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pv magazine webinars

Demonstrating durability in n-type modules

30 August 2022

2:00 pm – 3:00 pm | CET, Berlin
4:00 pm – 5:00 pm | GST, Dubai
3:00 pm – 4:00 pm | AST, Riyadh
1:00 pm – 2:00 pm | Morocco

Mark Hutchins
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PV Evolution Labs (PVEL)

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. 👀 💡

PVEL'S TEST RESULTS – HOW DO INITIAL TOPCON RESULTS COMPARE?

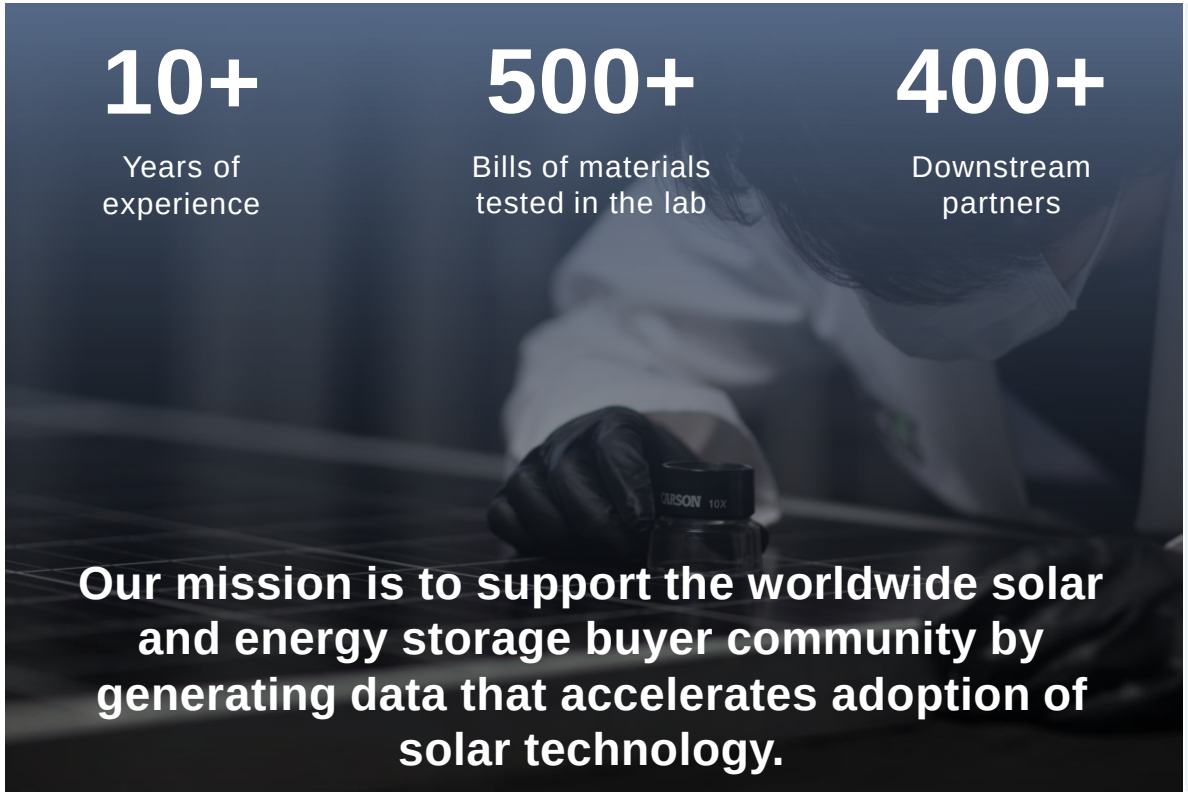
Tristan Erion-Lorico

VP of Sales and Marketing

tristan.erion-lorico@pvel.com

member of group kiwa

PV Evolution Labs (PVEL) is the Independent Lab of the Downstream Solar and Energy Storage Market



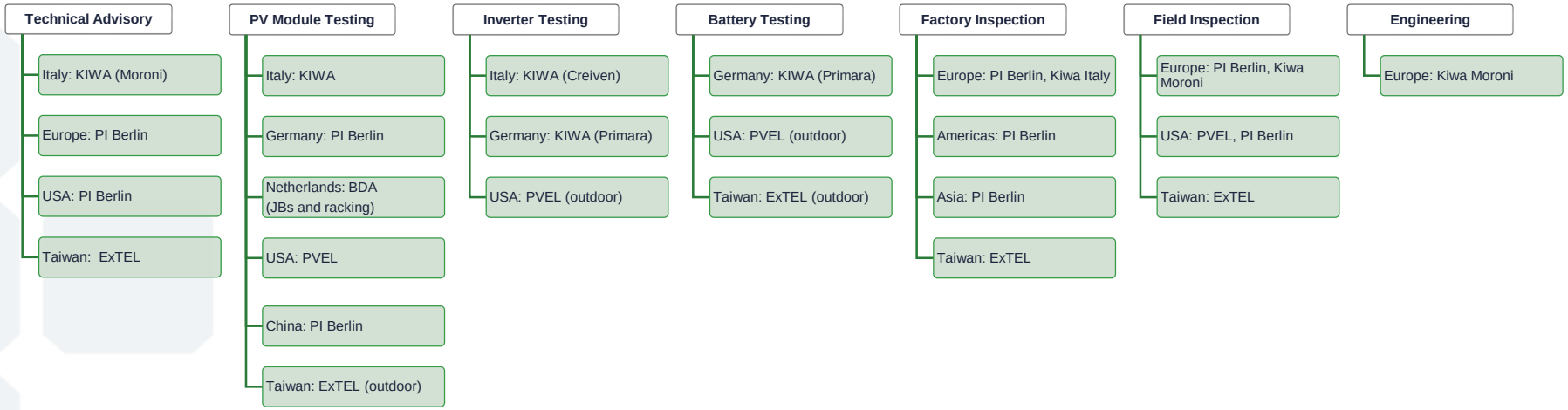
Services at a glance

- Extended reliability and performance testing for PV modules, inverters and energy storage systems
- Outdoor testing at PVUSA, an iconic grid-connected research site
- Data services for PV buyers and investors
- Field testing and EL imaging for operating assets

In 2021 PVEL became a member of the Kiwa Group.

Kiwa Overview

- Kiwa is a global testing, inspection and certification (TIC) company, founded in 1948
- Headquartered in Rijswijk, the Netherlands with more than 10,000 employees, working in over 37 countries. Kiwa is primarily active in renewable energy, construction, manufacturing, fire safety, medical devices, food & water.
- Kiwa's solar businesses at a glance:



- Kiwa's mission is to create trust by contributing to the transparency of the quality, safety and sustainability of products, services and organizations as well as of personal and environmental performance

Integrated PV module diligence in factory, lab and field

Pre-Production Procurement

Contracting Assistance
- Equipment specifications
- Manufacturing requirements
- Testing and certification requirements
- Quality assurance requirements

Pre-Production Diligence

Manufacturing Quality Verification
- Factory audit
- Corrective action
- Witnessed sample build

Module Reliability Verification
- Extended reliability testing (PQP)

Production Assurance

Manufacturing Quality Assurance
- Production supervision
- Pre-shipment inspection
- Pre-shipment testing
- Container loading inspection

Module Quality Assurance
- Batch-based stress testing

Post-Production Install & Operation

Module Delivery
- Inspection upon delivery (VI, EL)

Module Installation
- Installation supervision
- Inspection after installation (EL, IR)

Module Operation
- Trouble shooting
- Warranty or insurance claims


PVEL
MAKE DATA MATTER.
PVEL'S PQP
member of group
kiwa

PV Module Product Qualification Program (PQP)

We launched our PQP in 2012 with two goals:

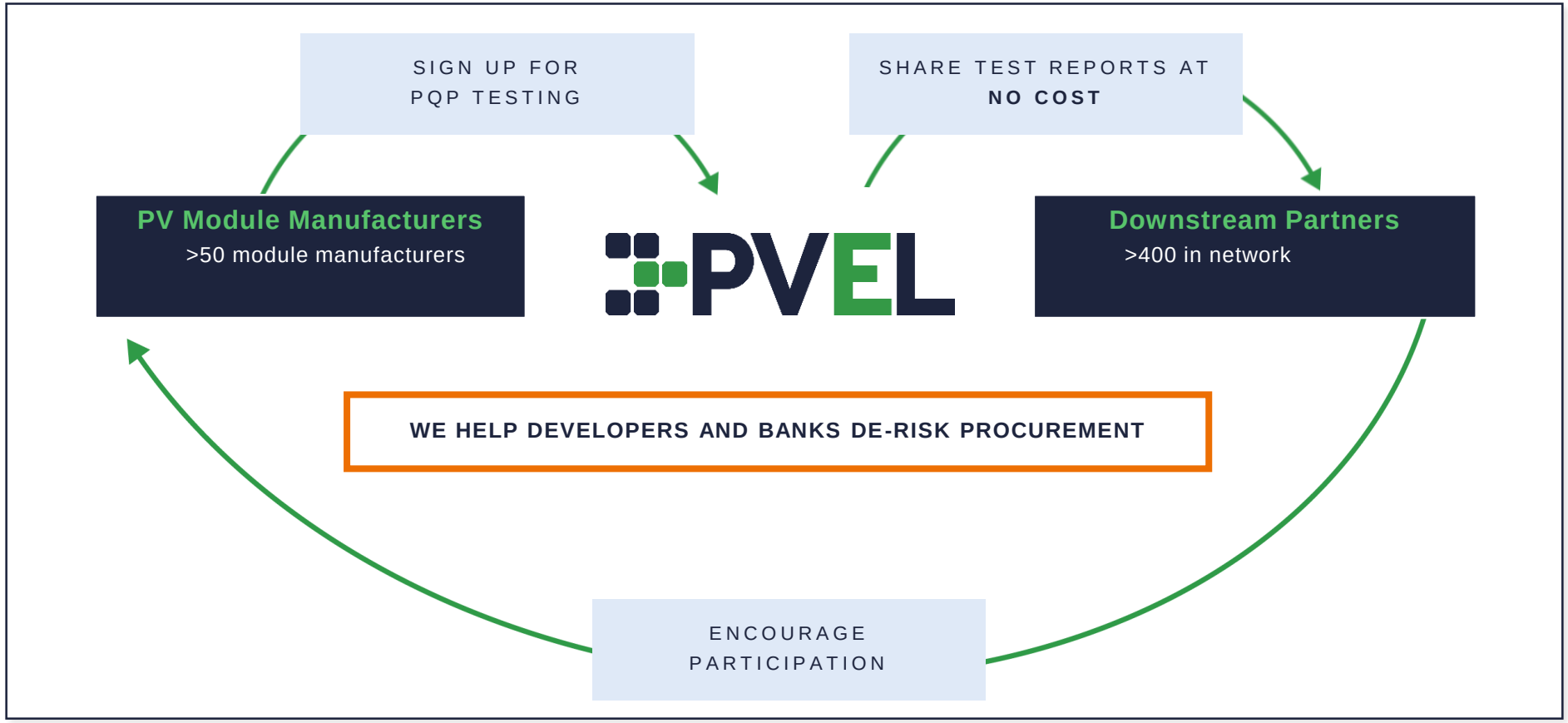
1. To provide independent reliability and performance data to PV module buyers.
2. To recognize manufacturers and products that excel in testing.

