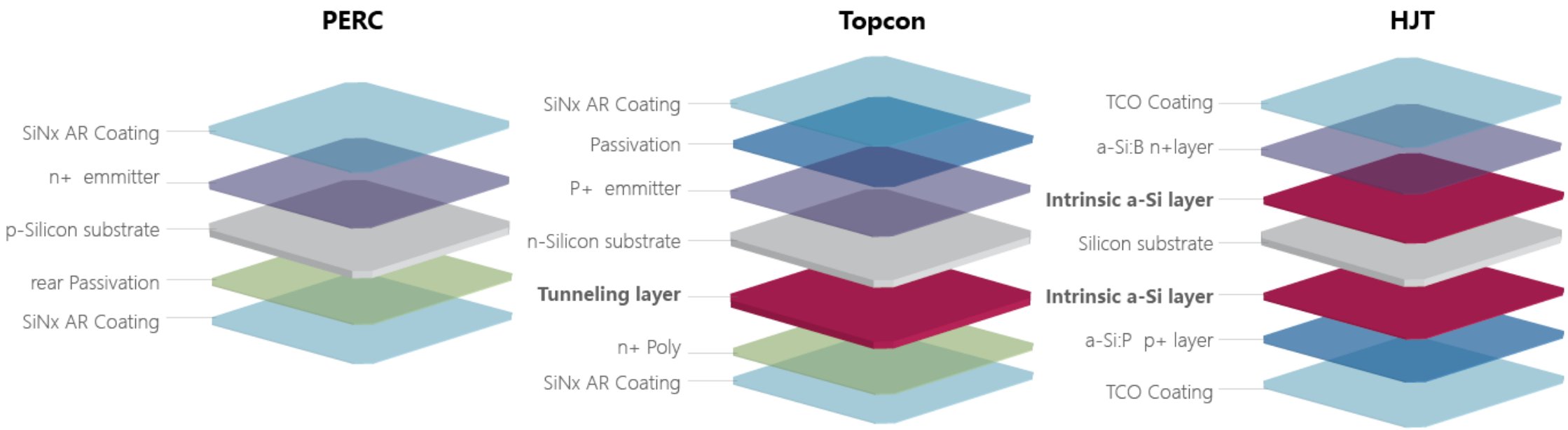
Nowdays, the N-type cells studied are mainly divided into: PERT, Topcon, HJT and IBC.

Among them, Topcon and HJT are the focus of attention of the current N-type technology and the focus of high-end products' competition.

The initial investment cost of N-type Topcon technology equipment is mass production affordable as the manufacturing process is partially compatible with PERC.



N-type Cell——Topcon & HJT



Both Topcon and HJT achieve power improvement through passivation. The former one uses tunneling oxide layer while HJT uses intrinsic amorphous silicon film. The differences in the methods lead to the differences in their respective processes, and, as result, Topcon is ready for mass production.

Technology Innovation —— Selective Passivation Contact

Passivation

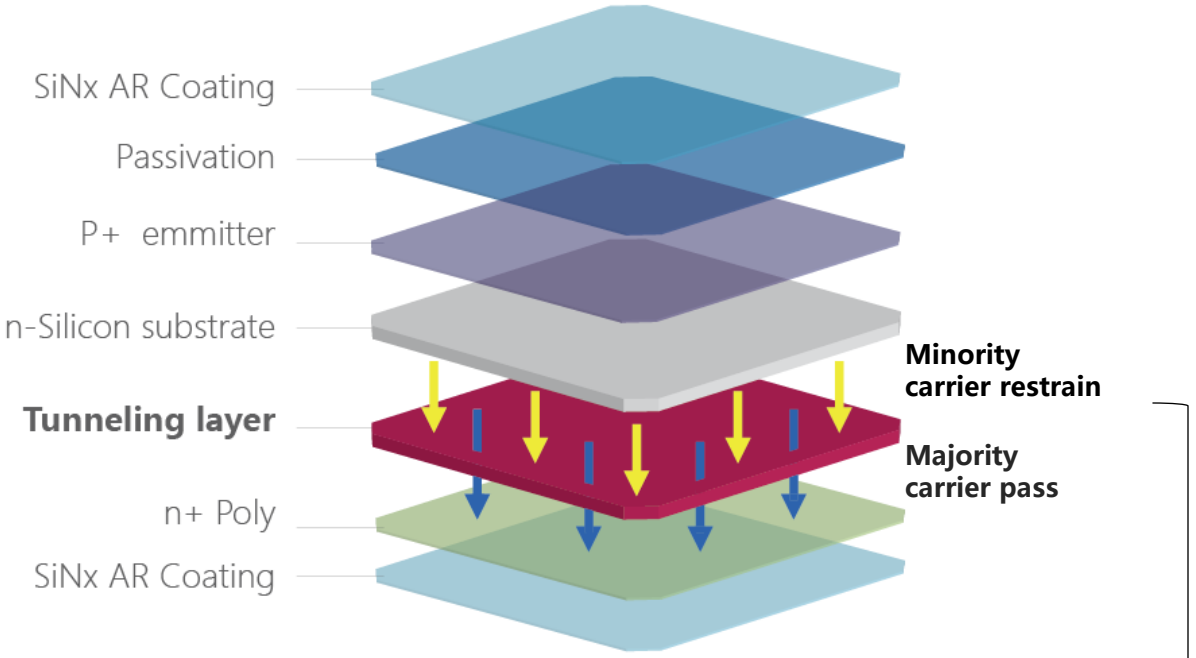
- Majority carrier pass → Resistance loss
- Minority carrier restrain → Carrier recombination

Passivation is the key technology that determines the maximum efficiency

Contacts near the surface are generally regions of high-recombination velocity.

