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Webinar is powered by
JinkoSolar

26 March 2024

10:00 am - 11:00 am | CET, Berlin

12:00 pm – 1:00 pm | AST, Riyadh

1:00 pm – 2:00 pm | Dubai



Emiliano Bellini

News Director
pv magazine

pv magazine
webinars

TOPCon overcoming obstacles: improving performance of backsheet- based monofacial products



Mohamed Saady

Head of Technical Services & Product
Management MENA
JinkoSolar




Joerg Althaus

Director Quality Assurance and
Engineering Services
Clean Energy Associates



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.  

Combining TOPCon Technology With Mono-Facial Backsheet Modules



01

About Jinko Solar

02

**TOPCon Humidity
Challenges**

03

**TOPCon 3xIEC Test
Results**

04

**Saudi Arabia Test
Project**

No.1 Shipment in 2023

With 78.5GW

225GW+

Delivered

15%

Market Share

26

World Records

120GW

Module capacity

Jinko Solar Global Layout

Solar
Jinko

14
Production Facilities

35
Sales Offices

160+
Covered Countries

3000+
Customers



Zero Carbon Factories



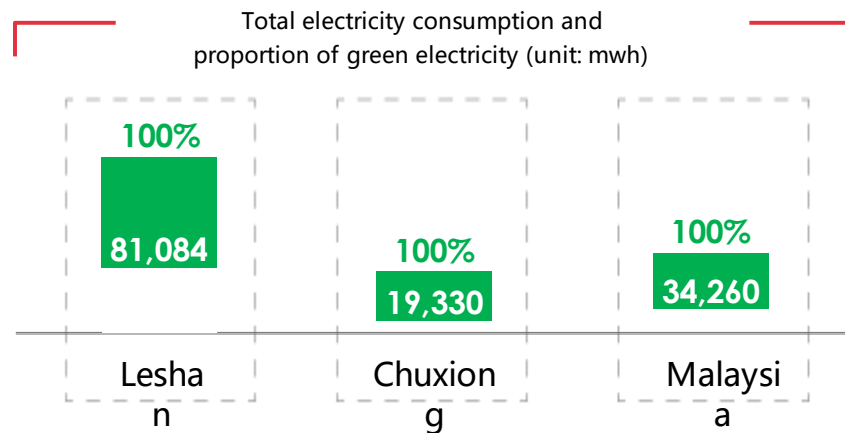
Yunnan Chuxiong



Leshan Sichuan



Malaysia



*Domestic grid green power share from China Energy Statistical Yearbook 2021; Malay, US, Vietnam grid green power share from local energy statistics agencies

Leading-edge Technology

25 times break the world record
 The conversion efficiency of the perovskite tandem solar cell based on N-type TOPCon reaches **32.33%**



3500+
Patent application



2000+
Granted Patents



330+
Core TOPCon Patents



409
Number of Patents



2278
R&D Team



6.9 Billion RMB +
R&D Investment in 2023

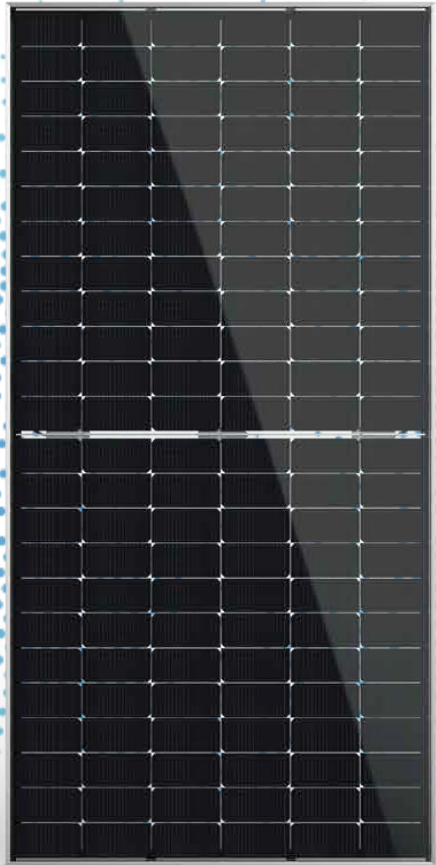
• Core Technology

- Low Oxygen and Low Concentric Circles Rate
- N-type Monocrystalline Technology
- N-type Silicon Wafer Thinning Technology
- N-type HOT 2.0 Cell Technology
- N-type IBC Cell Technology
- Tiger Neo Module Technology
- BIPV technology, etc.

• R&D Concepts

- Exploration of a new generation
- R&D of a new generation
- Mass Production of a new generation

N-Type Leading the Way



Leading in technical indicators



Highest efficiency in cell R&D
32.33%

Average efficiency for mass production by the end of 2023
26.1%

Module power higher than P-Type
Around 30W

Leading in production capacity scale



The world's largest N-type TOPCon cell capacity
55GW in production

2023 N-Type capacity share
75%

The world's largest N-type integrated manufacturing base
56GW pulling crystal + slicing+ cells + modules