Our Process

- Samples are witnessed in production and detailed bills of materials (BOMs) are recorded.
- All PV module BOMs are tested in consistent environments with calibrated equipment.

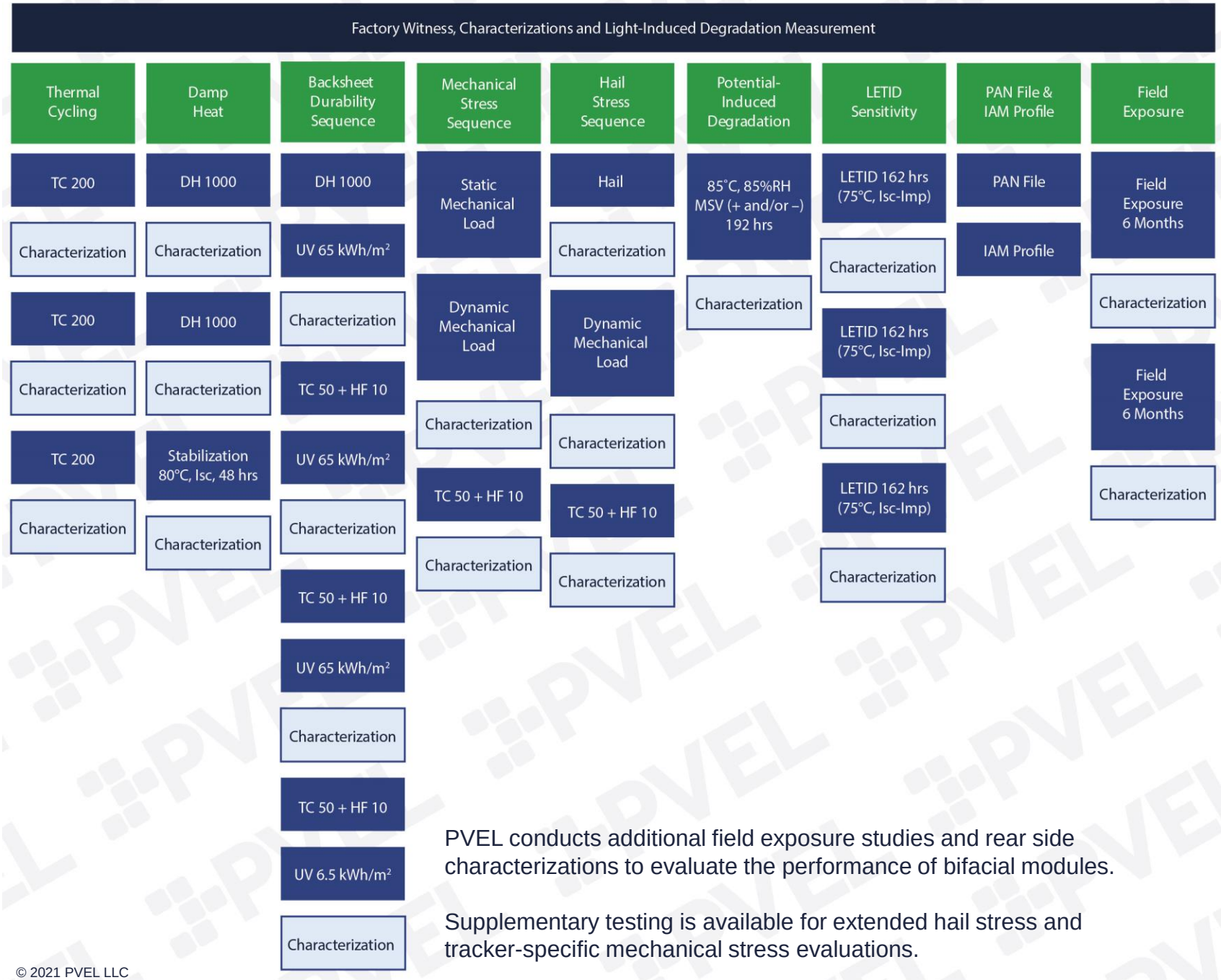
To date, we have tested nearly 500 PV module BOMs from 50+ module manufacturers in our PQP.

How PVEL's Module PQP Works



Module PQP Test Sequence

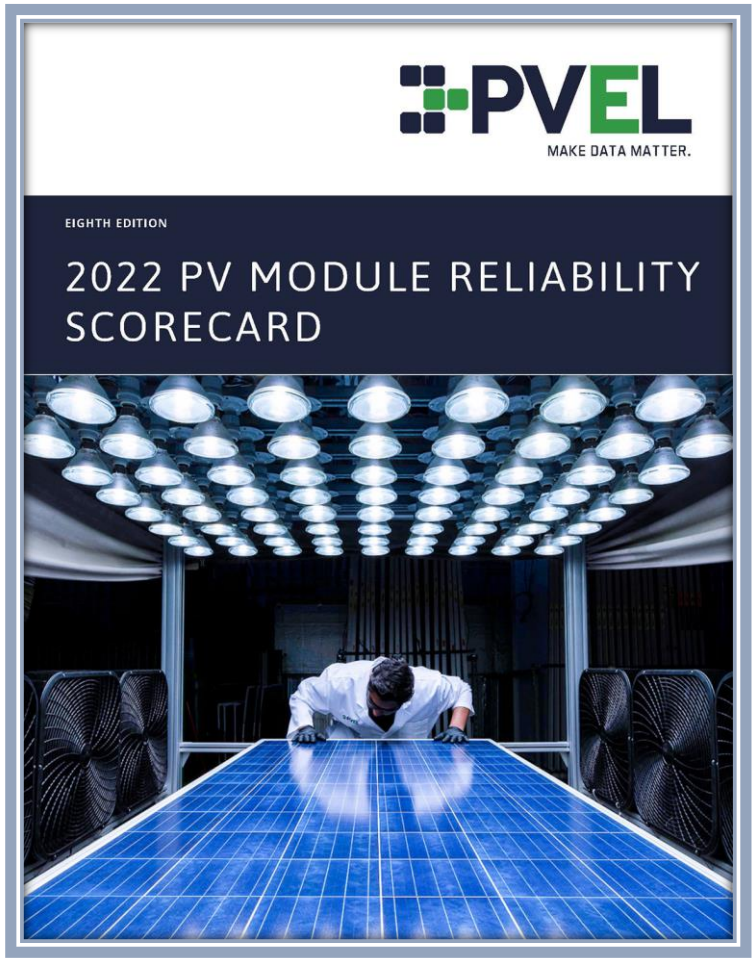
These test streams are reviewed regularly and evolve based on feedback from PVEL's downstream partners, module manufacturers, and the industry's collective understanding of module failure modes and test mechanisms.



PVEL conducts additional field exposure studies and rear side characterizations to evaluate the performance of bifacial modules.

Supplementary testing is available for extended hail stress and tracker-specific mechanical stress evaluations.