Passivation select the carriers and avoid recombination.

Topcon



Low resistance loss & high Voc

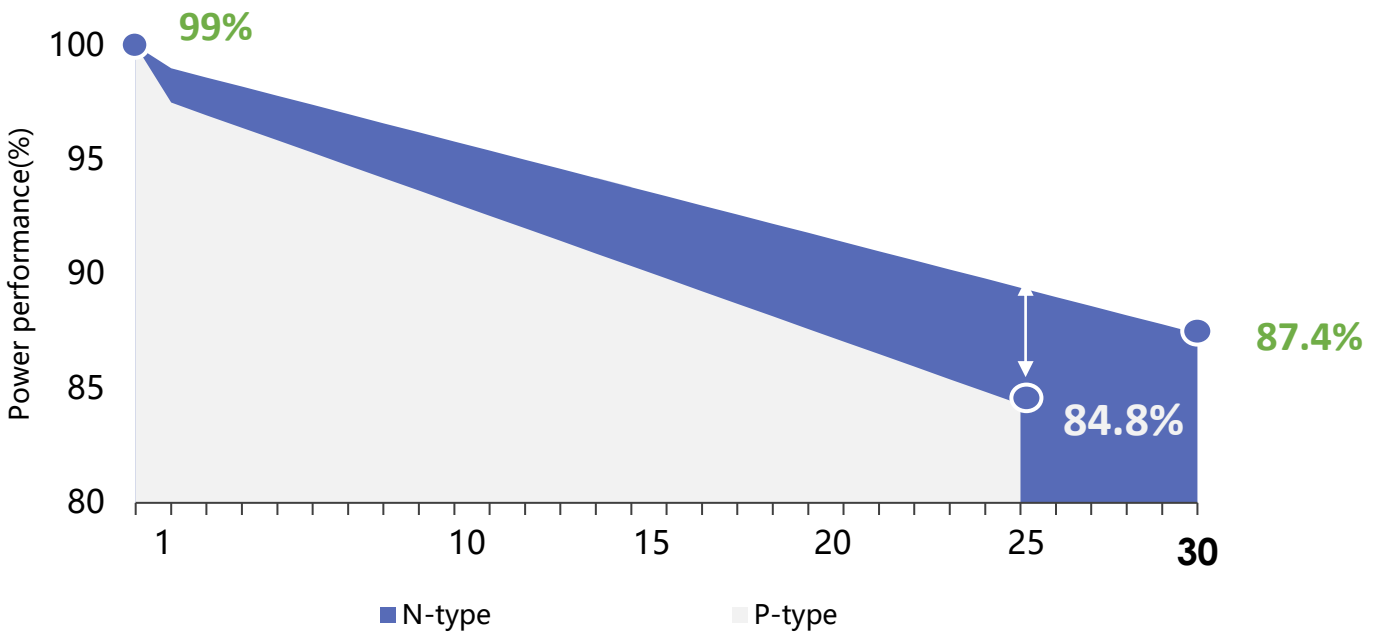
Product Advantage I
Optimized degradation
Leading Warranty

N-type module power warranty is up to 30 years, 1st year degradation is less than 1%, to ensure that the output power is not less than 87.40% of the original output power after 30 years.