Global sales leadership

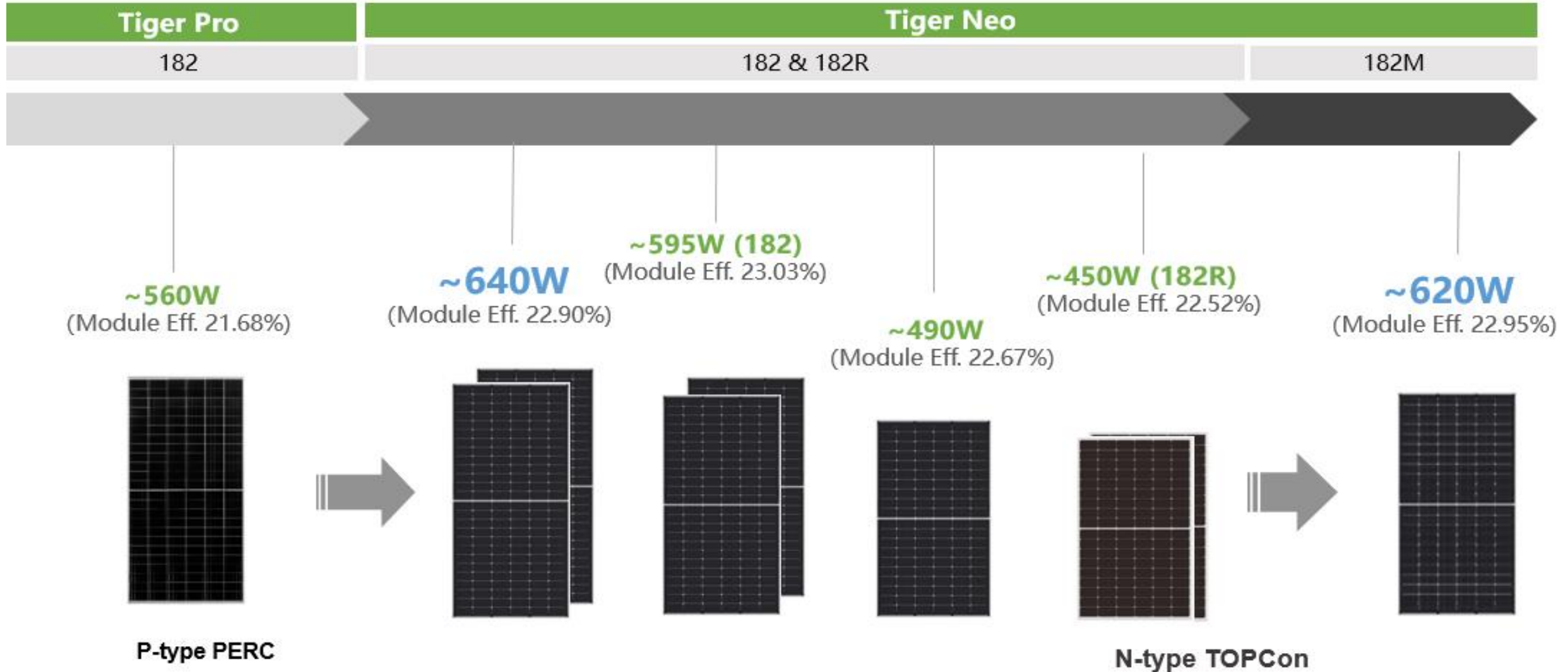


2022 N-Type global shipments
10.7GW

2023 N-Type shipments share
Estimated 60%

2023 N-Type shipments
45GW+

N-Type Leading the Way



01

About Jinko Solar

02

**TOPCon Humidity
Challenges**

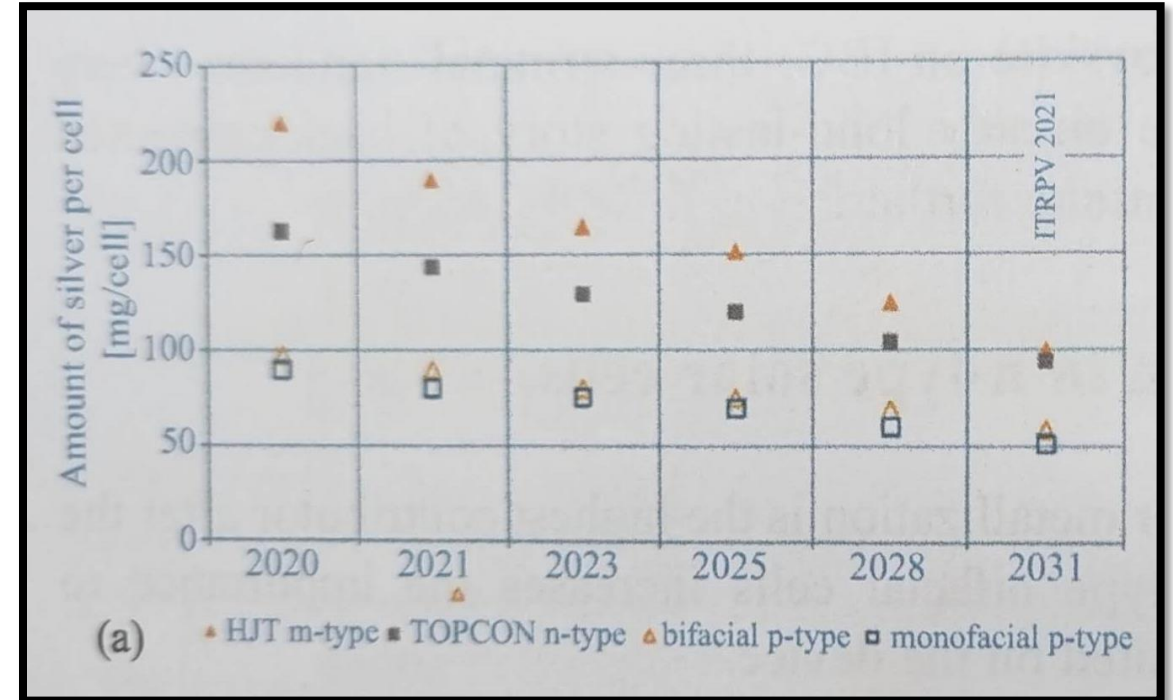
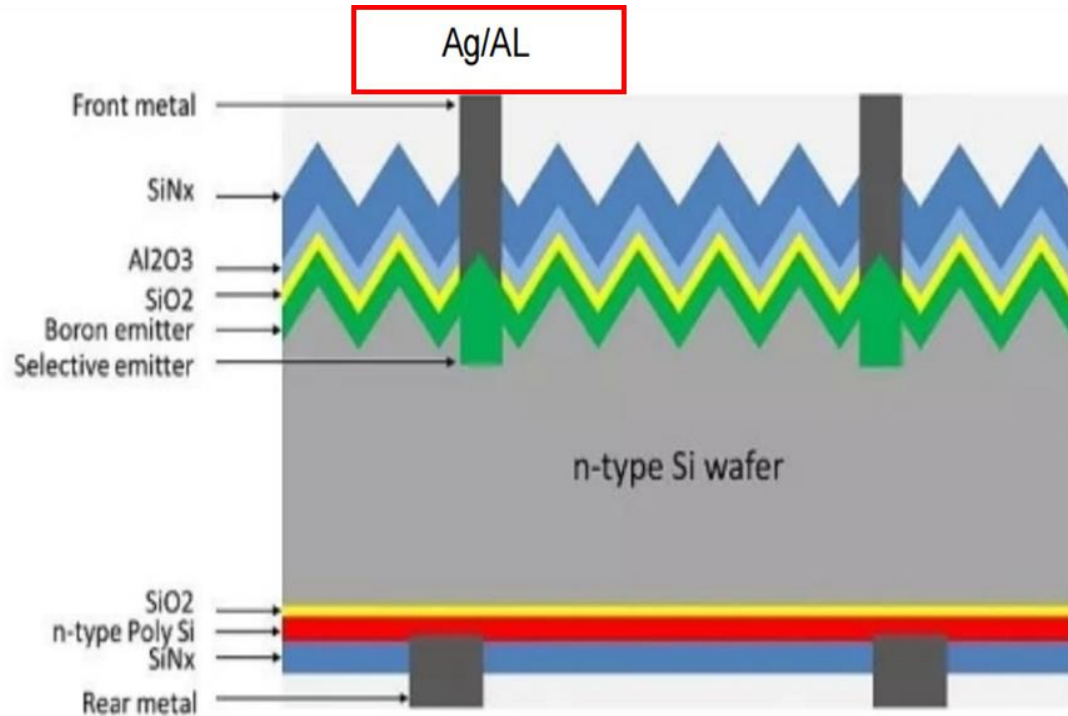
03

**TOPCon 3xIEC Test
Results**

04

**Saudi Arabia Test
Project**

Mono-facial DH Test Failure Mechanism Analysis



- In TOPCon cells, the silver paste is applied on both sides of the cell unlike the PERC where the silver paste is applied on the rear side.
- The AL is added to the silver paste to reduce the contact resistivity to the boron-doped emitter.
- Aluminum has Poor Resistance to Water Vapor/Acid Corrosion.

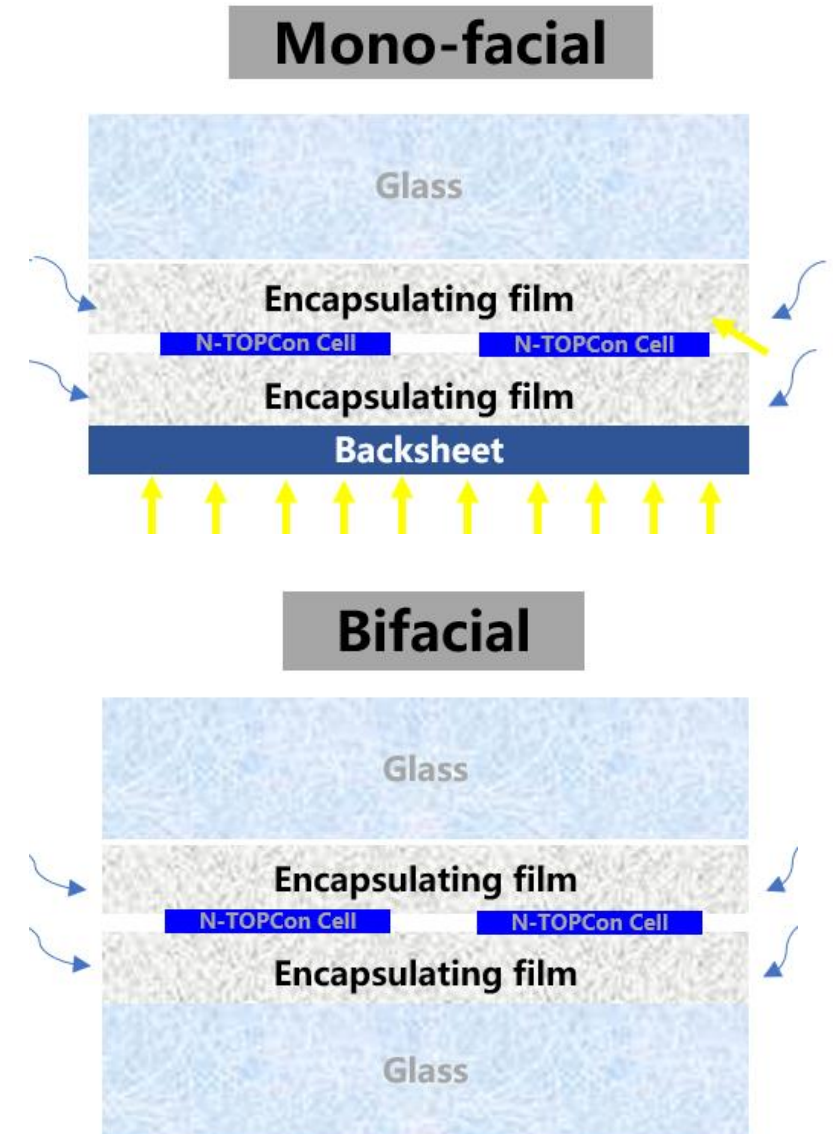
Mono-facial DH Test Failure Mechanism Analysis

➤ Mono-facial failure path

- Water vapor can enter the interior of the PV modules through the backsheet
- From the edge of the cell to the center of the cell
- Then from center of the cell to the interface between the encapsulation film and the cell

➤ Bifacial failure path

- The glass will prevent the water vapor from entering from the rear side
- Only small portion of water vapor will enter from the edges of the module to the cell





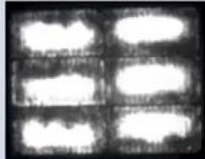
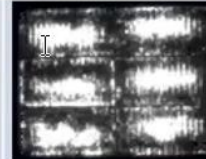


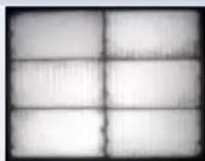

Jinko Solution For TOPCon Backsheet Modules

On the Cell Level

- ❑ SMBB technology, reduce contact between the ribbon and busbar (ribbon contains Pb, flux is acid)
- ❑ Unique temperature design for the front sintering, increase the fluidity and the non-uniformity pulp of glass material
- ❑ The front busbar and finger material comes from the same manufacturer, reduce the mismatch caused by the void area
- ❑ ALD prepares dense alumina to prevent water vapor from entering the PN junction on the front side of the cell

On the Module Level

- ❑ Professional SMBB welding equipment reduces the influence of fine diameter ribbon offset on busbar
- ❑ Special POE film (TF4N) is applied on the front side. No acid is released under the condition of high temperature and humidity.
- ❑ Low water permeability back plate, with respiratory function to release small acetic acid molecules decomposed by EVA on the back, to avoid the accumulation of acid
- ❑ High-performance silicone edge sealing is applied in modules to reduce the water vapor transmission at the edge

Front layer	Initial	PCT48h	PCT96h	PCT144h	FF loss
POE 1					~70%
TF4N POE					<5%

Steven Tang, Hangzhou First: Packaging Solutions for Bifacial n-type Module, Taiyang News Webinar

Jinko Solution For TOPCon Backsheet Modules



Spotlight on TOPCon: PI Berlin shares concerns about degradation

Asier Ukar, the director of PI Berlin Spain, discusses the importance of addressing the risks associated with tunnel oxide passivated contact (TOPCon) tech early on, even though it outperforms (passivated emitter rear contact (PERC) when considering standard and tangible indicators.