PVEL's PV Module Reliability Scorecard

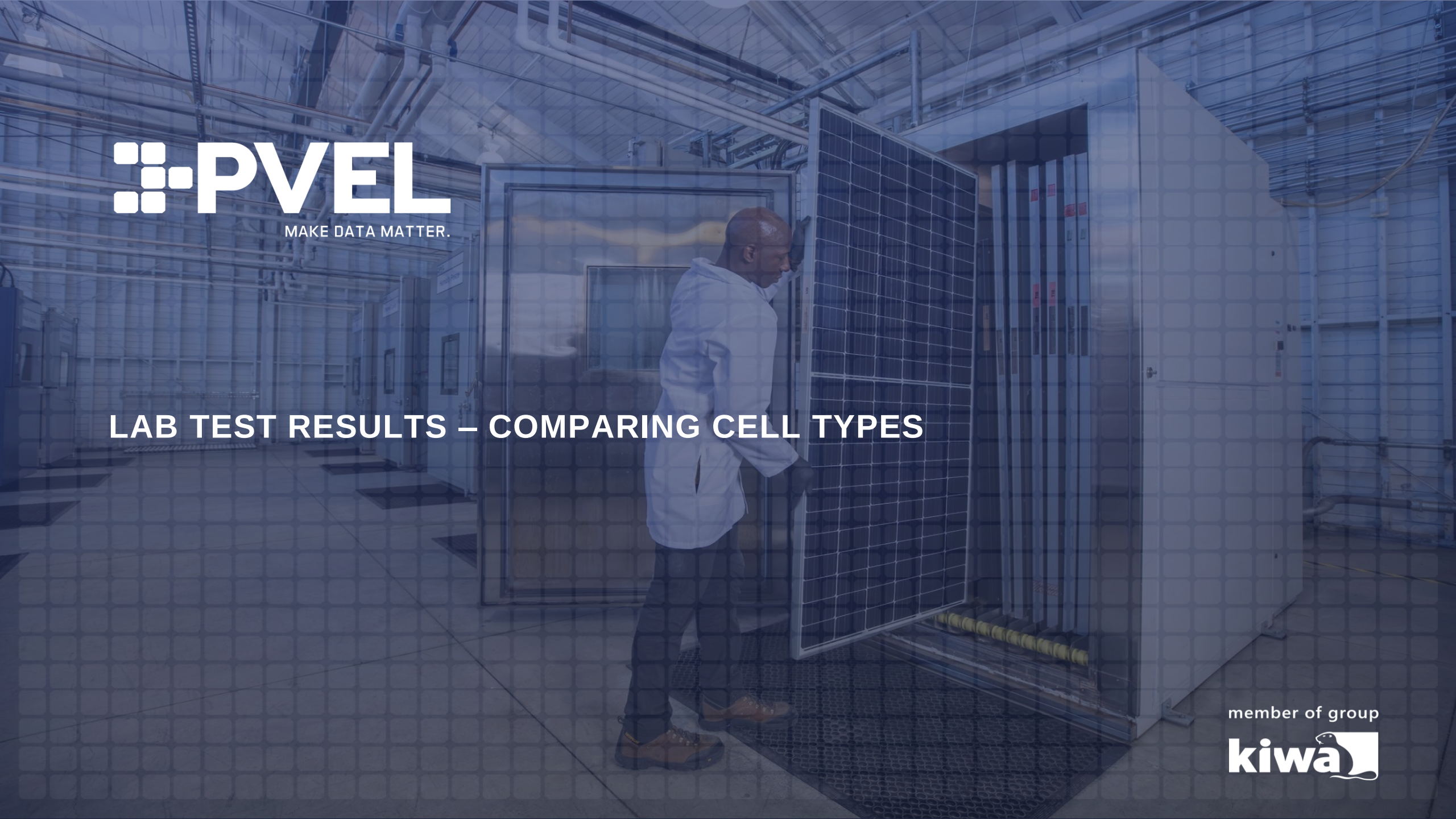


- Each year PVEL publishes results from the PQP in the much-read PV Module Reliability Scorecard.
- This publicly-available report is accessed over 15,000 times per year from industry participants in over 100 countries.
- In the 8th Edition, released in 2022, 122 model types from 25 manufacturers were named as Top Performers for obtaining superior results in PQP testing.
- The 2022 Scorecard site features a free searchable database with filters for module design meta data and factory location.

- Visit: **modulescorecard.pvel.com**

JinkoSolar as a PVEL Scorecard Top Performer

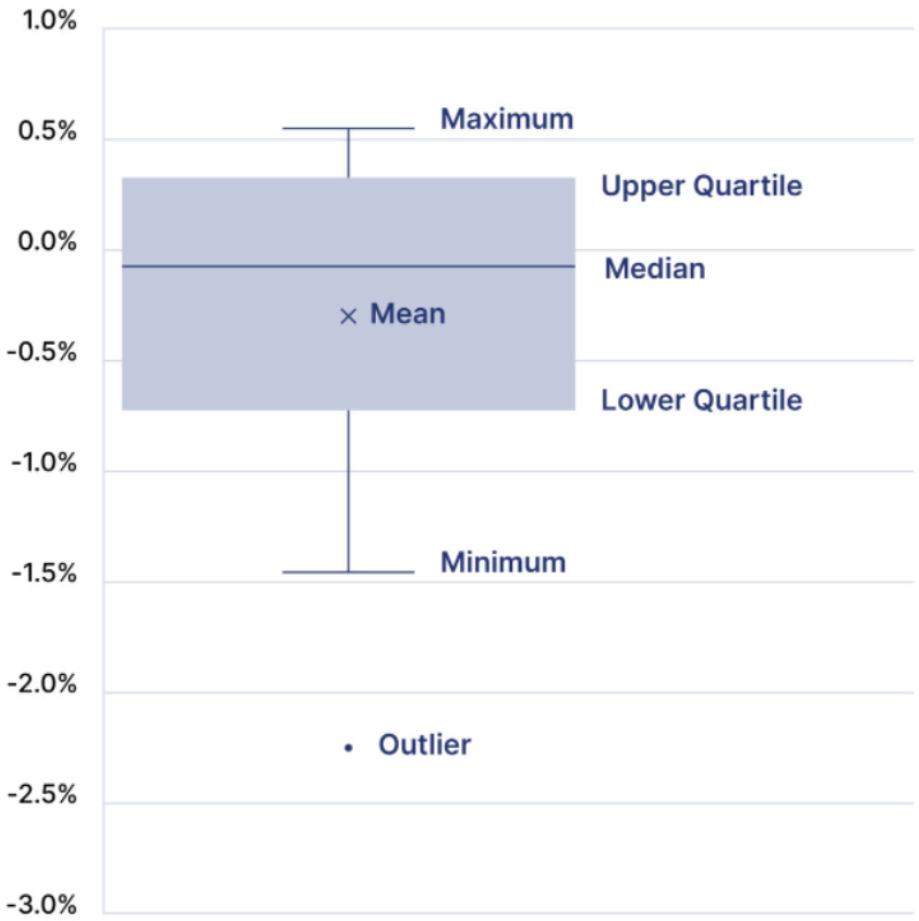
- Jinko has appeared in the PV Module Reliability Scorecard every year since its inception in 2014.
- Jinko had 15 model types listed as Top Performers in the 2022 Scorecard.
- Top Performers from Jinko were represented in each of the six PQP tests highlighted in the 2022 Scorecard.
- Three of Jinko's modules were listed as Top Performers in all of the 2022 Scorecard's reliability tests.



LAB TEST RESULTS – COMPARING CELL TYPES

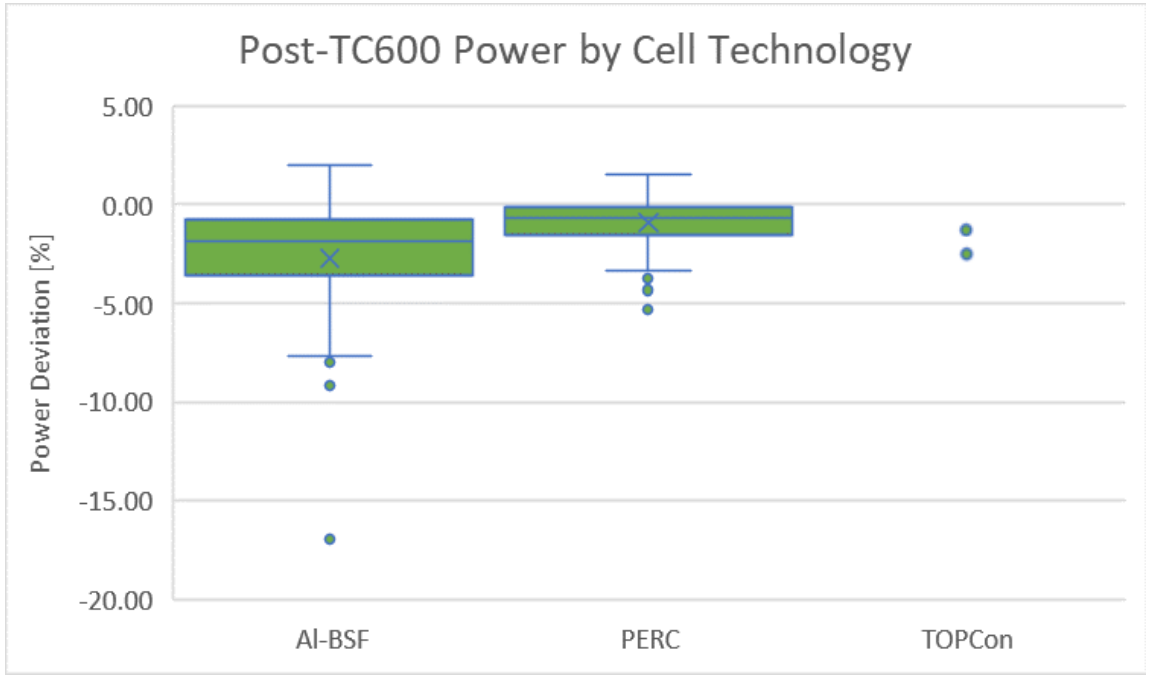
member of group kiwa

Box Plot Interpretation Guide

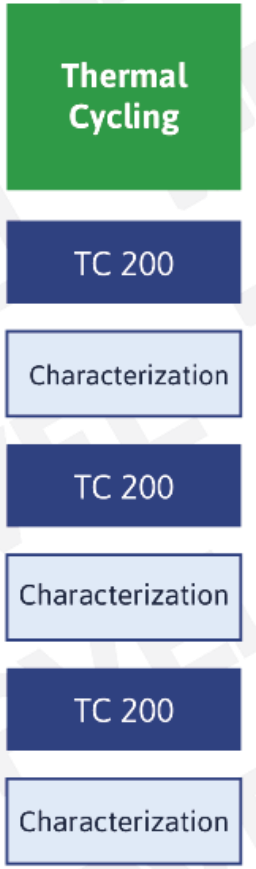


- Box plots are used in the upcoming slides.
- Also known as box and whisker plots, these are graphical representations of data sets that identify key values.