30 years power warranty

≤ 1%
1st year degradation

0.4%
Linear degradation



Product Advantage Ⅱ

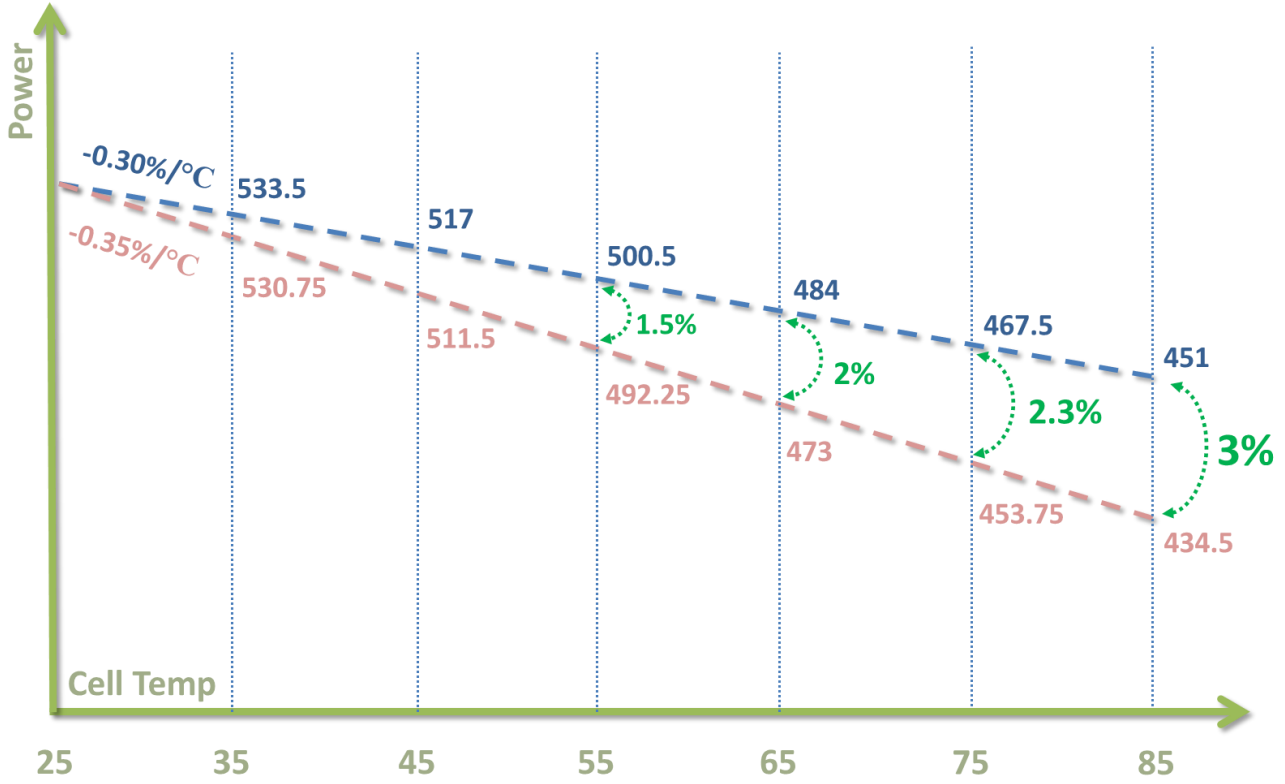
Temperature co.

-0.30%/℃

The temperature coefficient of P-type modules is -0.35%/°C

N-type modules have particularly outstanding power generation in high temperature environments.

- Output power decreases with temperature increases, and the temperature co. of Jinko Solar N is better than PERC (lead to 0.75% output ↑).
- Under the same external environment, Tiger Neo has a lower average daily operating temperature than PERC (>1 °C) resulting in lower heat loss.
- Tiger Neo brings more power generation in high temperature areas (~ **+2%** compared to P-type).

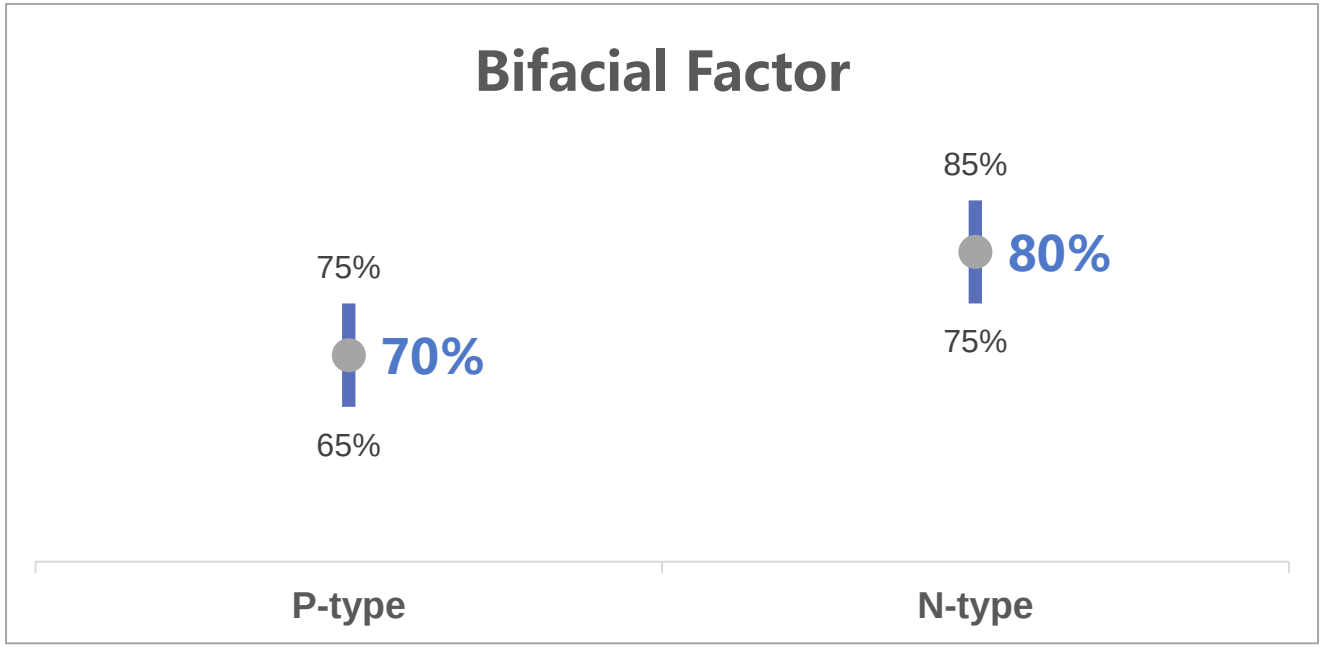


Product Advantage Ⅲ

Bifacial factor 80%

N-type's higher bifacial factor will bring significant power gain

around **1,35%**



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)