JUNE 20, 2023 **PV MAGAZINE**

Weekend Read: Getting to the bottom of TOPCon degradation

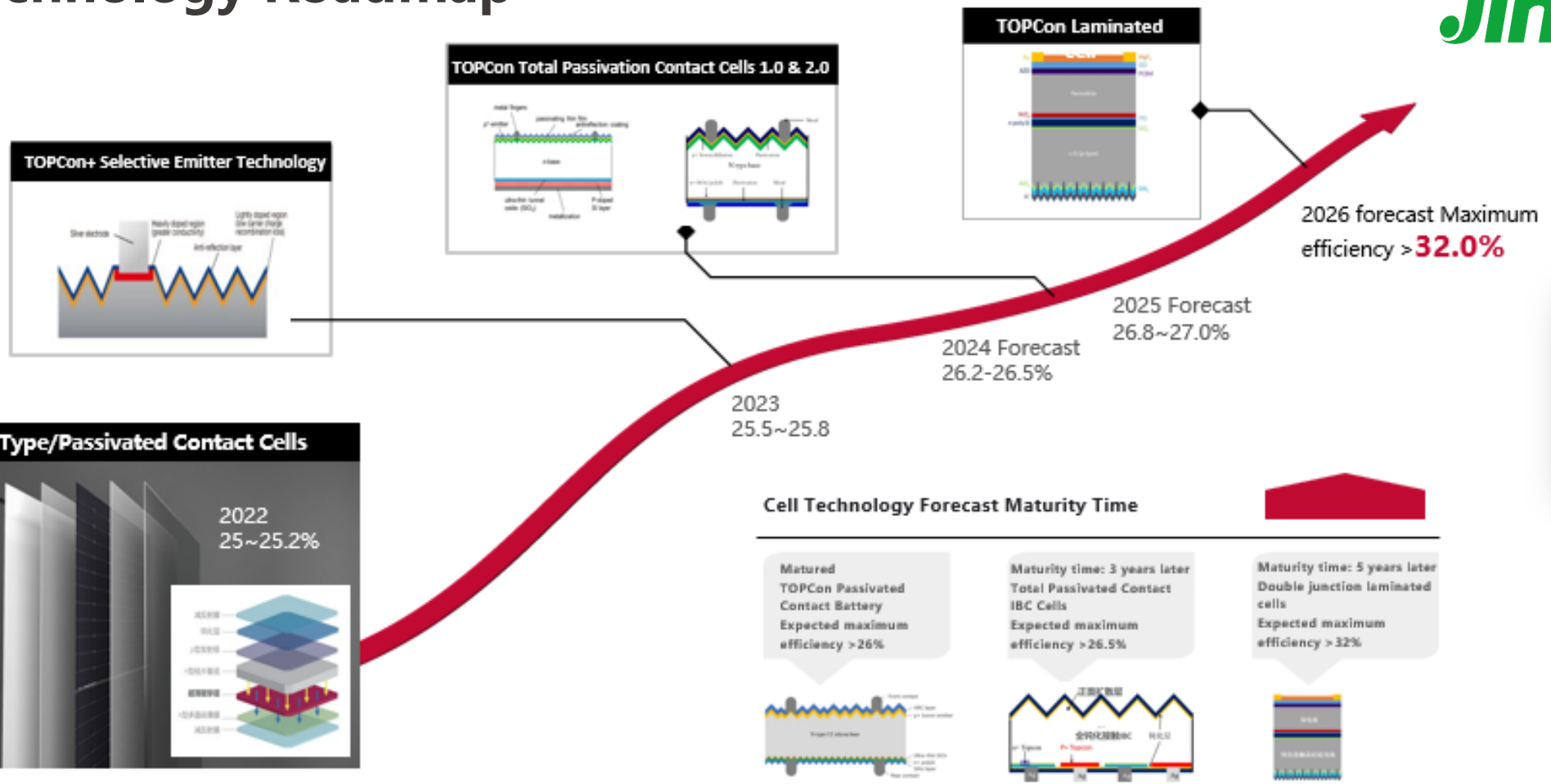
Should the industry be alarmed at the potential degradation susceptibility of tunnel oxide passivated contact (TOPCon) solar cells? Or are the problems easily addressed and more a reflection of rushed-to-market products? **pv magazine** contributor and consultant **Götz Fischbeck** reports.

SEPTEMBER 16, 2023 **PV MAGAZINE**

Within the bill of materials (BOM) for TOPCon modules, the encapsulant is a key component. An inadequate or low-quality encapsulant can nullify the benefits of TOPCon compared to PERC.

As a takeaway, one can conclude that the chemical reaction that ultimately leads to corrosion, and thus degradation, is already well known. So one would therefore assume that manufacturers have taken this aspect into account from the onset and have dealt with it through the proper choice of encapsulant.

N-Type Technology Roadmap



JinkoSolar Sets 'New Record' For TOPCon Module Efficiency
 Chinese Manufacturer Reports Record 24.76% Efficiency For N-Type TOPCon Panels; Achieves 32.33% Tandem Cell Efficiency

Nov 09, 2023

JinkoSolar claims 26.89% efficiency rating for new N-type solar cell

OCTOBER 30, 2023 ANGELA SKUJINS

New Solar Cell World Record from JinkoSolar

Chinese Manufacturer JinkoSolar Achieves 26.89% Maximum Solar Conversion Efficiency For TOPCon Cell

Oct 31, 2023

Jinko Solar Mono-Facial Products

- ✓ **Weight:** Around 4kg lighter than dual glass which makes it more suitable for rooftop installations.
- ✓ **Higher Power:** Power enhancement procedures can be implemented (special grid, white EVE ...), usually mono-facial module is one power bin higher than bifacial module.
- ✓ **Lower Operation Temperature:** The backsheet allows for more heat dissipation, in some sites the temp of the mono-facial modules is around 1C lower than dual glass modules.
- ✓ **Cheaper:** Around 0.5-1 US cent lower than dual glass modules.



01

About Jinko Solar

02

**TOPCon Humidity
Challenges**

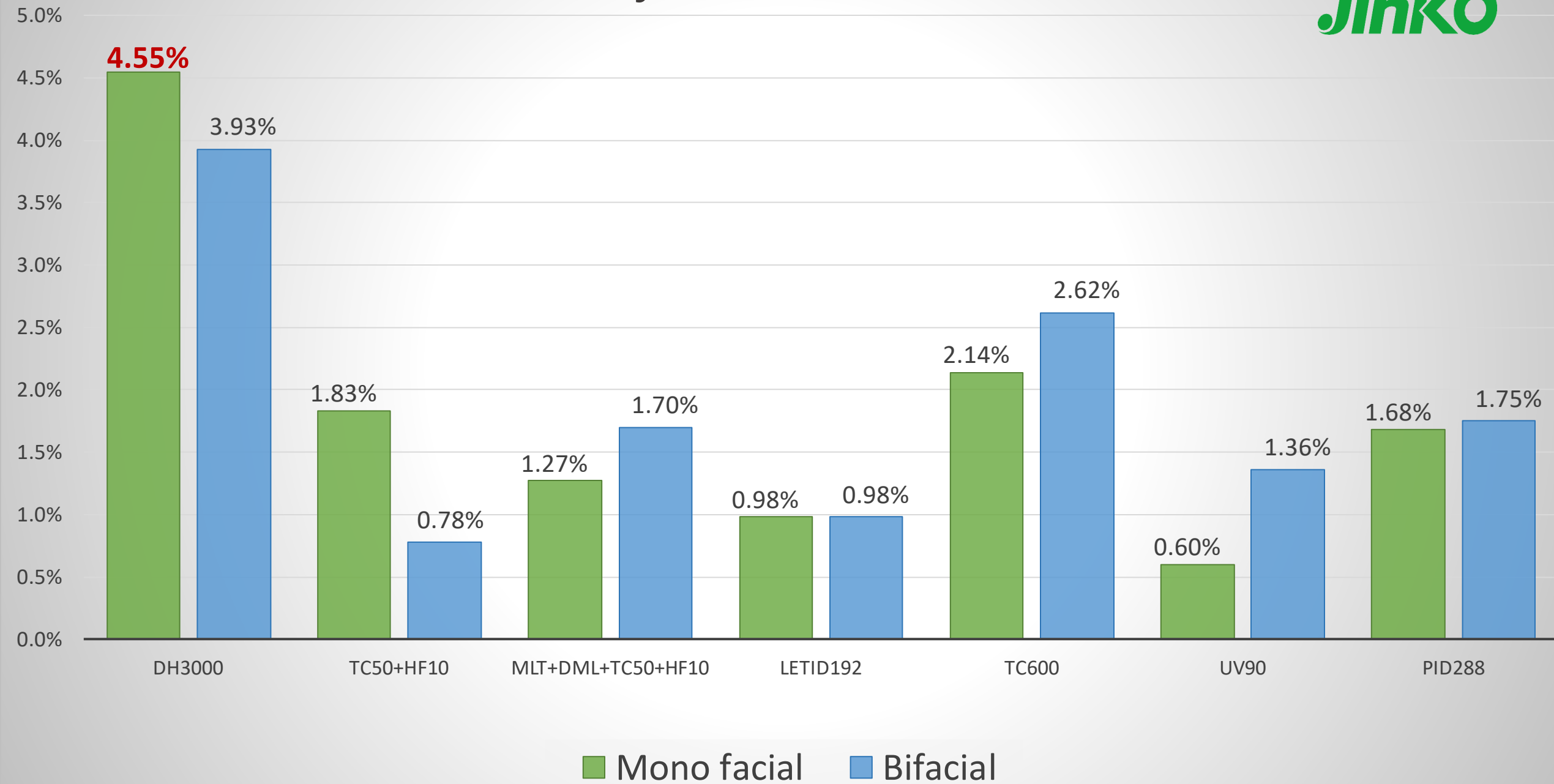
03

**TOPCon 3xIEC Test
Results**

04

**Saudi Arabia Test
Project**

3xIEC Reliability Tests Results – TUV NORD



Saudi Arabia Outdoor Performance Test Project



Location: King Abdullah University of Science and Technology (KAUST)