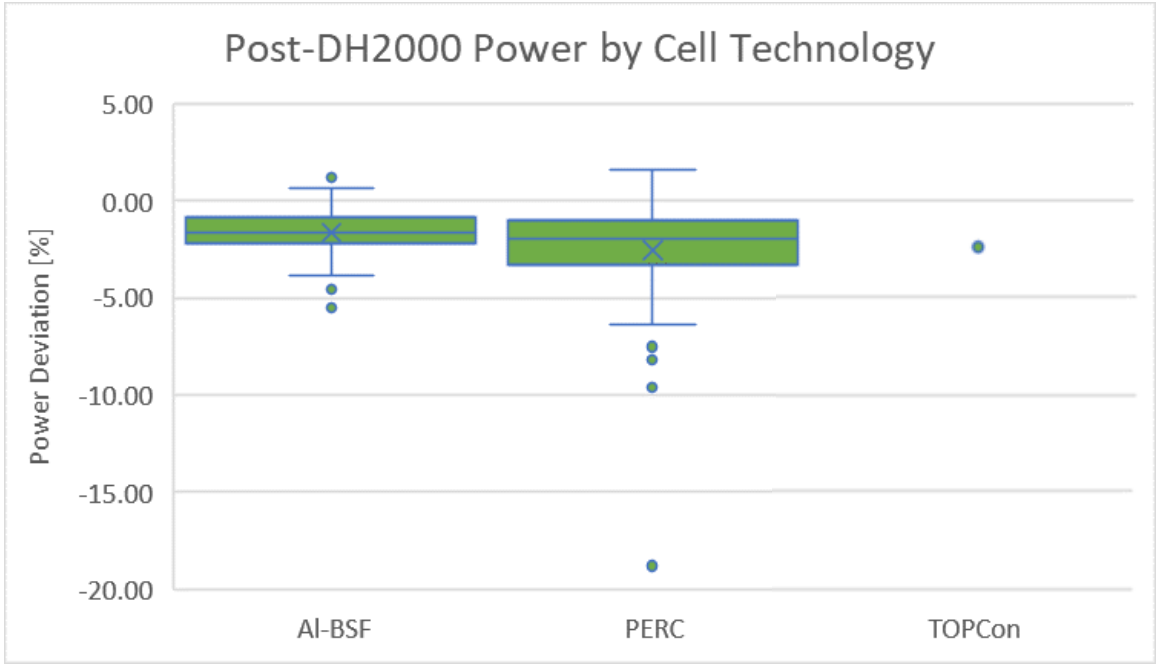
Comparing cell technologies: **Thermal Cycling**



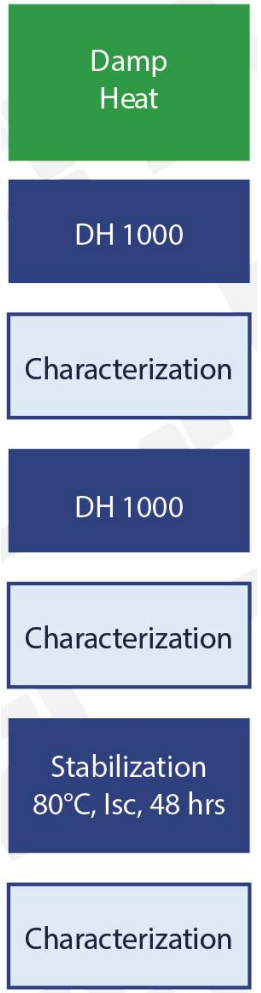
- Historically we saw a wide range of TC results for Al-BSF modules.
- Modules built with PERC cell technology performed better in thermal cycling compared with Al-BSF.
- Initial TOPCon results are encouraging for TC, with room for small improvements.



Comparing cell technologies: **Damp Heat**



- DH results for Al-BSF were relatively stable with a median and mean degradation of <2%.
- PERC-based modules showed higher levels of degradation, some of which was based on boron-oxygen destabilization.
- Initial TOPCon DH results show that there can be corrosion issues related to the cell passivation layers if not properly made.



Damp Heat for TOPCon – Case Study

Damp Heat

DH 1000

Characterization

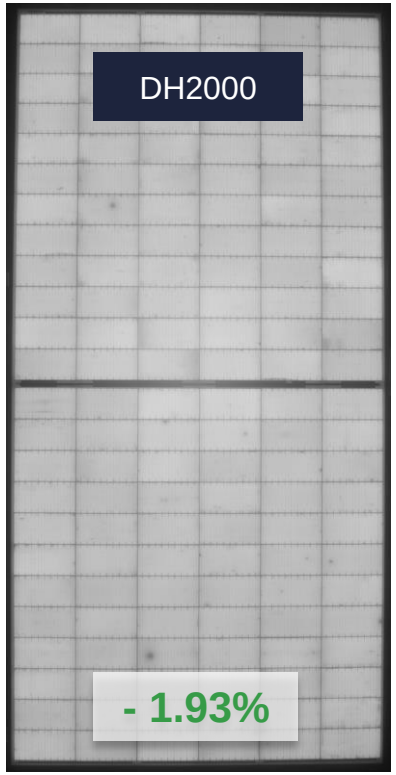
DH 1000

Characterization

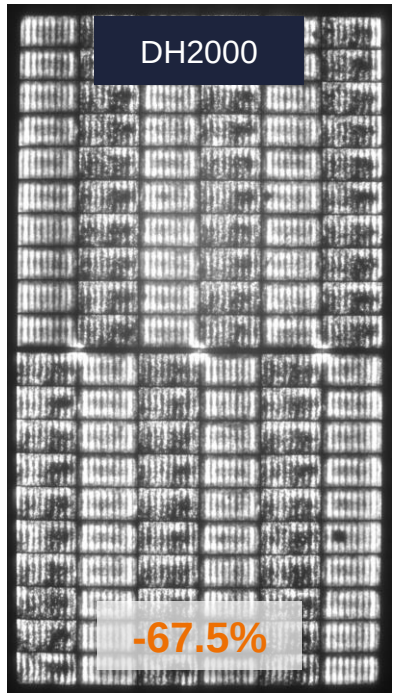
Stabilization
80°C, Isc, 48 hrs

Characterization

Damp Heat results for TOPCon modules from **two different manufacturers**.

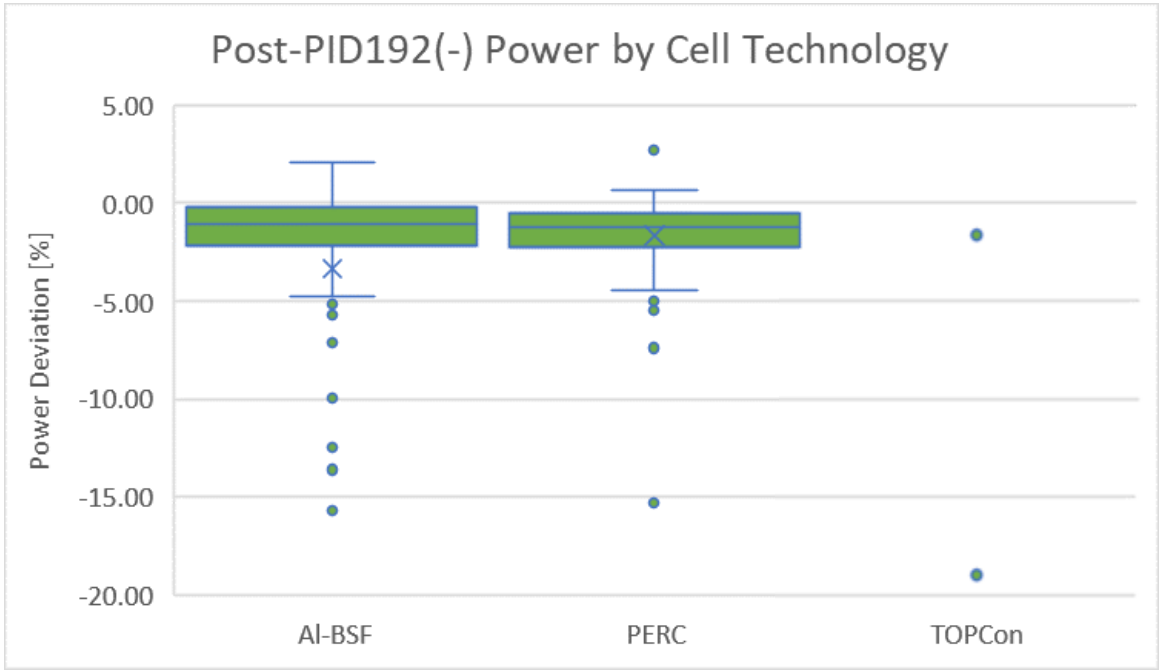


› N-type TOPCon
› Strong damp heat results



› N-type TOPCon
› Worst damp heat results in PVEL history

Comparing cell technologies: **PID**



- PID test results have had a wide spread historically.
- There are many examples of very poor performers, i.e., >10% degradation, but at least half of Al-BSF and PERC modules have less than 2% degradation.
- Wide range continues with the initial TOPCon results.