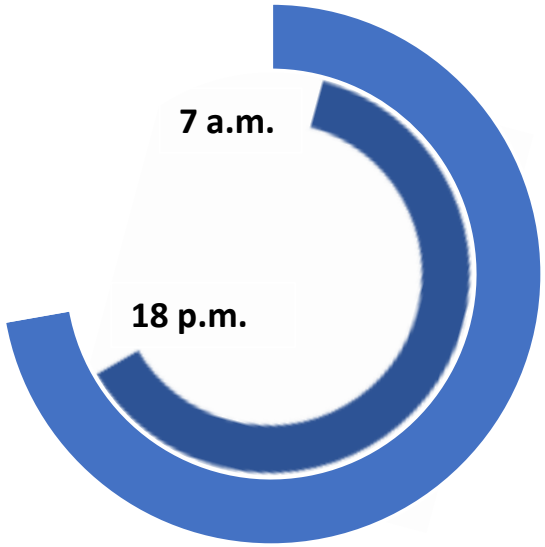
Generation gain due to bifacial factor increase.

PERC: BSI*Bifi （70%） ≈**9.45%**

TOPCon: BSI*Bifi （80%） ≈ **11.08%**

Product Advantage IV
Better low light performance

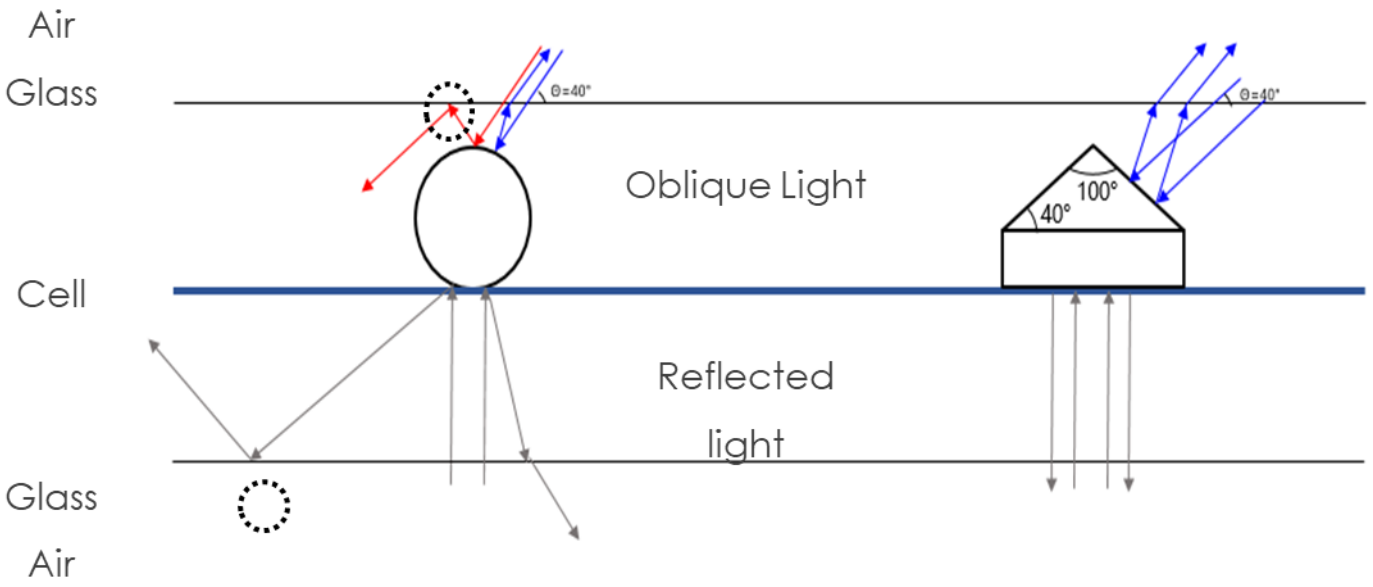
N-type cell, have longer minority carriers life, naturally better low light response



- 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 V
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%**

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 -0.30% (N-type)

2

Higher Bifacial Gain

N-type modules have higher bifacial factor : 70% (P-type) up to 80% (N-type), significantly optimizing power generation capacity.