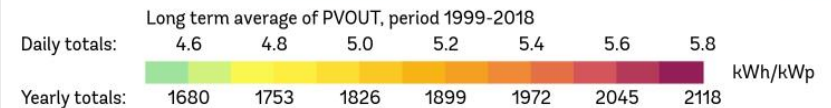
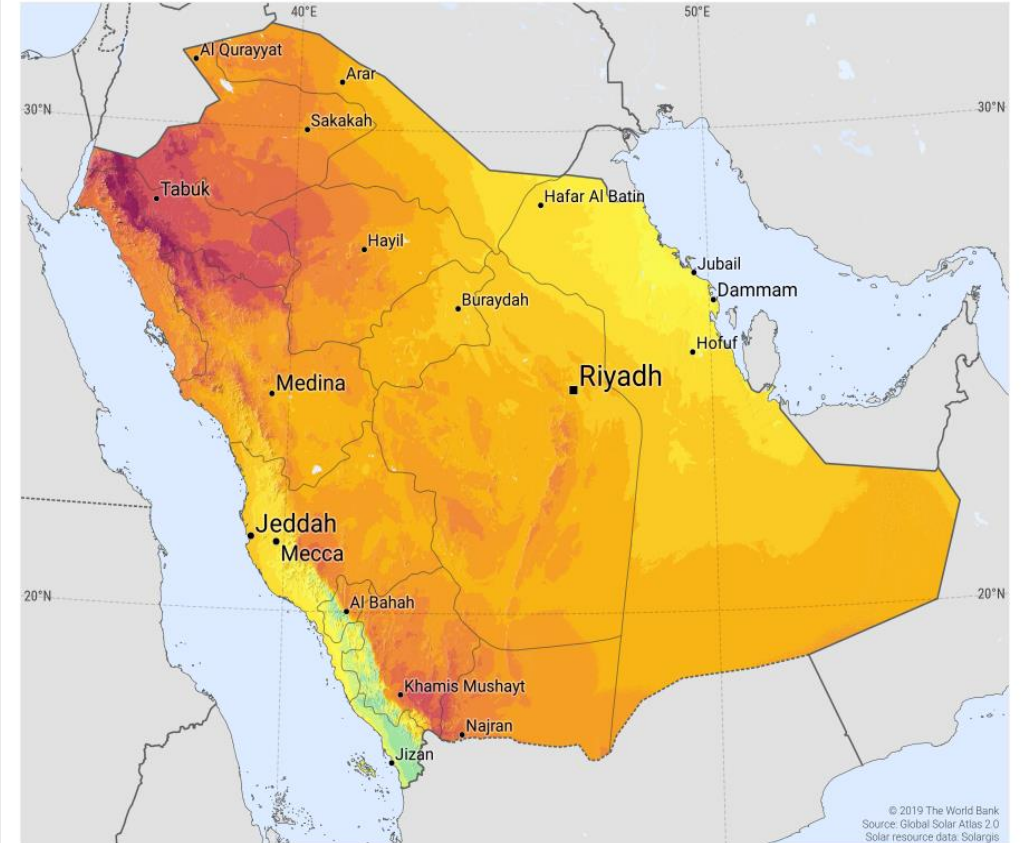
Testing Partners: TUV Rhineland, SGS

Testing During: 3 months (July – Sep)

**Testing Samples: TOPCon mono-facial backsheet JKM555N-72HL4-V
TOPCon bifacial dual glass JKM550N-72HL4-BDV**

SOLAR RESOURCE MAP

PHOTOVOLTAIC POWER POTENTIAL SAUDI ARABIA



This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit <http://globalsolaratlas.info>.

Saudi Arabia Outdoor Performance Test Project



Month	Jul.		Aug.		Sep		Average	
Module Type	Mono-facial	Bifacial	Mono-facial	Bifacial	Mono-facial	Bifacial	Mono-facial	Bifacial
Performance Ratio (PR)	83.2%	93.6%	81.9%	90.4%	80.6%	89.4%	81.9%	91.1%
Bifacial PR Improvement	BL	12.5%	BL	10.38%	BL	10.92%	BL	11.26%
Bifacial Yield	Baseline	12.54%	BL	10.44%	BL	11.06%	BL	11.34%

THANK YOU !



Mohammed Saady Al-Dweik
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Advances in TOPCon technology and application in hot climate

PV Magazine Webinar

Jörg Althaus

Director Quality Assurance and
Engineering Services

March 26th, 2024



Company Snapshot

Clean Energy Associates is a technical advisory company that provides unrivaled insight into the solar PV, energy storage and hydrogen manufacturing industries to ensure the success of solar PV, storage and electrolyzer projects worldwide.

1,000+

Years of industry experience

225+

Professionals

150+

Engineers

15

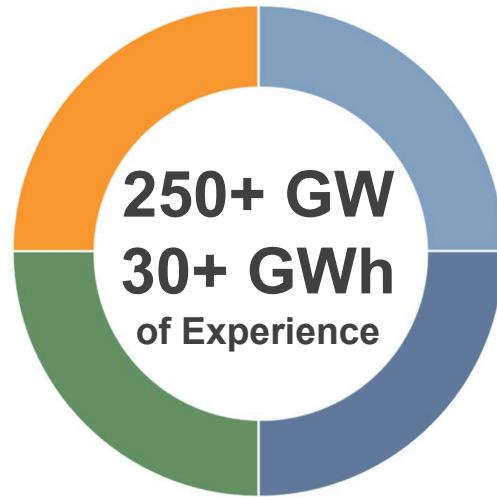
Year track record

15

Countries with a physical presence

Supply Chain Management

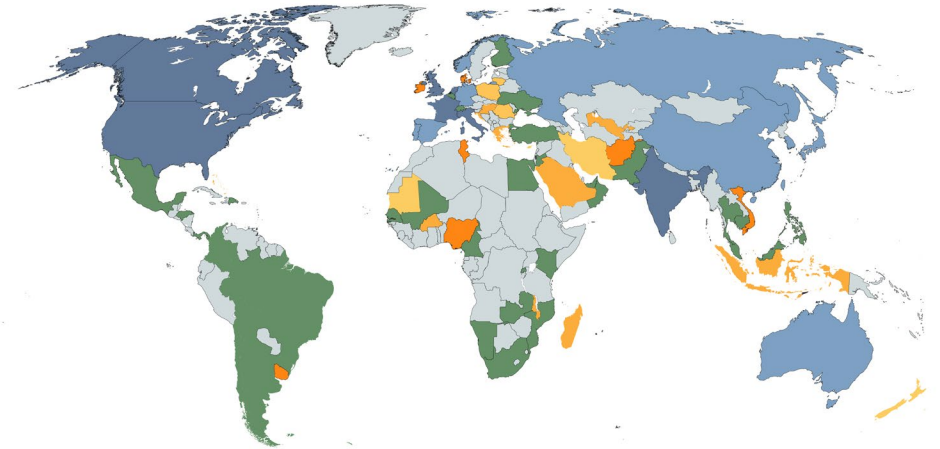
Market Intelligence



Engineering Services

Quality Assurance

Client engagements in **75+** countries



Engagements in **350+** solar and storage factories worldwide

Proud member of:



Technologies



PV Solar System



- PV Modules
- Mounting Structures & Racking



Battery Energy Storage System



- Cell
- Module
- Rack
- Integrated Container



Electrolyzer System



- Electrolyzer stack
- Gas-liquid separator
- Gas purification system
- Auxiliary Units