Potential-Induced Degradation

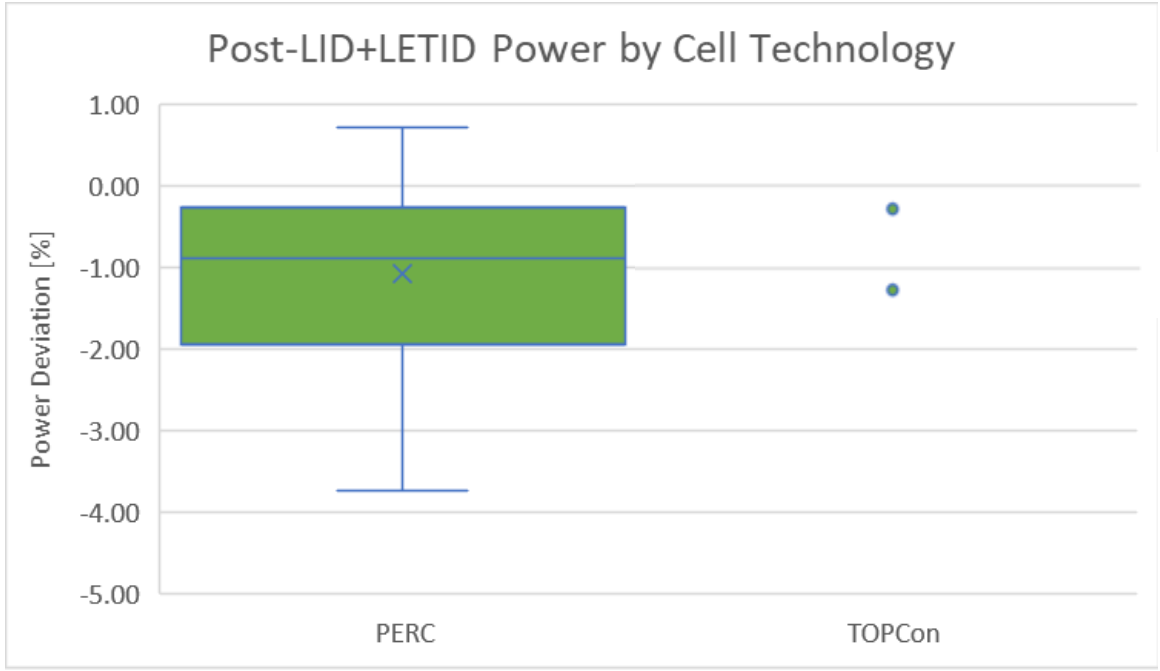
85˚C, 85%RH
MSV (+ and/or –)
96 hrs

Characterization

85˚C, 85%RH
MSV (+ and/or –)
96 hrs

Characterization

Comparing cell technologies: **LID+LETID**



- This test combines the average post-LID result + the average post-LETID result.
- Wide range for PERC modules, but most of the higher degradation is relatively historic (2+ years ago).
- Initial TOPCon modules show very minor impacts for LID and LETID.

LETID Sensitivity

LETID 162 hrs (75°C, Isc-Imp)

Characterization

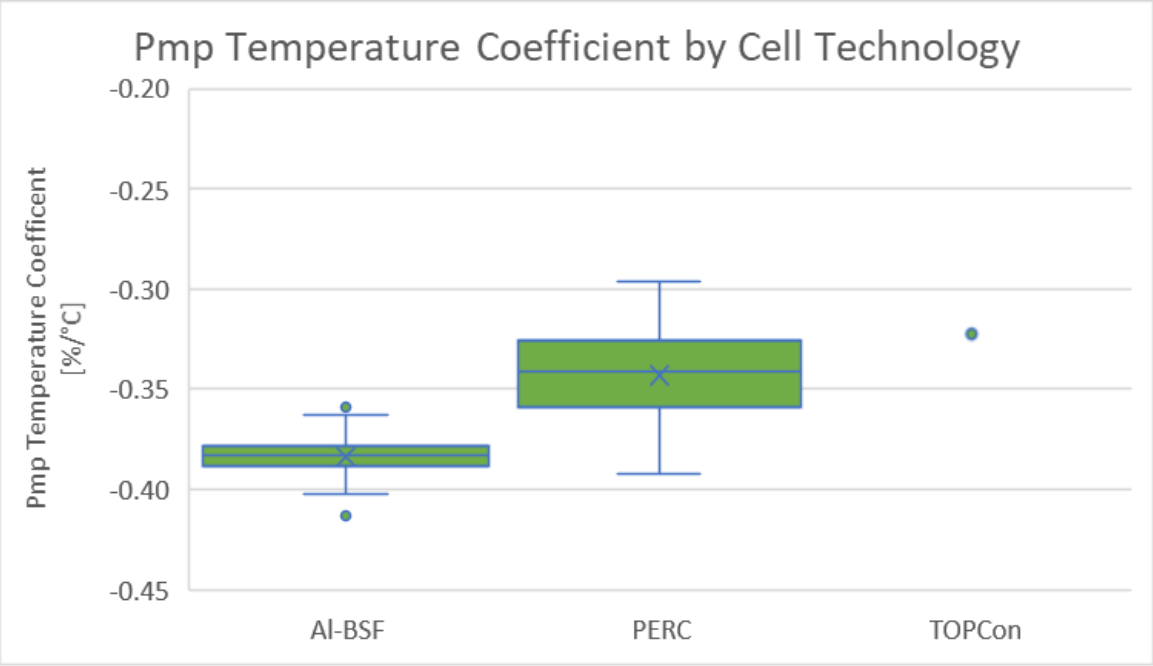
LETID 162 hrs (75°C, Isc-Imp)

Characterization

LETID 162 hrs (75°C, Isc-Imp)

Characterization

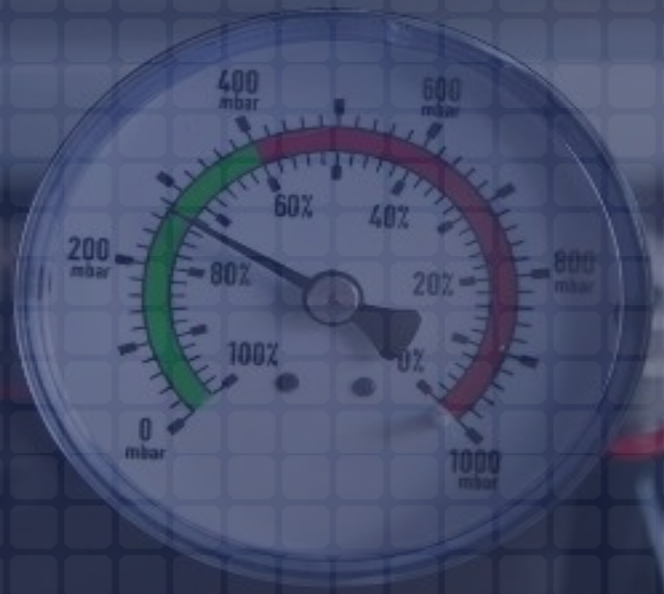
Comparing cell technologies: **PAN (Temperature Coefficients)**



- PVEL's PAN testing includes flash testing at different irradiances and temperature. An optimized .pan file is one of the deliverables from this test, as is a detailed report that includes the temperature coefficients.
- Most PERC modules have better temperature coefficients than Al-BSF, meaning the hotter it is, the better PERC will perform relative to Al-BSF.
- This improvement trend looks to be continuing in the initial TOPCon results.

PVEL

MAKE DATA MATTER.



CONCLUSIONS

member of group kiwa

Conclusions

- TOPCon modules have some advantages, especially with higher efficiency, and lower temperature coefficients.
- The initial PQP results are mixed:
  - Thermal cycling and LID+LETID results meet expectations
  - There’s room for improvement in damp heat and PID
- Testing each module type/BOM is critical to ensure high reliability.


PVEL
MAKE DATA MATTER.
THANK YOU
Learn more at pvel.com
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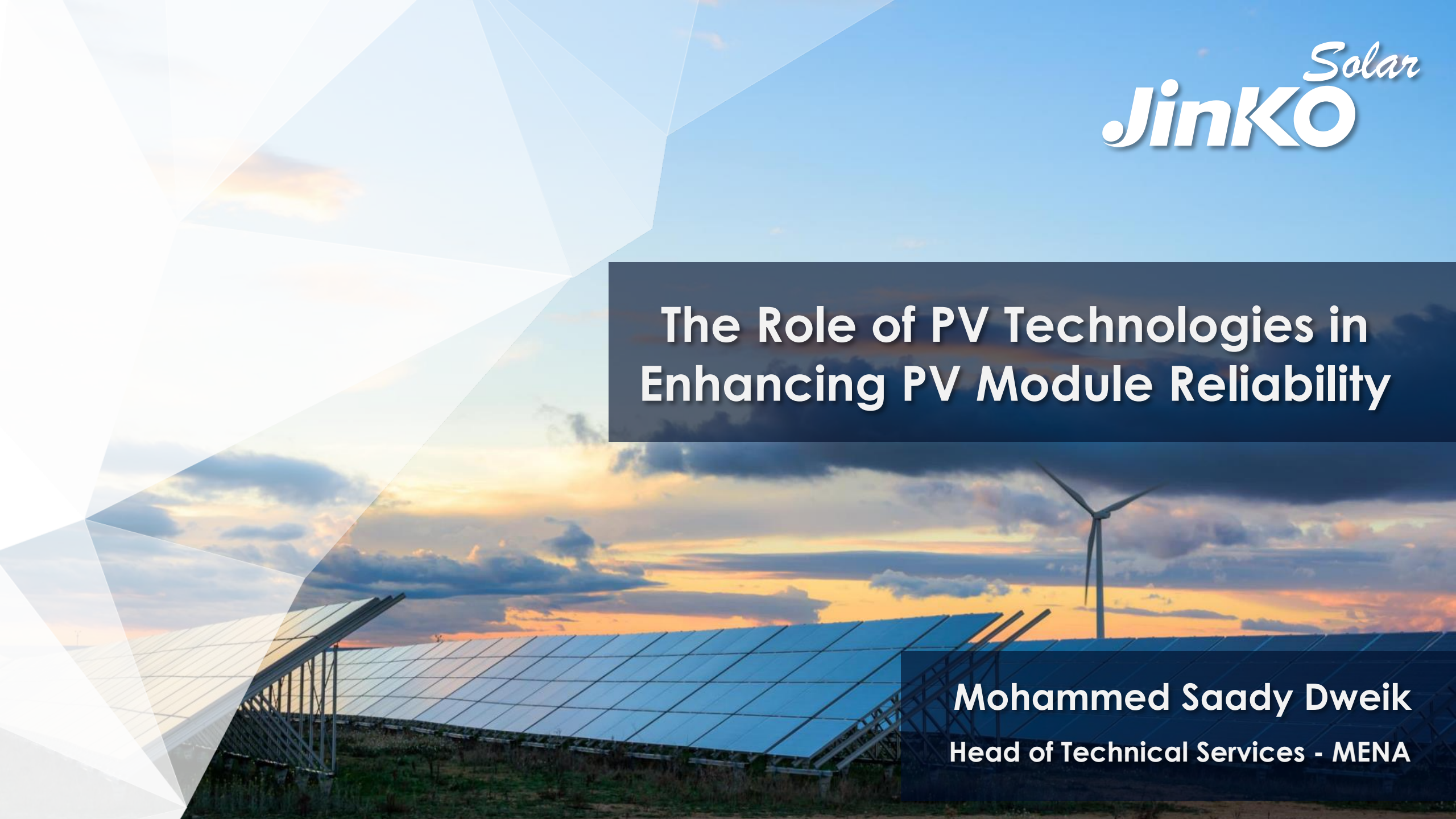
kiwa