3

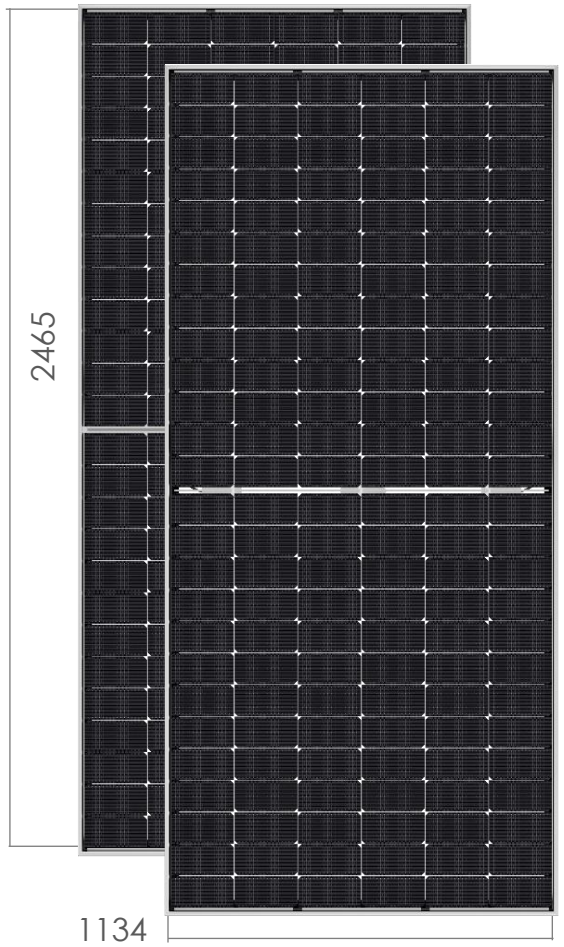
Lower LID / LETID

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%)

Tiger-Neo

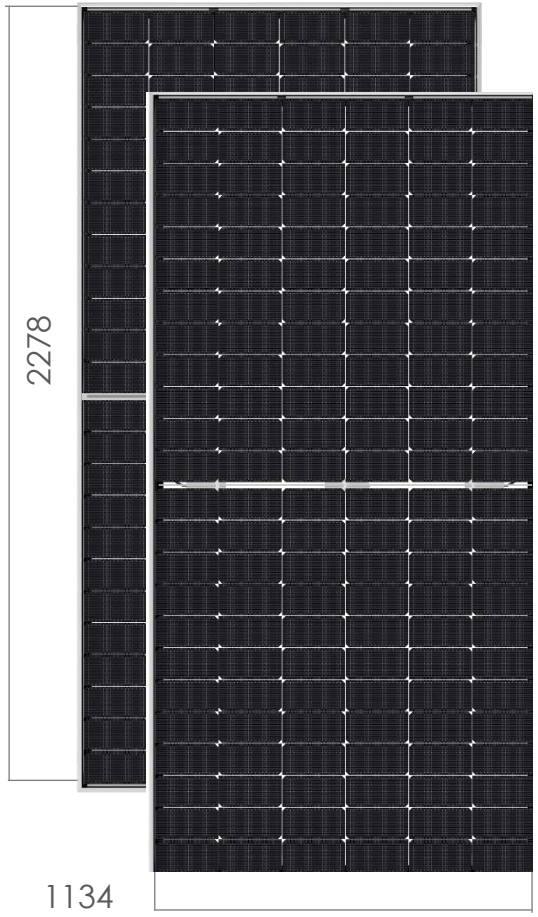
Tiger-Neo 78P
Max 610/605W

Mono/Bifacial



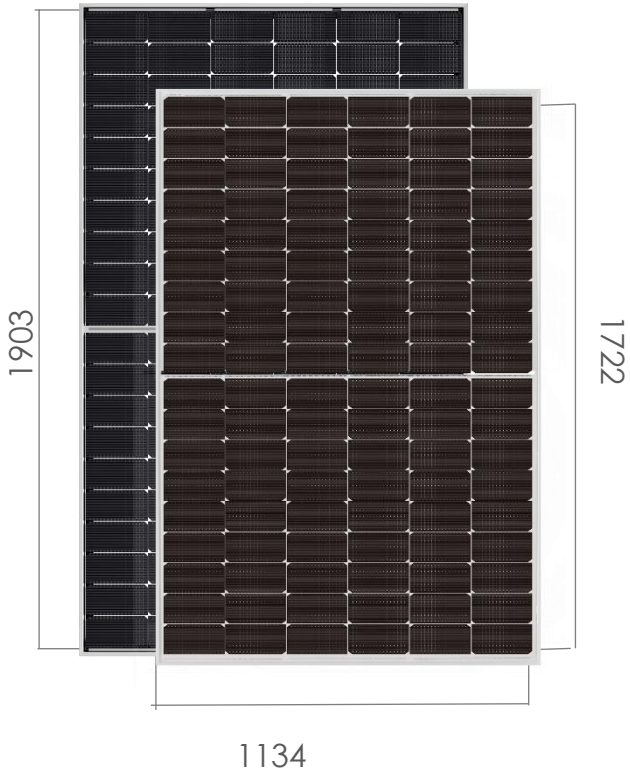
Tiger-Neo 72P
Max 565/560W

Mono/Bifacial



Tiger-Neo 60P/54P
Max 475/425W

Monofacial



Outstanding applicability to multiple application scenarios

Utility

Tiger Neo 78P
- Maximum power 610W
- Lowest LCOE in certain senario

Tiger Neo 60P/54P
- Maximum power 475W/425W
- Compatible with residential Roofing and C&I
- High eff. module for DG market