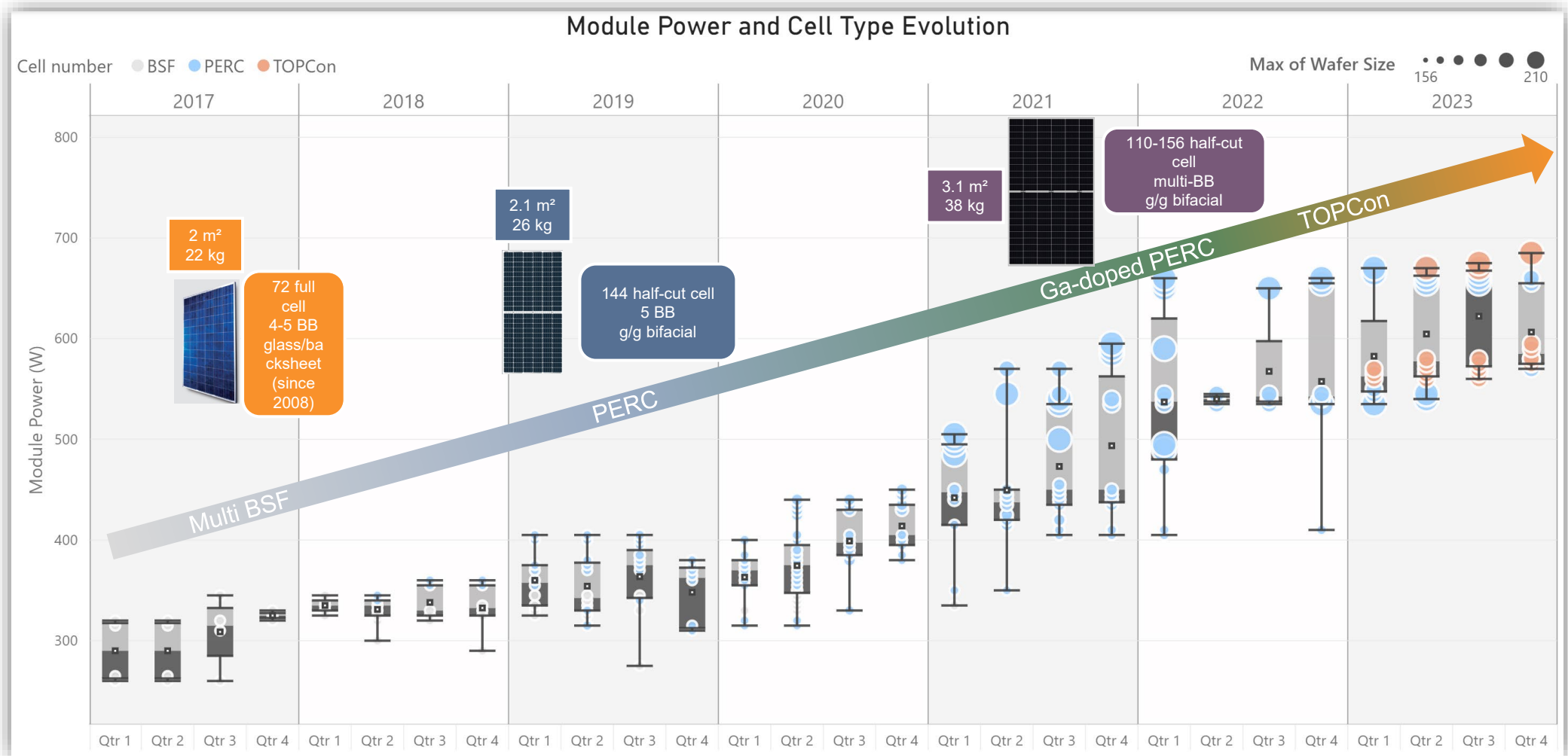


Balance of System



- Inverter/PCS
- Transformer

Module Technology Has Drastically Changed In The Last 5 Years – New Challenges For Performance And Quality

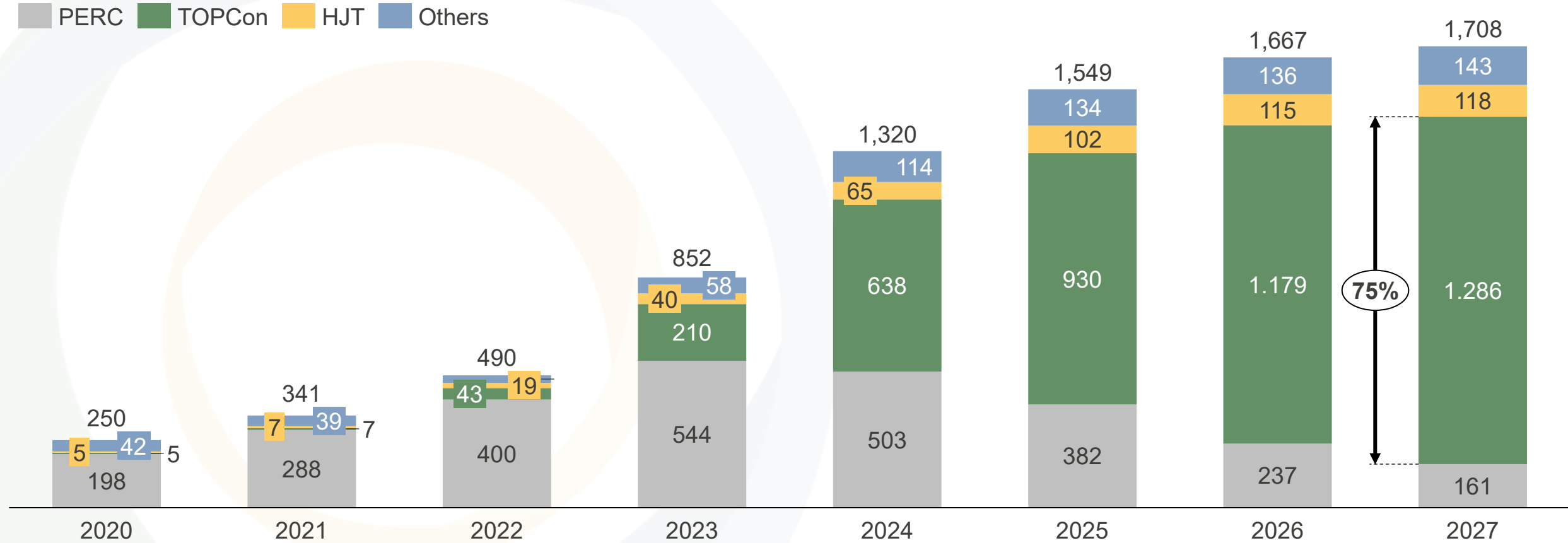


Source | CEA Quality Assurance Project Data Statistics

~75% of overall cell capacity likely to be TOPCon as PERC transitions

HJT and other technologies will be a viable minority of overall capacity shares

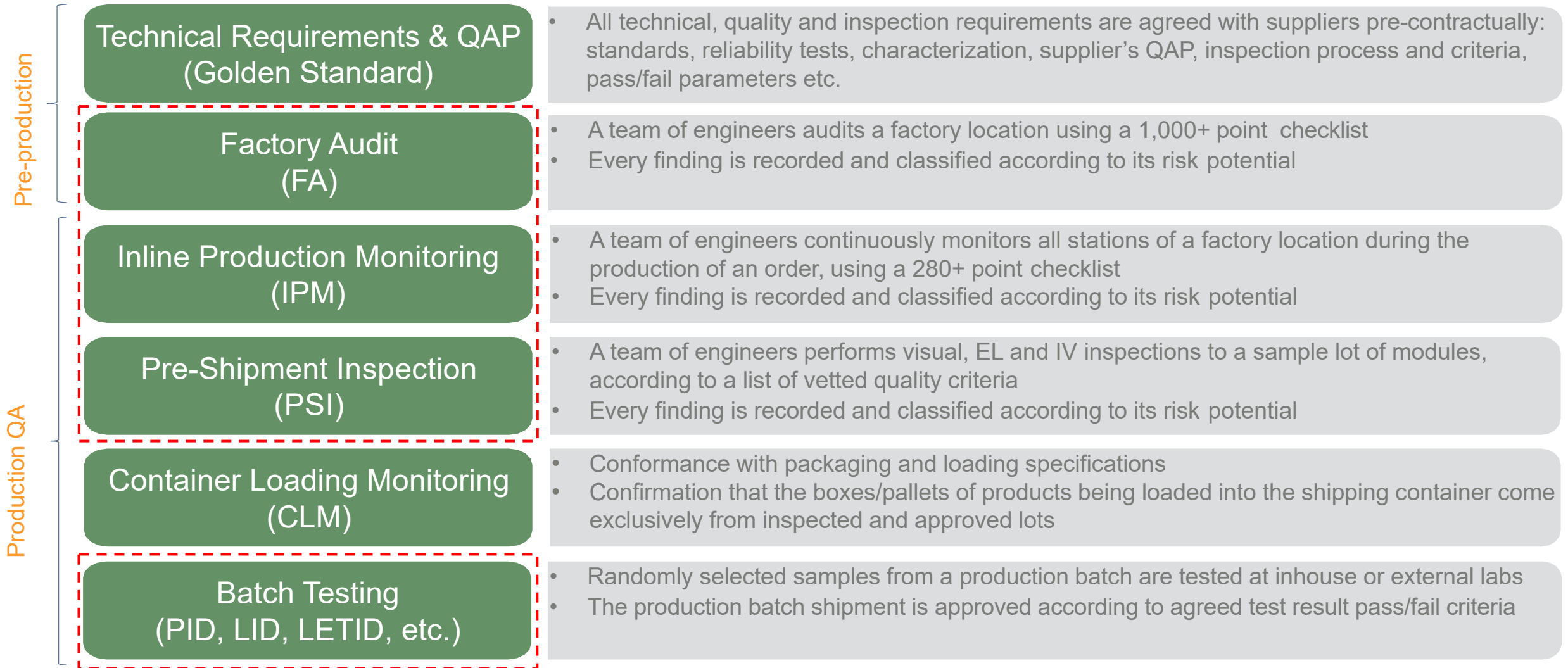
Outlook for global likely cell production capacity by technology (GW)



Notes | Data aggregated by CEA based on company announcements and disclosures. Data does not account for utilization, but factors in ramp times and potential production delays. Overall timelines are based on supplier statements or industry best practices if no timeline data was reported. Capacity totals are discounted by CEA based on supplier track records to remove unlikely expansion plans

The Main Upstream Quality Assurance Activities

CEA performs quality assurance work before, during and after the production of PV modules, conducting 6 main activities, that are necessary to ensure pre-installation quality.