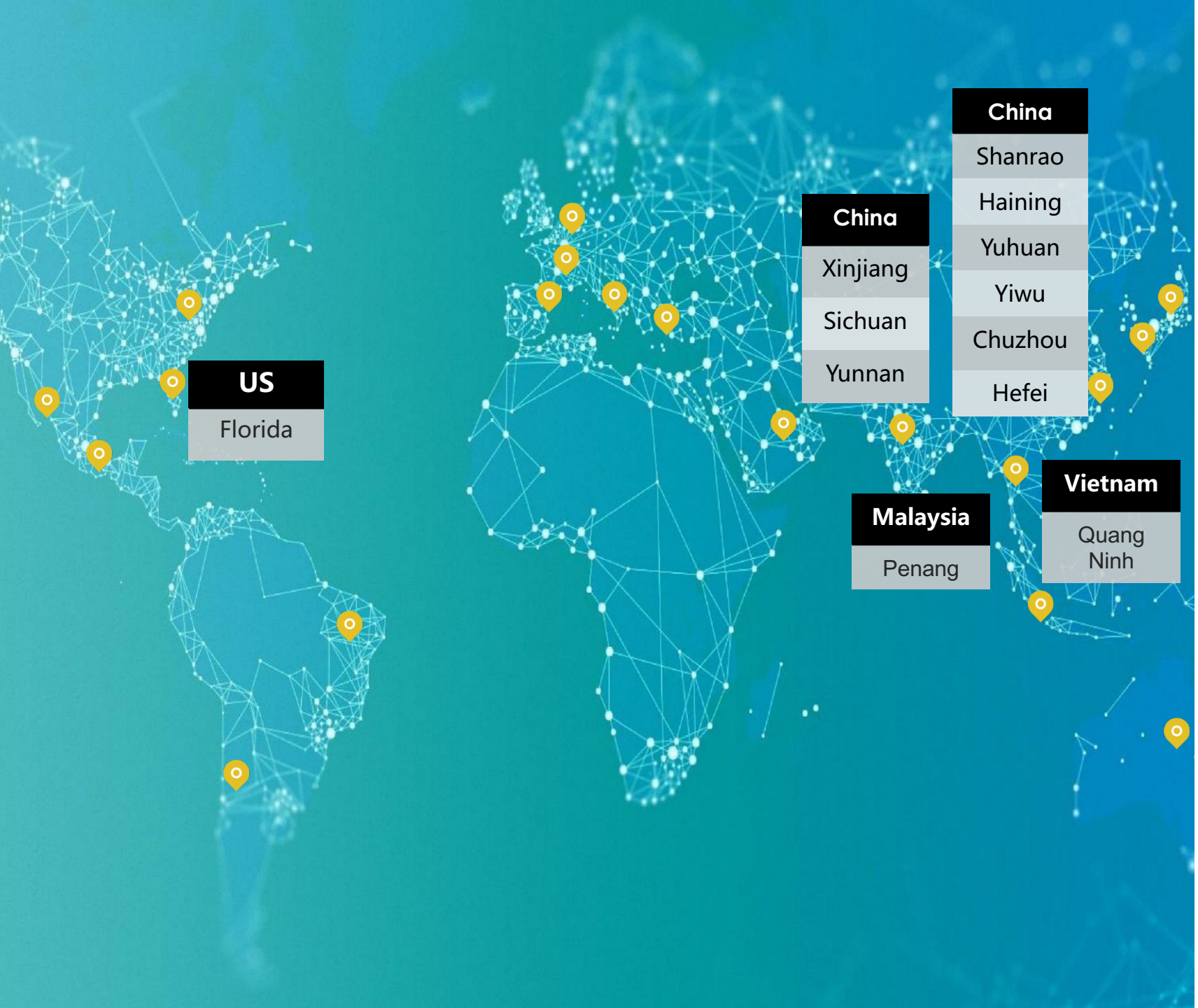
The Role of PV Technologies in Enhancing PV Module Reliability

Mohammed Saady Dweik

Head of Technical Services - MENA

Contents


Jinko Solar
No.1 Shipment
for 4 Consecutive Years
+100GW
Delivered
12%
Market Share
19
World Records
50GW
Module Capacity
*Data as of 2022 Q1
Jinko Solar Co., Ltd.



Solar
JinKO

JinkoSolar Global Layout

Providing highly localized solutions

12
Production Facilities

31000+
Employees

35+
Service Centers

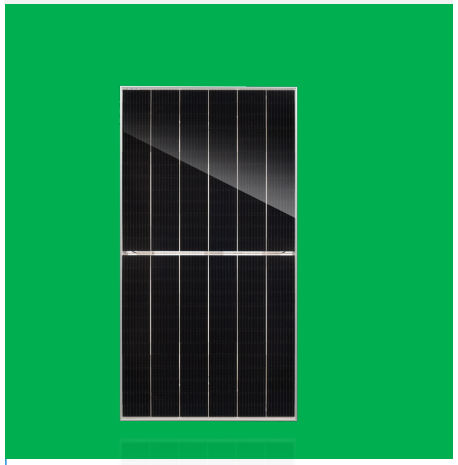
3000+
Customers

160+
Covered Countries

Our Products – P-Type Solar Modules

Tiger 66 Cell

- Up to 410 Wp
- 66 cells
- 164mm wafer
- Efficiency up to 21.48%
- 25 Year Linear Power Warranty

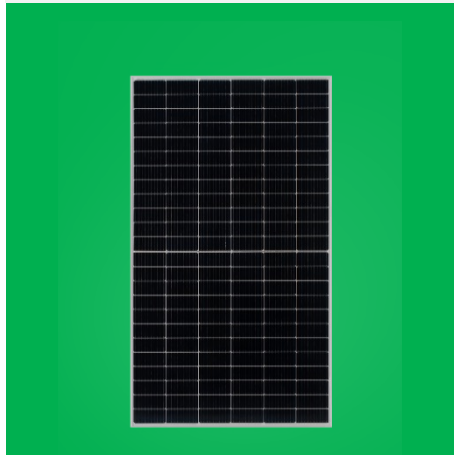


Tiger 78 Cell

- Up to 480 Wp
- 78 cells
- 164mm wafer
- Efficiency up to 21.38%
- 25 Year Linear Power Warranty

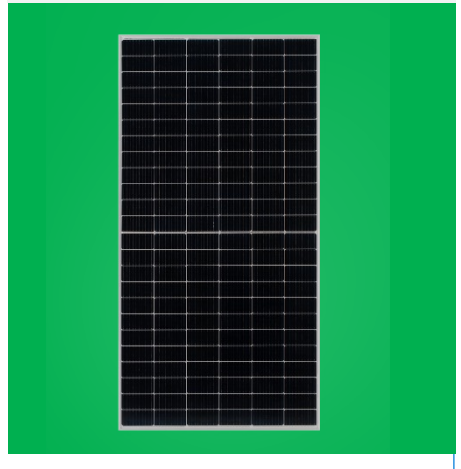
Tiger Pro 54 Cell

- Up to 415 Wp
- 54 cells
- 182 mm wafer
- Efficiency up to 21.25%
- 25 Year Linear Power Warranty



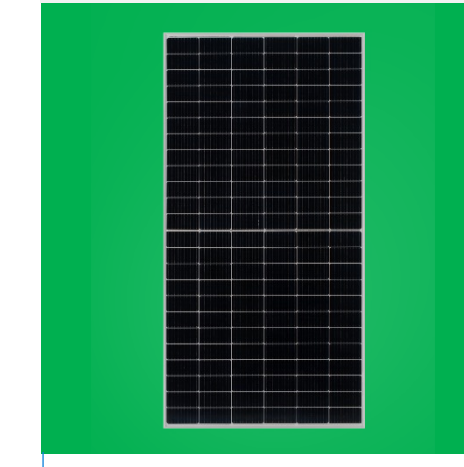
Tiger Pro 72 Cell

- Up to 550 Wp
- 72 cells
- 182 mm wafer
- Efficiency up to 21.29%
- 25 Year Linear Power Warranty