DG

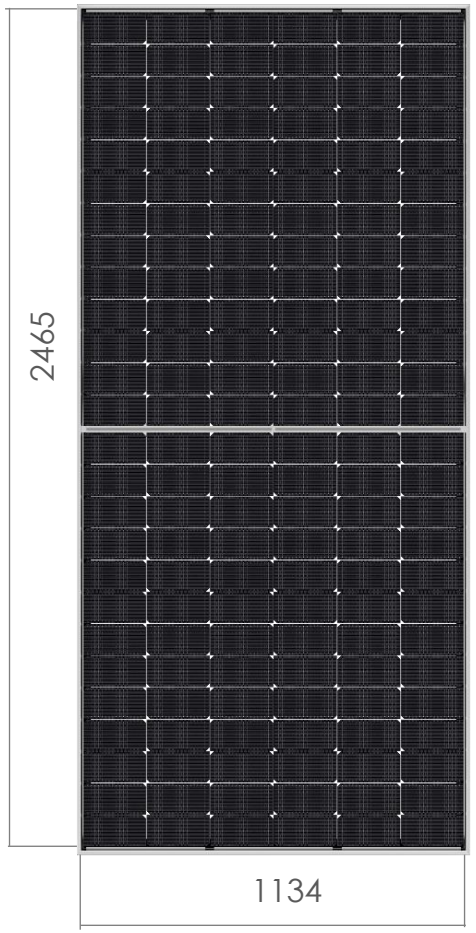
C&I

Tiger Neo 72P
- Maximum power 565W
- Low voltage， flexible string setting
- Moderate size, widely applicable to different power stations

Tiger-Neo in Utility scale application

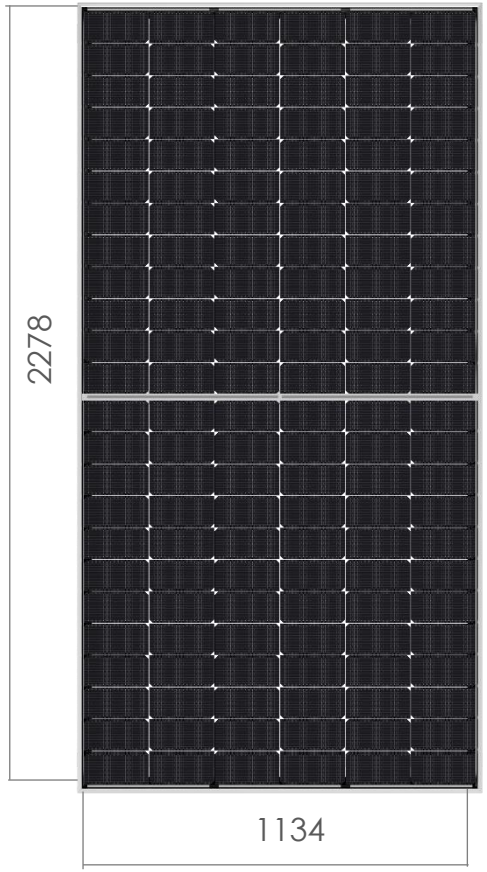
- Utility scale applications are now mostly developed with Bifacial Modules
- TopCon high efficiency Tiger NEO leads to more power density
- Limited LID/LeTID effect (<1% - <0.4%/y)
- Low temperature coefficient results in lower heat loss and fits well hot environment (-0.30%/℃)
- Higher bifacial factor increases the energy gain compared to PERC modules (80% ± 5%)