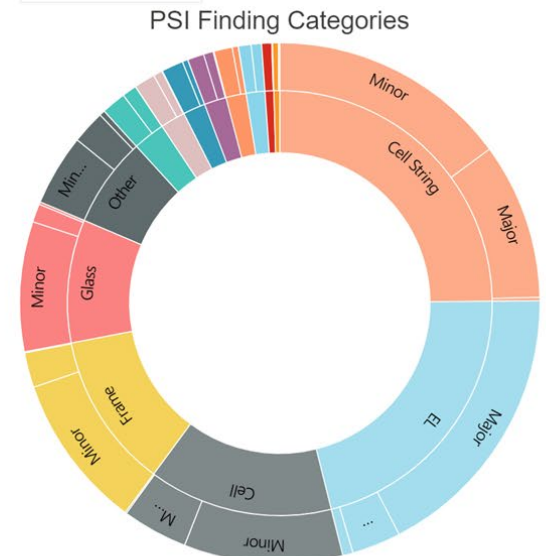
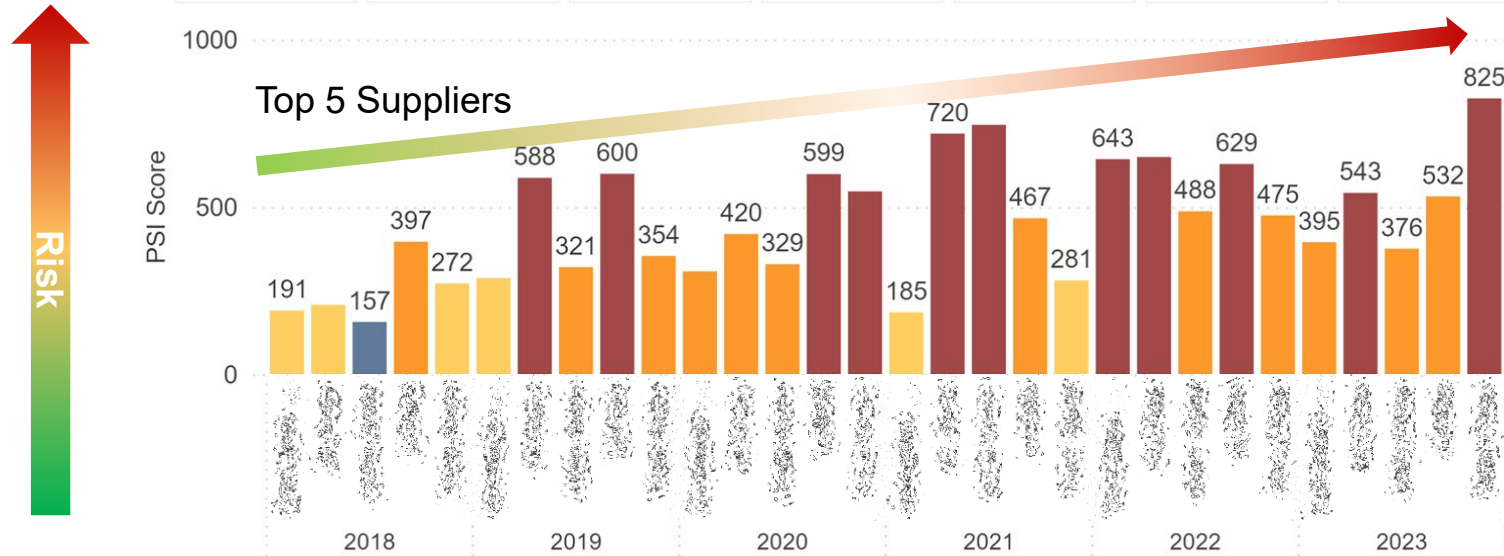
The Rapid And Sometimes Simultaneous Introduction Of New Technologies Increased Overall Quality Risk

Supplier Benchmarking Program: Pre-shipment Inspection (PSI)

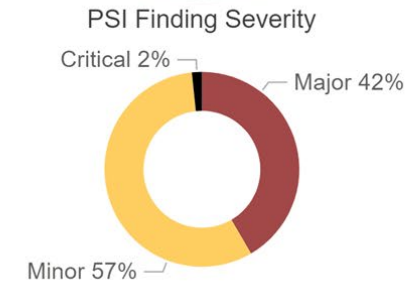
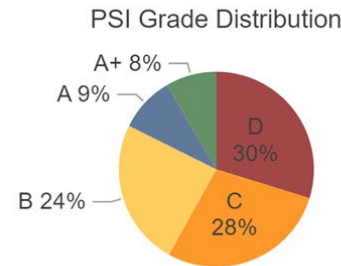


Supplier: Multiple sele...
 Manufacturer: All
 Country: All
 Location: All
 Grade: All
 Latest: All
 In-House: In-House

Severity: All



Supplier	PSI Score
	303
	318
	394
	536
	541



Source | CEA Quality Assurance PSI Risk Score Data

TOPCon Shows Some Advantage to PERC, More Data Needed

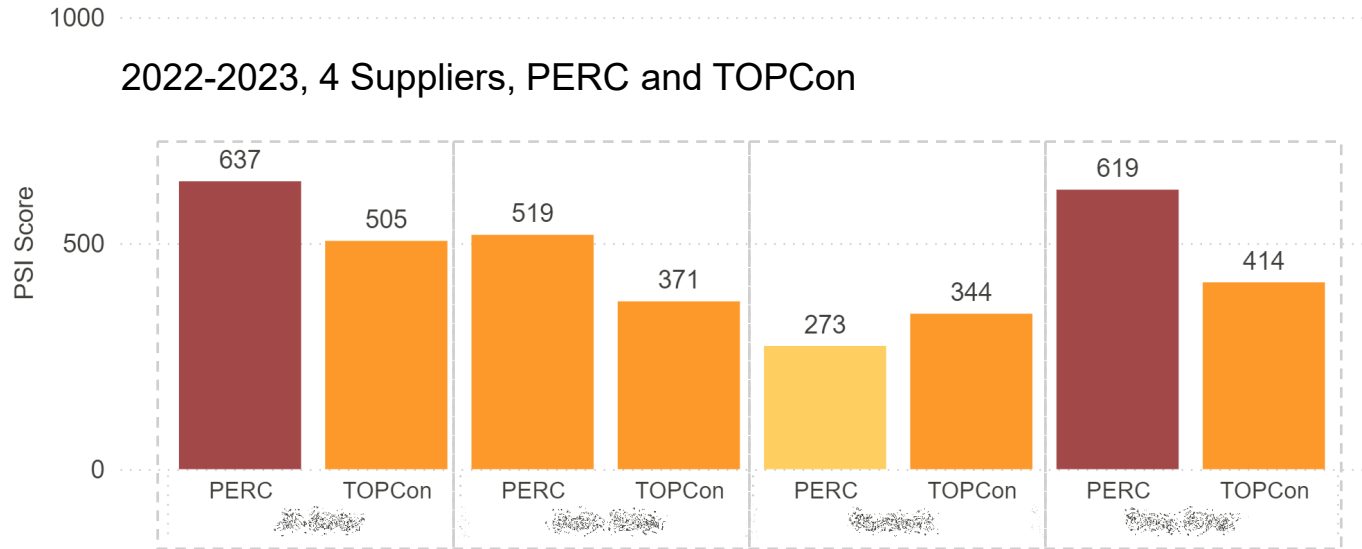
Supplier Benchmarking Program: Pre-shipment Inspection (PSI)



Supplier: Multiple sele... Manufacturer: All Country: All Location: All Grade: All Latest: All In-House: In-House Severity: All cellStructure: Multiple sele...



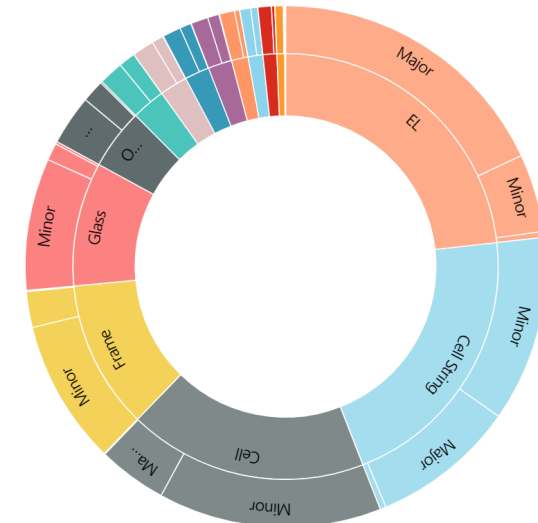
2022-2023, 4 Suppliers, PERC and TOPCon



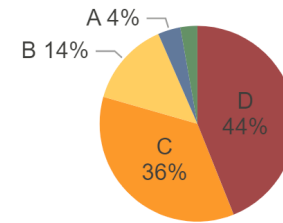
Supplier	PSI Score
Supplier 1	624
Supplier 2	456
Supplier 3	287
Supplier 4	593