Tiger Pro 72 Cell

- Up to 550 Wp
- 72 cells
- 182 mm wafer
- Efficiency up to 21.29%
- Dual Glass or TB
- 30 Year Linear Power Warranty



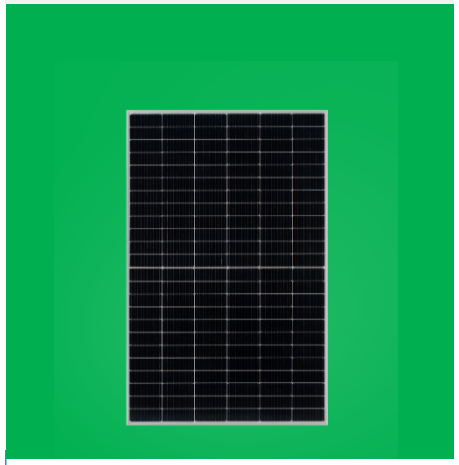
Monofacial

Bifacial

Our Products – N-Type Solar Modules

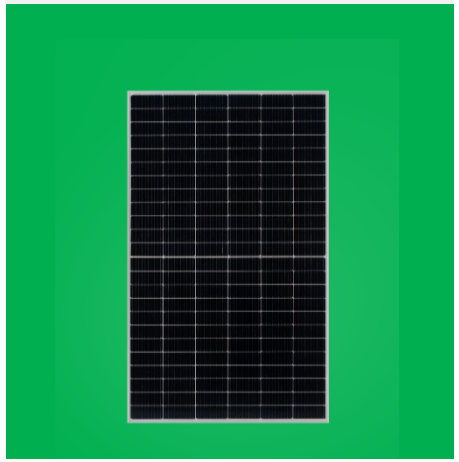
Tiger Neo 54 Cell

- Up to 430 Wp
- 54 cells
- 182mm wafer
- Efficiency up to 22.02%
- 30 Year Linear Power Warranty



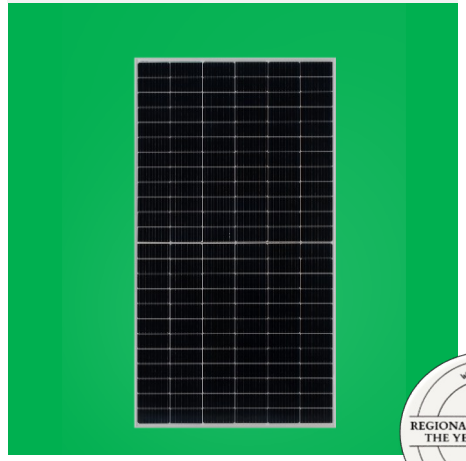
Tiger Neo 60 Cell

- Up to 480 Wp
- 60 cells
- 182mm wafer
- Efficiency up to 22.24%
- 30 Year Linear Power Warranty



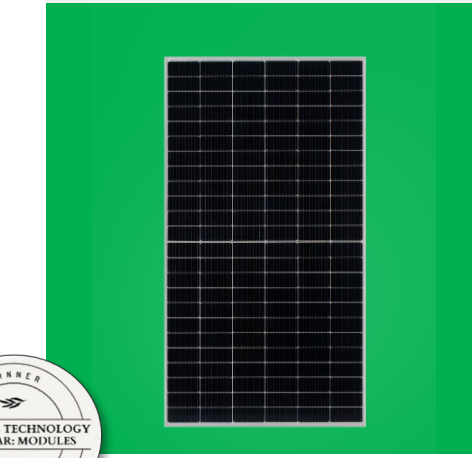
Tiger Neo 72 Cell

- Up to 575 Wp
- 72 cells
- 182 mm wafer
- Efficiency up to 22.26%
- 30 Year Linear Power Warranty



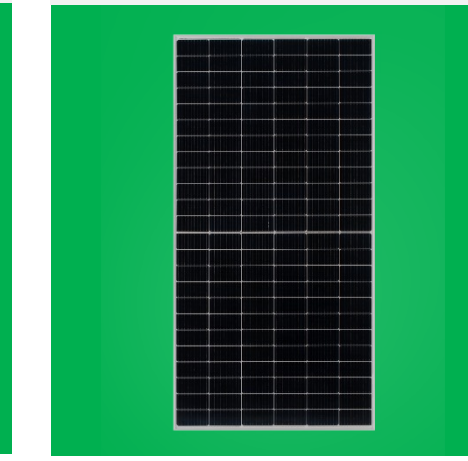
Tiger Neo 72 Cell

- Up to 570 Wp
- 72 cells
- 182 mm wafer
- Efficiency up to 22.07%
- 30 Year Linear Power Warranty



Tiger Neo 78 Cell

- Up to 610 Wp
- 78 cells
- 182 mm wafer
- Efficiency up to 21.82%
- 30 Year Linear Power Warranty



WINNER
REGIONAL TECHNOLOGY THE YEAR: MODULES
2022 CEREMONY

Monofacial

Bifacial

Our Products – Energy Storage

Residential Storage System

(1kWh-50kWh)

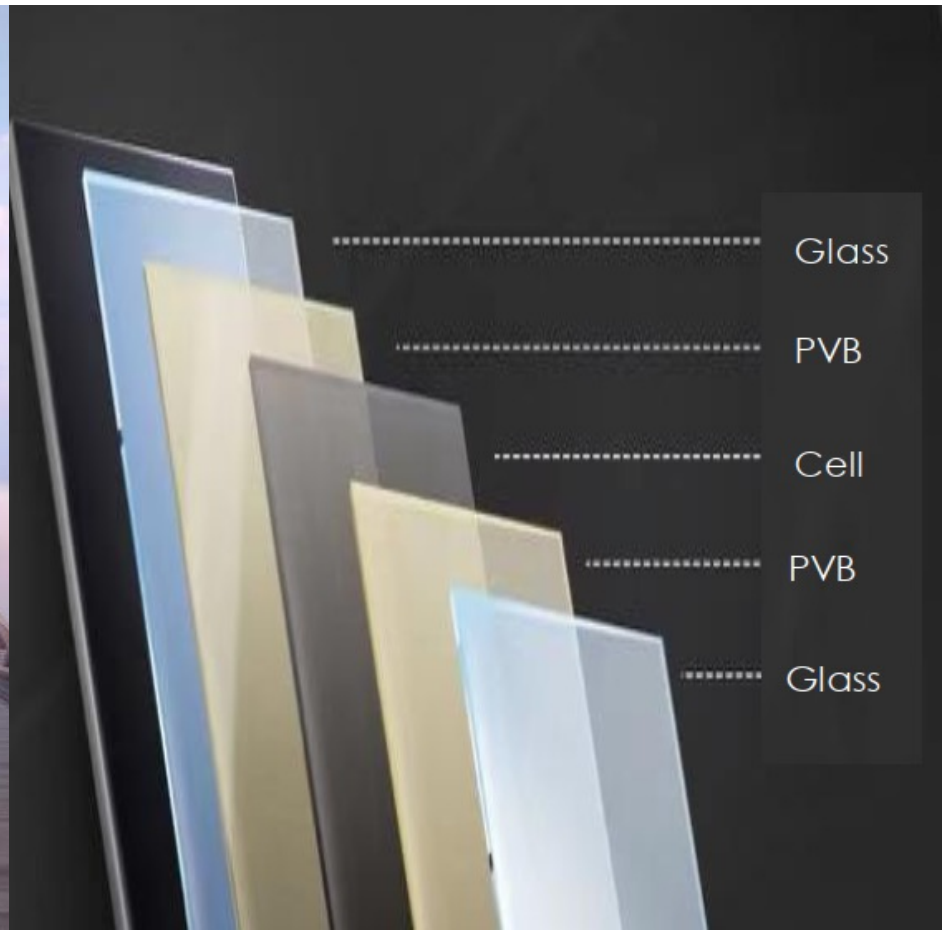
C&I Storage System

(50kWh-1MWh)

Utility Storage System

(≥1MWh)