Tiger-Neo 78P
Bifacial, Dual Glass



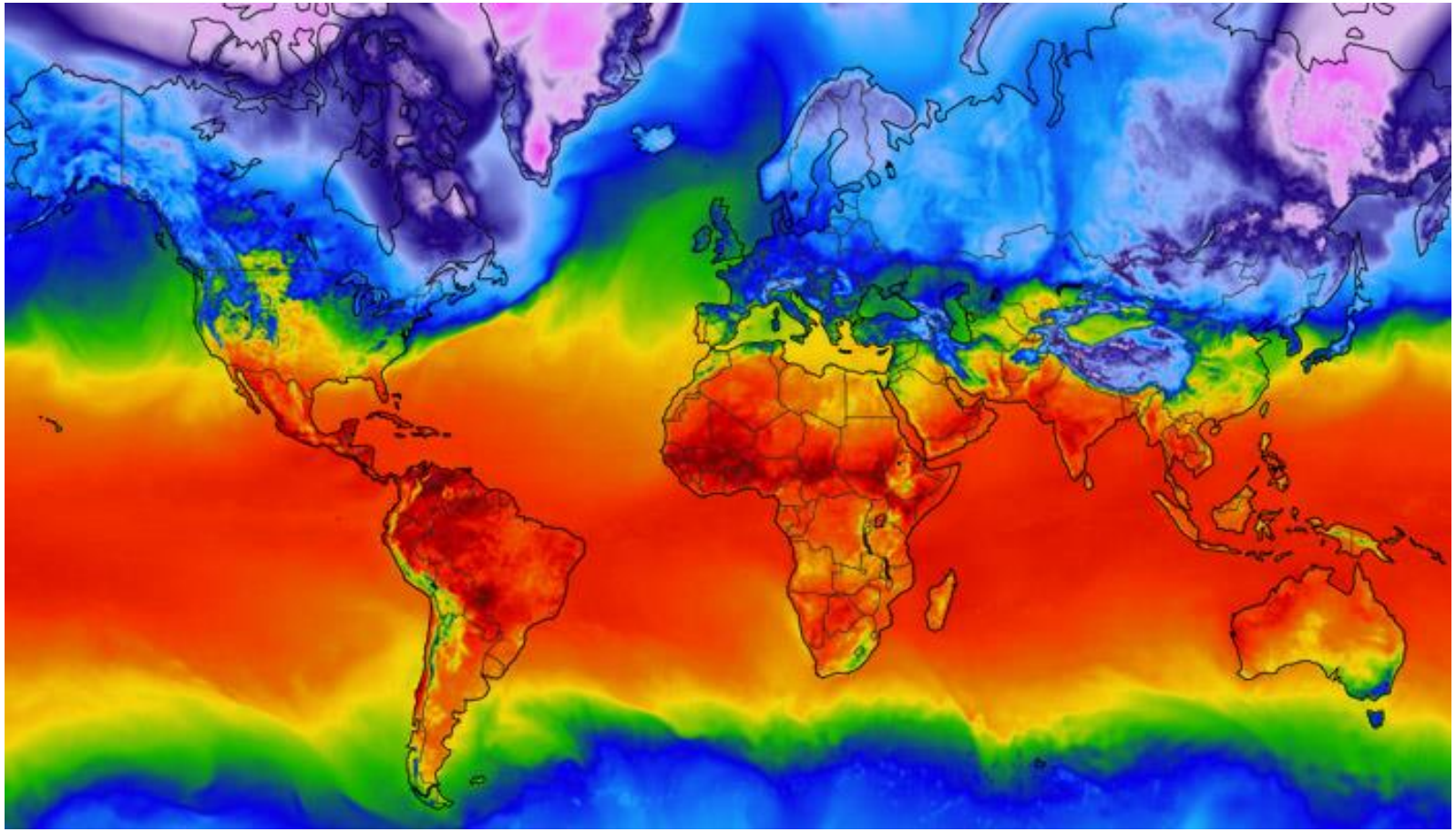
605 Wp

Tiger-Neo 72P
Bifacial, Dual Glass



560 Wp

Tiger-Neo in Utility scale application



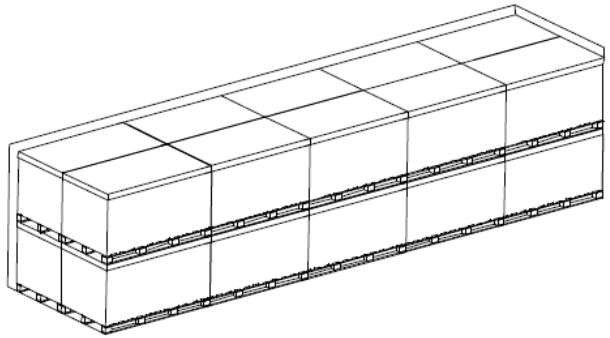
Source: https://www.aerisweather.com

- More stable performance specially higher temperatures.
- Reduces the risks of hotspots due to lower cell temperature.
- Reduces the modules temperature with >1% less than PERC.
- Tiger NEO is the right module to lower LCOE

Tiger-Neo in Utility scale application

- **Test run in our outdoor demonstration project shows a N Type premium energy gain in case of fixed structure up to 2,90% compared to similar PERC bifacial modules (Albedo over 25%)**
- **Simulation vs real data shows consistency**
- **BOS calculation must consider a cable size (4mm^2) as Tiger NEO I_{SC} is lower than 15A, while higher minimum temperature (Typical to hot environment) leads to more modules per string.**
- **Tiger NEO 72BDV M10 has one of the most power density per container (till +10% compared to market peers).**
- **NEO used the safest packing method.**

40' HQ:
36Pcs/Pallets
20Pallets/Container
720Pcs/Container

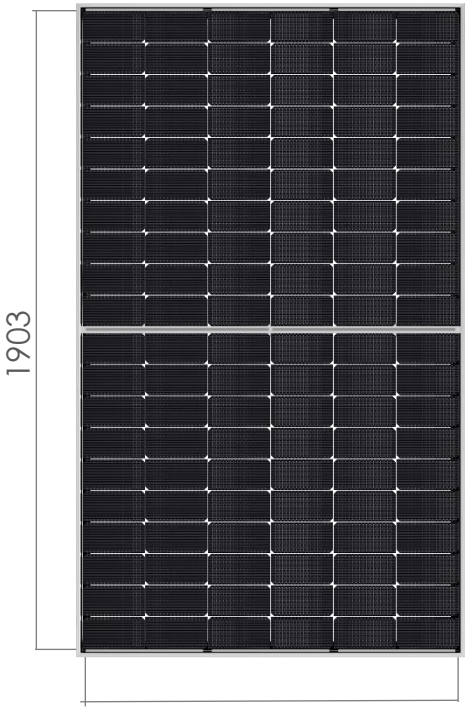


Tiger-Neo in Rooftop application

- **Different sizes to cover from residential to C&I rooftop application**

- **TopCon power density leads to more installation flexibility, with the result of more energy generation with the same roof size**