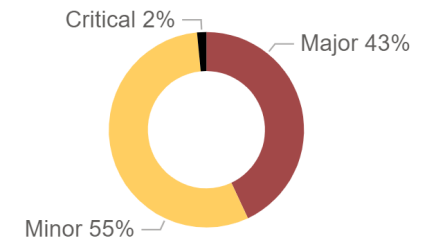
PSI Finding Categories



PSI Grade Distribution

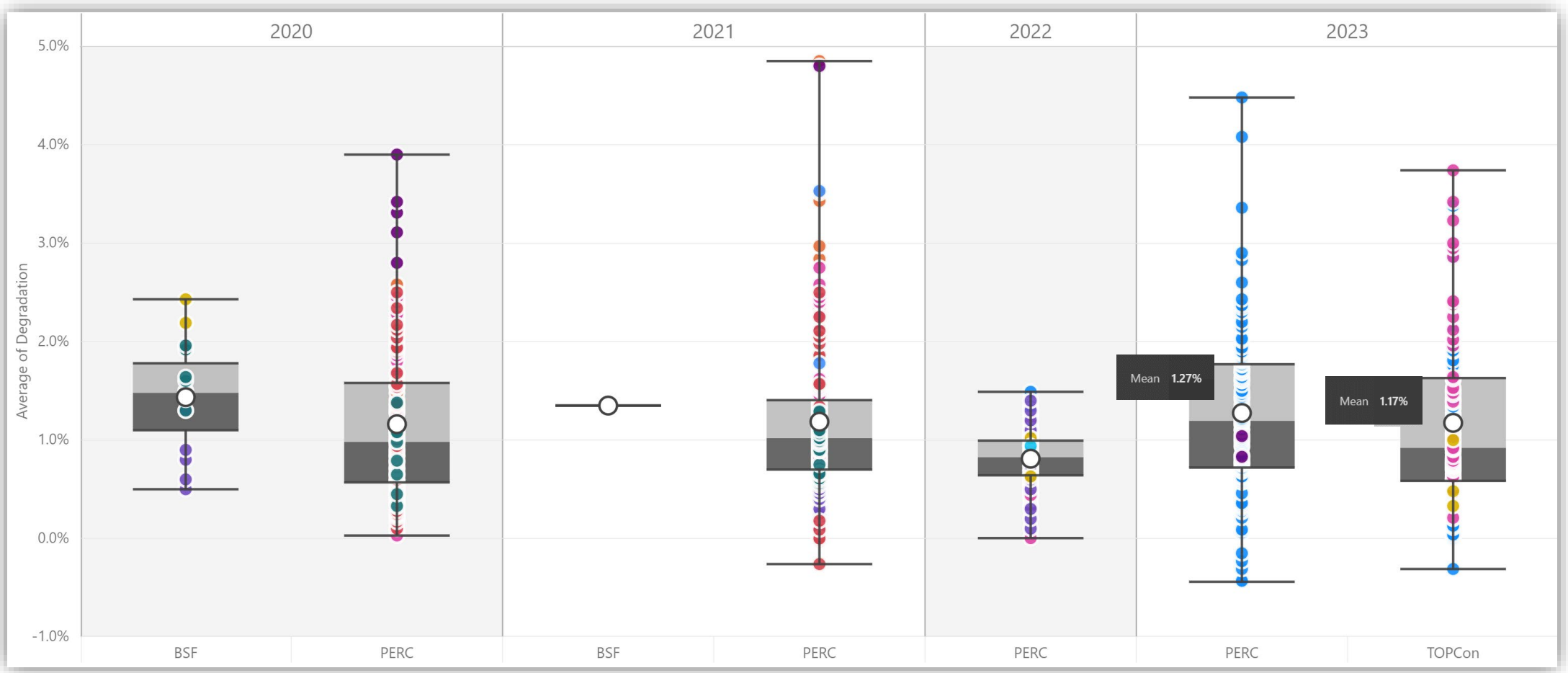


PSI Finding Severity



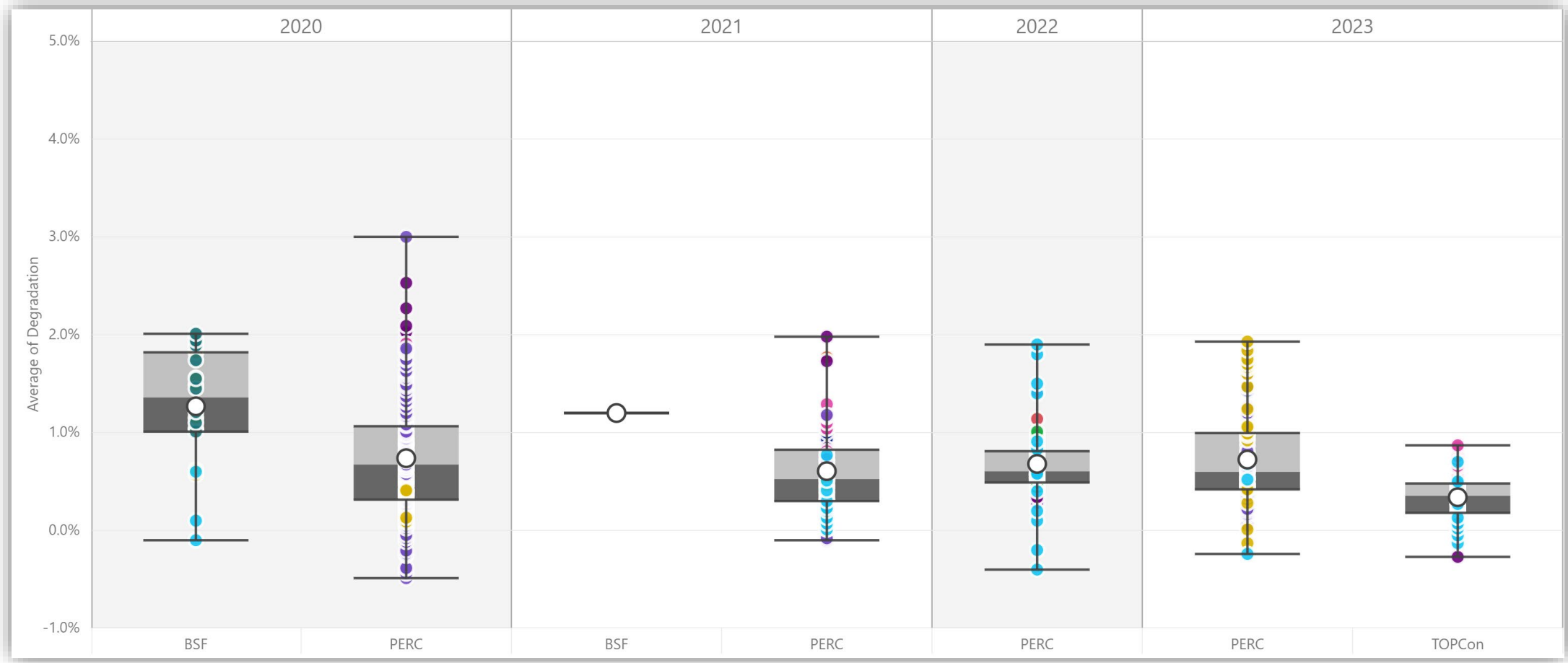
Source | CEA Quality Assurance PSI Risk Score Data

PID Trends: Outliers Persist, TOPCon on a Learning Curve



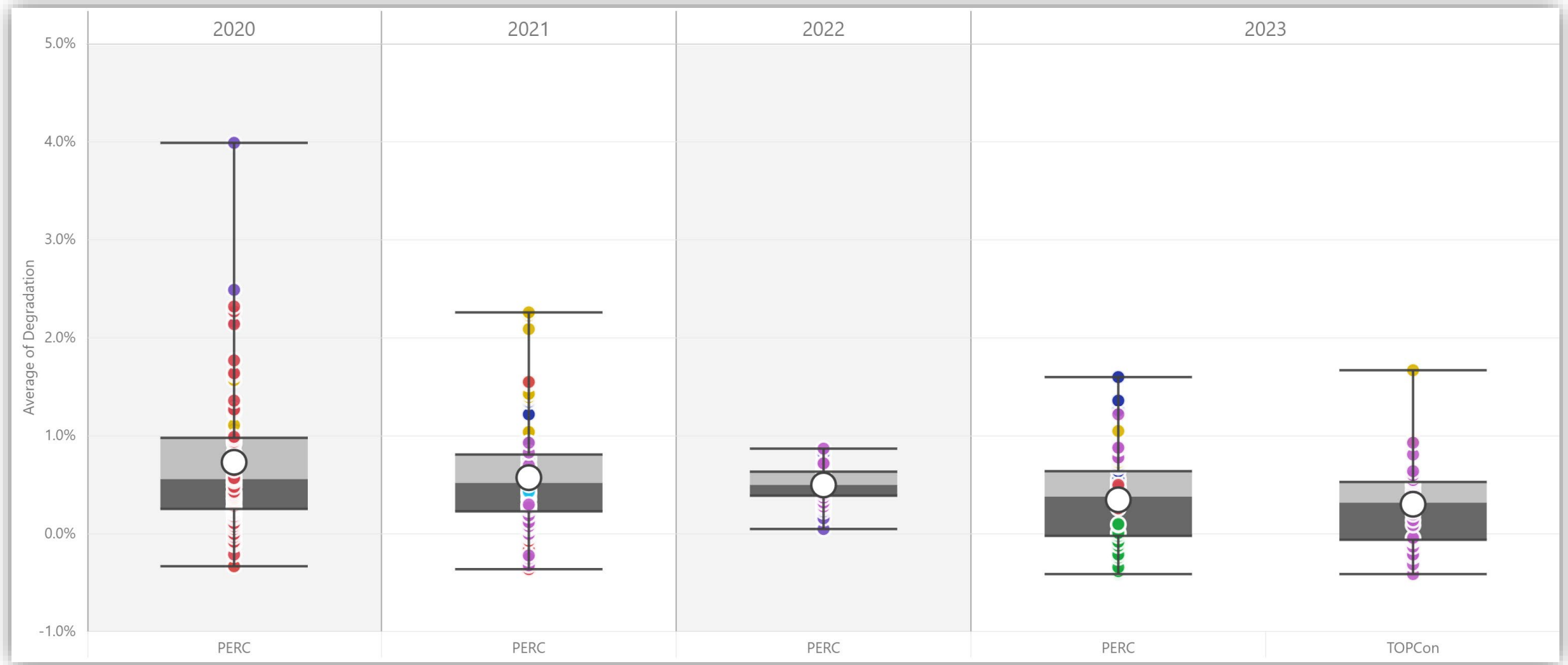
Source | CEA batch testing data, multiple labs. PID at 85°C/85%RH/96h
TOPCon data from 4 suppliers.

LID Trends: TOPCon Better Than PERC



Source | CEA batch testing data, multiple labs. LID at 60 – 80 kWh/m²
TOPCon data from 3 suppliers.

LeTID Trends: TOPCon Showing Slight Advantage Over PERC



Source | CEA batch testing data, multiple labs.
Test conditions: (Isc-Imp) or 2*(Isc-Imp), 75 C, 162h-324h, with stabilization.
TOPCon data from 3 suppliers.

CEA - PV Magazine Test Program: How does TOPCon and Other Technologies Perform Compared to PERC?