Tiger-Neo 60P Monofacial



475 Wp

Tiger-Neo 54P Monofacial

415 Wp

Tiger-Neo in Rooftop application

- Tiger NEO 60HC and 54HC are fully compatible with current mainstream DG String inverter
- Both fit regional market requirement that privilege one solution able to cover the needs of their customers.
- Tiger NEO 54HC with his limited weight and lower length is preferred for his versatility in rooftop design, where roof shape and dimension limit the available area.
- Tiger NEO 60HC is the best selling products in market where it is needed good compromise in power and dimension.
- Premium warranty condition and high efficiency differentiate Tiger NEO 60HC and 54HC from P type mainstream products.

Tiger Neo Global Capacity

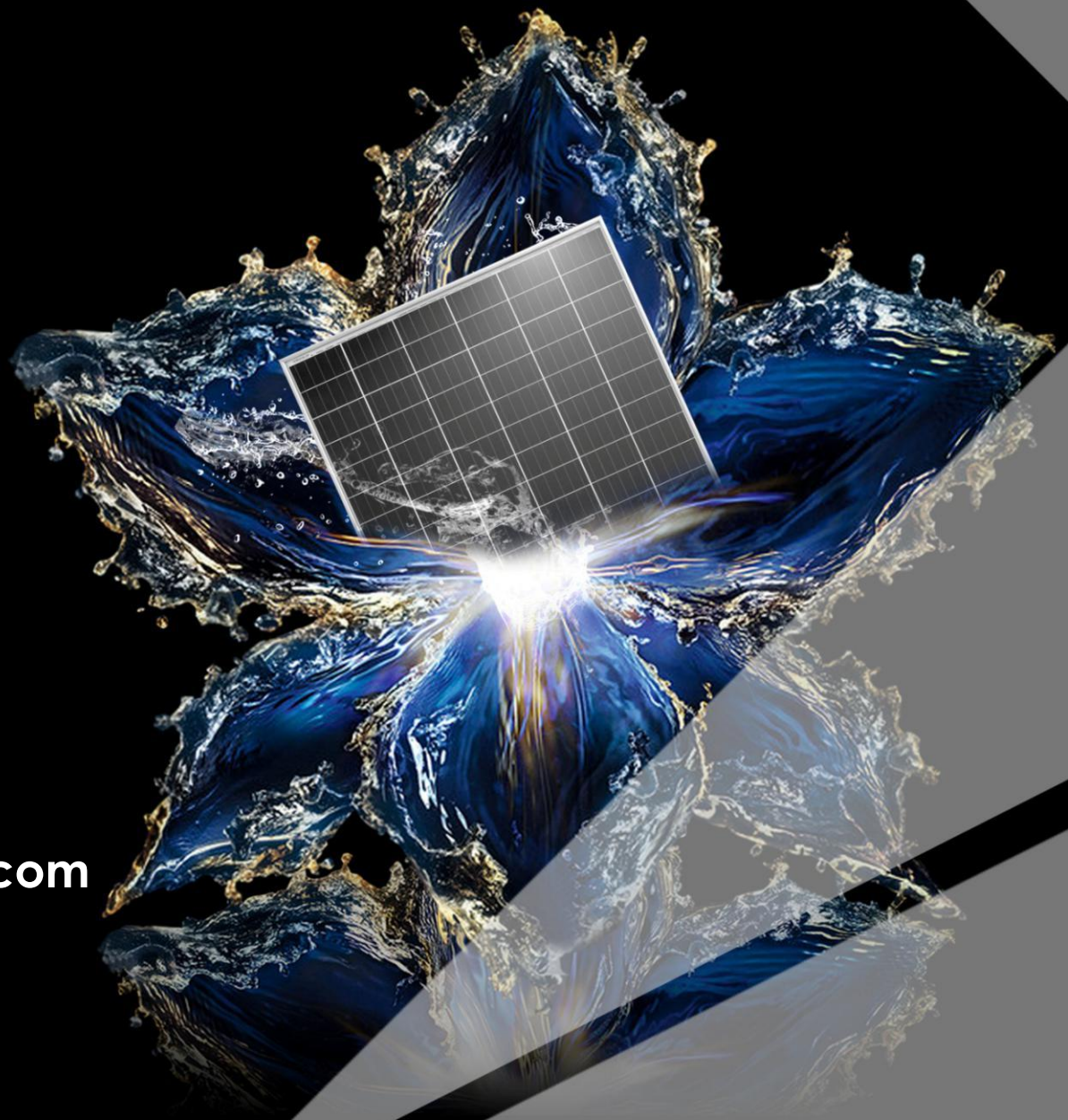
As of 2021 Annual report, Tiger Neo mass production started in January 2022

Q1

2022 Q1 mass-production start

16,9 GW

Total capacity at end of 2022

Thanks!

antonio.ruta@jinkosolar.com