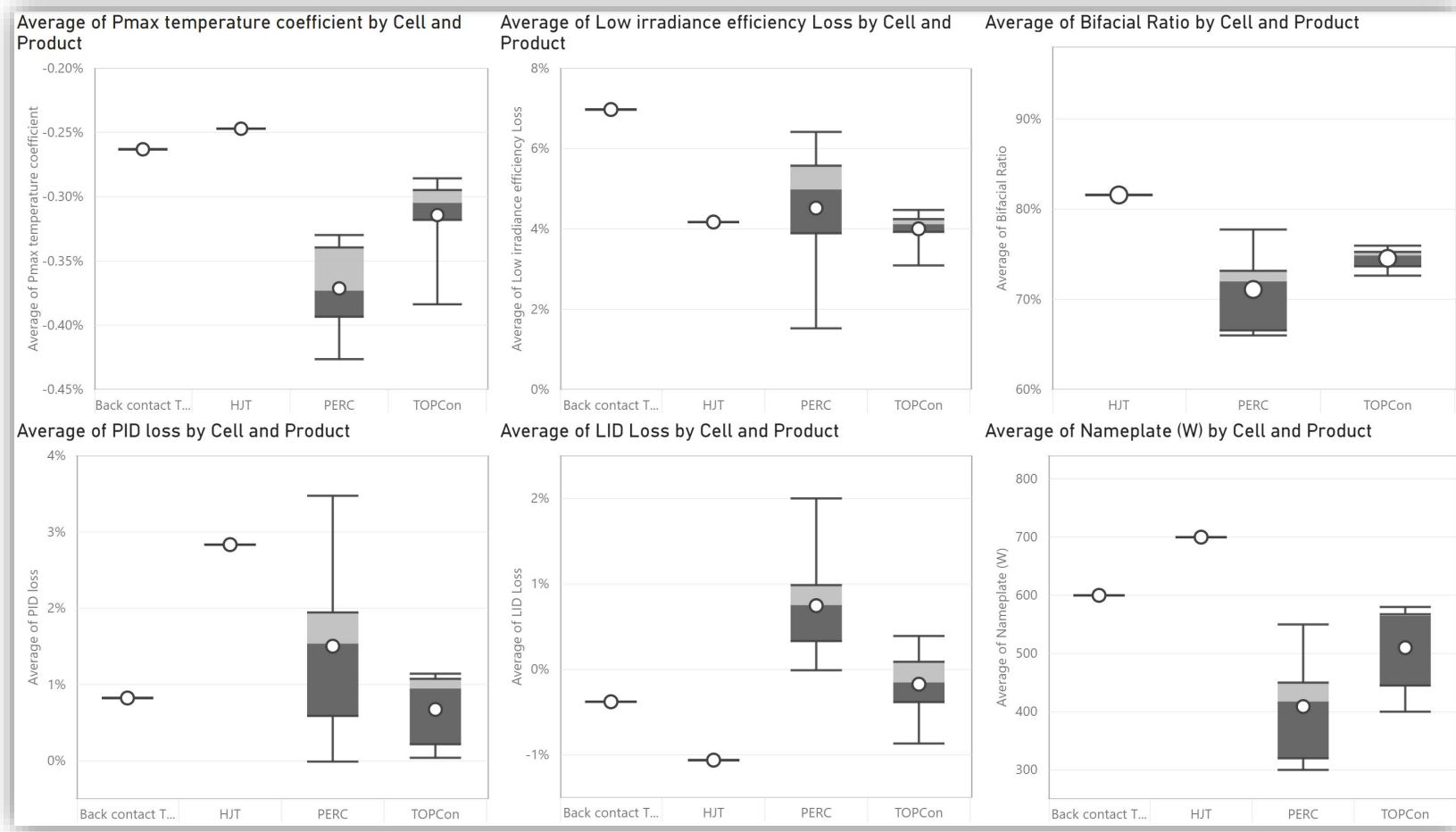
CEA has been testing PV modules in collaboration with PV Magazine at Gsola's Xi'an facilities since 2017. Products are characterized and tested before being installed in the field.

TOPCon products have better Pmax temperature coefficient, reduced low irradiance losses, lower PID and LID and higher bifaciality ratio.

All these factors can contribute to higher specific energy yield for TOPCon.

Newly tested HJT and back modules show even better characteristics, which must be validated in the field, when they are installed.

Suppliers typically select these products from small production runs, not necessarily representative of mass production.



Source | CEA - PV Magazine Xi'an, China, indoor data since 2017. Indoor test results published at pv magazine's website (<https://www.pv-magazine.com/pv-magazine-test-results>)

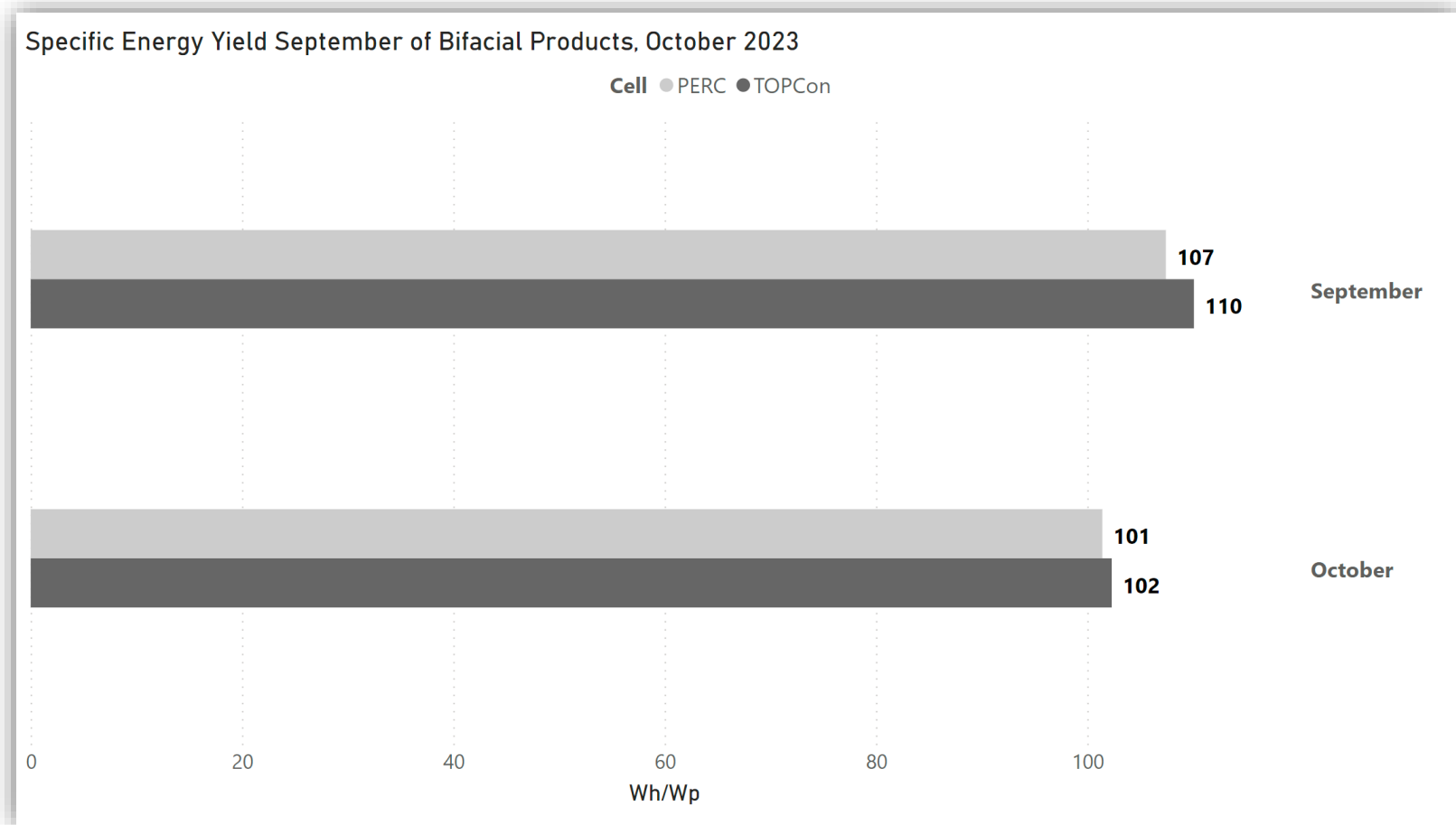
CEA - PV Magazine Test Program: Does TOPCon Have Higher Energy Yield than PERC?

Recent additions of bifacial TOPCon products to the outdoor test field will allow us to have more insights in TOPCon's advantages.

6 out of a total of 13 bifacial products are TOPCon, with the rest being PERC.

A first insight is that TOPCon has higher energy yield advantage in September's warmer and sunnier weather of Xi'an, as it has a better Pmax temperature coefficient, helping it perform better in warmer months.

We need more data over a full year to perform a detailed analysis of TOPCon's advantages due to its temperature and bifaciality characteristics.



Source | CEA - PV Magazine Xi'an, China test field data from October 2023. Bifacial modules only shown. Detailed monthly results get published in [CEA's blog \(https://www.cea3.com/cea-blog/pv-magazine-test-september-2023\)](https://www.cea3.com/cea-blog/pv-magazine-test-september-2023) and [pv magazine's website \(https://www.pv-magazine.com/features/pv-magazine-test\)](https://www.pv-magazine.com/features/pv-magazine-test).



Thank You

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26 March 2024

10:00 am - 11:00 am | CET, Berlin

12:00 pm – 1:00 pm | AST, Riyadh

1:00 pm – 2:00 pm | Dubai

pV magazine
webinars

TOPCon overcoming obstacles: improving performance of backsheet- based monofacial products

Q&A



Emiliano Bellini

News Director
pv magazine



Mohamed Saady

Head of Technical Services & Product
Management MENA
JinkoSolar



Joerg Althaus

Director Quality Assurance and
Engineering Services
Clean Energy Associates

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[U.S. Boiler unveils hydronic heat pump for residential applications](#)

by Emiliano Bellini



Most-read online!

[Sodium-ion batteries – a viable alternative to lithium?](#)

by Marija Maisch



Coming up next...

Wednesday, 27 March 2024

2:30 pm – 3:30 pm CET, Berlin, Paris, Madrid

Wednesday, 3 April 2024

5:00 pm – 6:00 pm CEST, Berlin, Paris, Madrid

Many more to come!

**Weather alert
– measuring
module load
in snowy
regions**

**Hail risk
mitigation
strategies for
solar assets**

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joining today!**