Our Products – BiPV Modules



Superposition of double PVB film

Optimized sound insulation performance

3C quality certification

High mechanical load Over 50% improvement

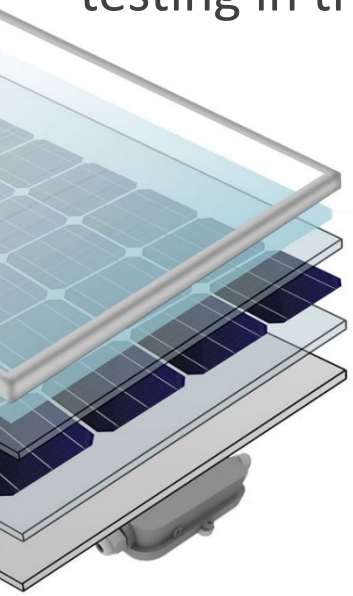
01 About JinKO Solar

02 **The Importance of PV Modules Reliability in MENA**

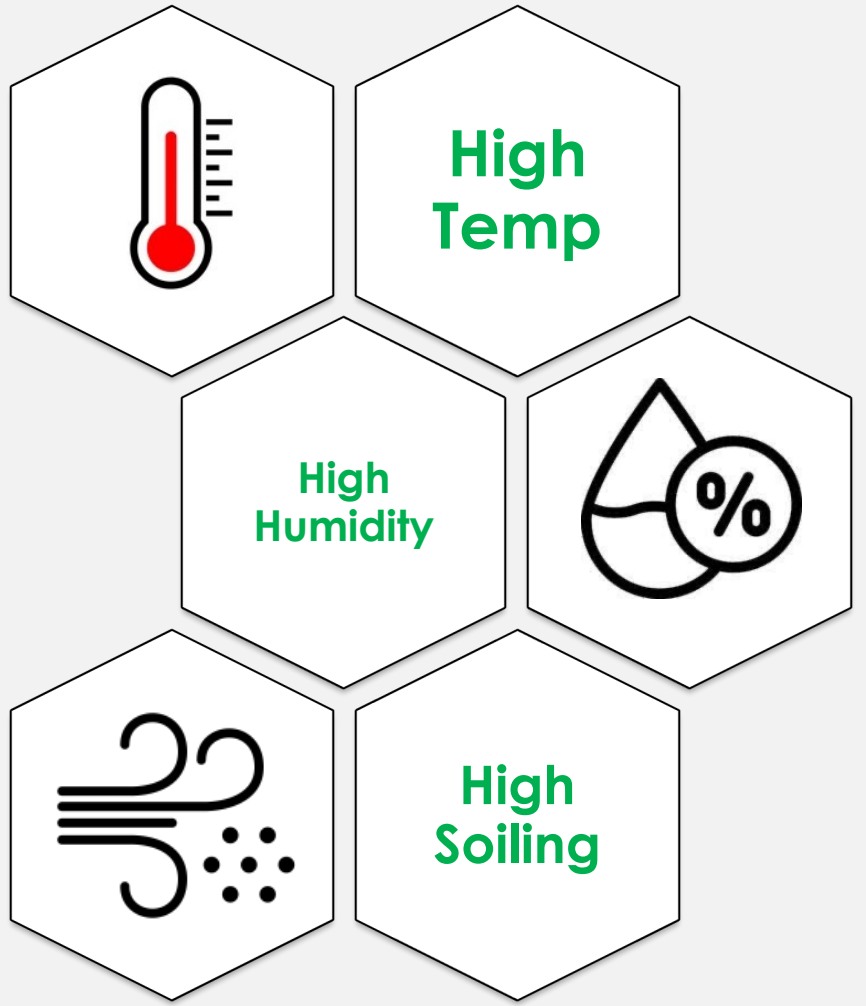
03 PERC vs. TOPCon

Reliability of PV Modules in MENA

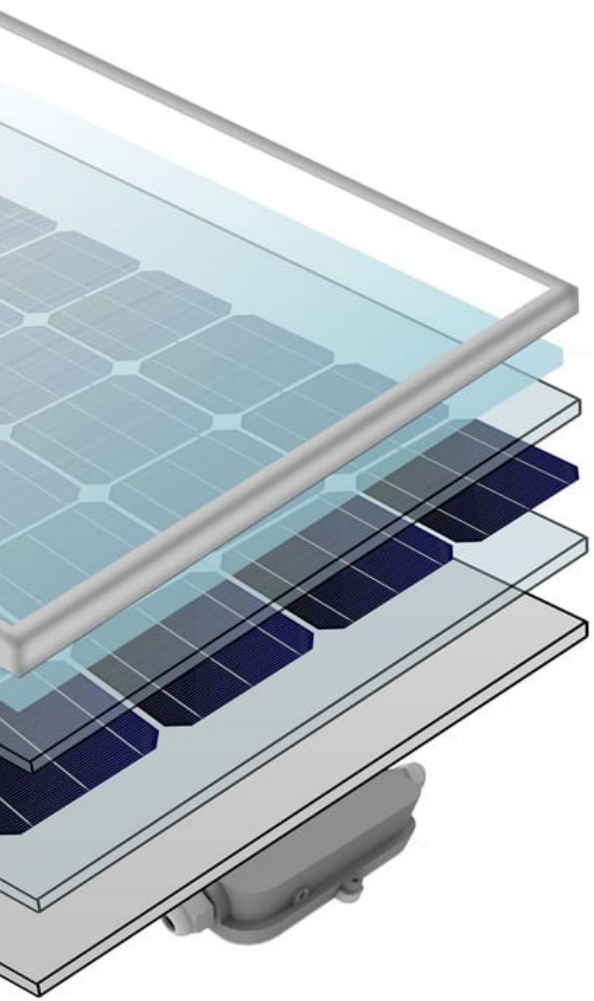
- MENA region is considered one of the most promising solar markets globally due to its vast areas and high irradiance.
- MENA weather is very challenging, the PV modules in MENA are exposed to high temperature, humidity and soiling.
- PV module reliability is considered essential requirement in MENA, and many projects are including extended reliability testing in their requirements.

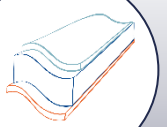


- Two major factors improve the reliability of PV modules:
  - **Premium BOM**
  - **Advanced PV technology**



Enhancing BOM of PV Modules





The top supplier have shifted from the low-quality AAA Backsheets to more reliable materials such as PVDF which has the biggest market share globally and Tedlar PVF which is considered the best backsheet with lowest defect rate.

The AL frame have been optimized to be able to protect large modules by Increasing the internal thickness and frame cavity and adding wavy stiffeners.

All the major supplier use IP68 rating for their electrical parts which is considered the highest rating in protecting against solid particle and liquid ingress for prolonged immersion in water (more than 1 m)

New connectors to handle the high power output for the new 500+Wp modules, and the mechanical properties have been improved to easier connectivity.

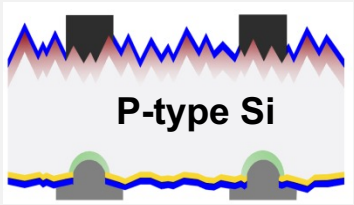
POE is getting more market share compared to EVA, all bifacial modules have at least one layer of POE which improves power generation & PID resistance.

Solar Cell Development Trends

~2021
PERC

24.45%

PERC



~25%

HOT 2.0

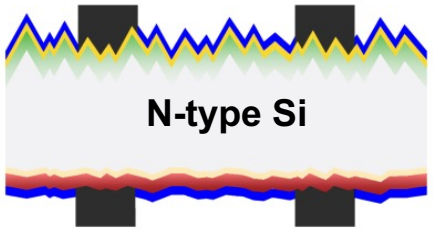
Passivated Contact Cell

2022~2024
TOPCon

~25.5%

HOT 2.0+

Selective Emitter



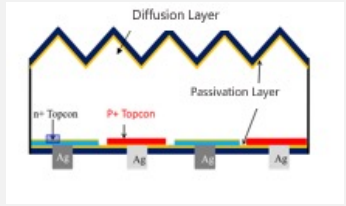
~26.0%

HOT 3.0

2025~
Future

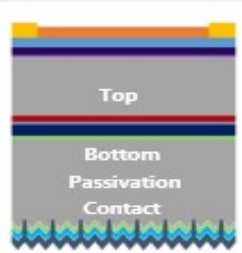
~26.5%

HOT 4.0



~32%

Next Generation?



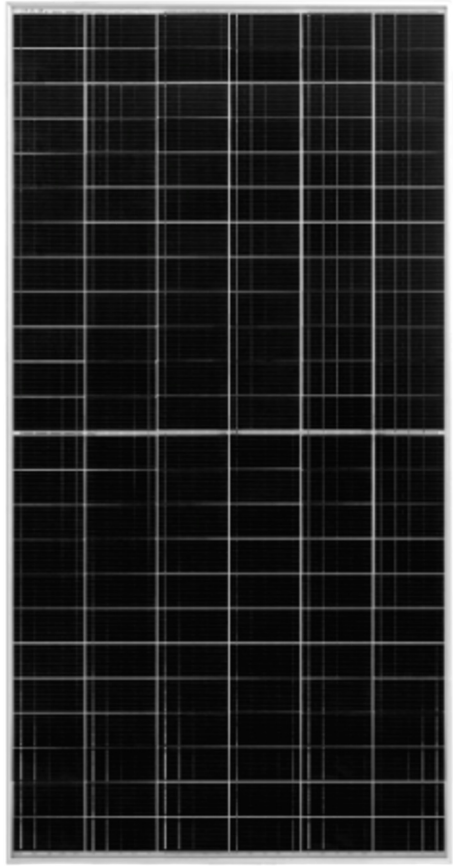
01 About JinKO Solar

02 The Importance of PV Modules Reliability in MENA

03 **PERC vs. TOPCon**

Reliability Tests: P-Type PERC vs. N-Type TOPCon

Tiger Neo
Bifacial Dual Glass 72 cells
N-Type TOPCon



Same BOM

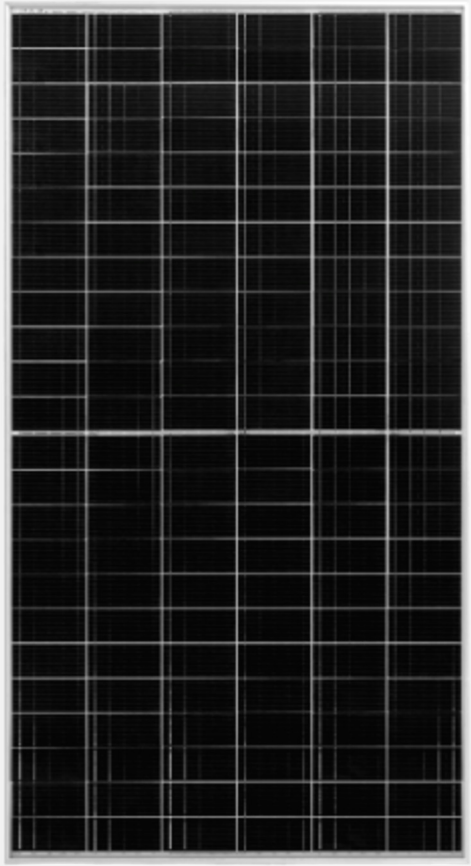
Same Dimensions

Same Cell Size

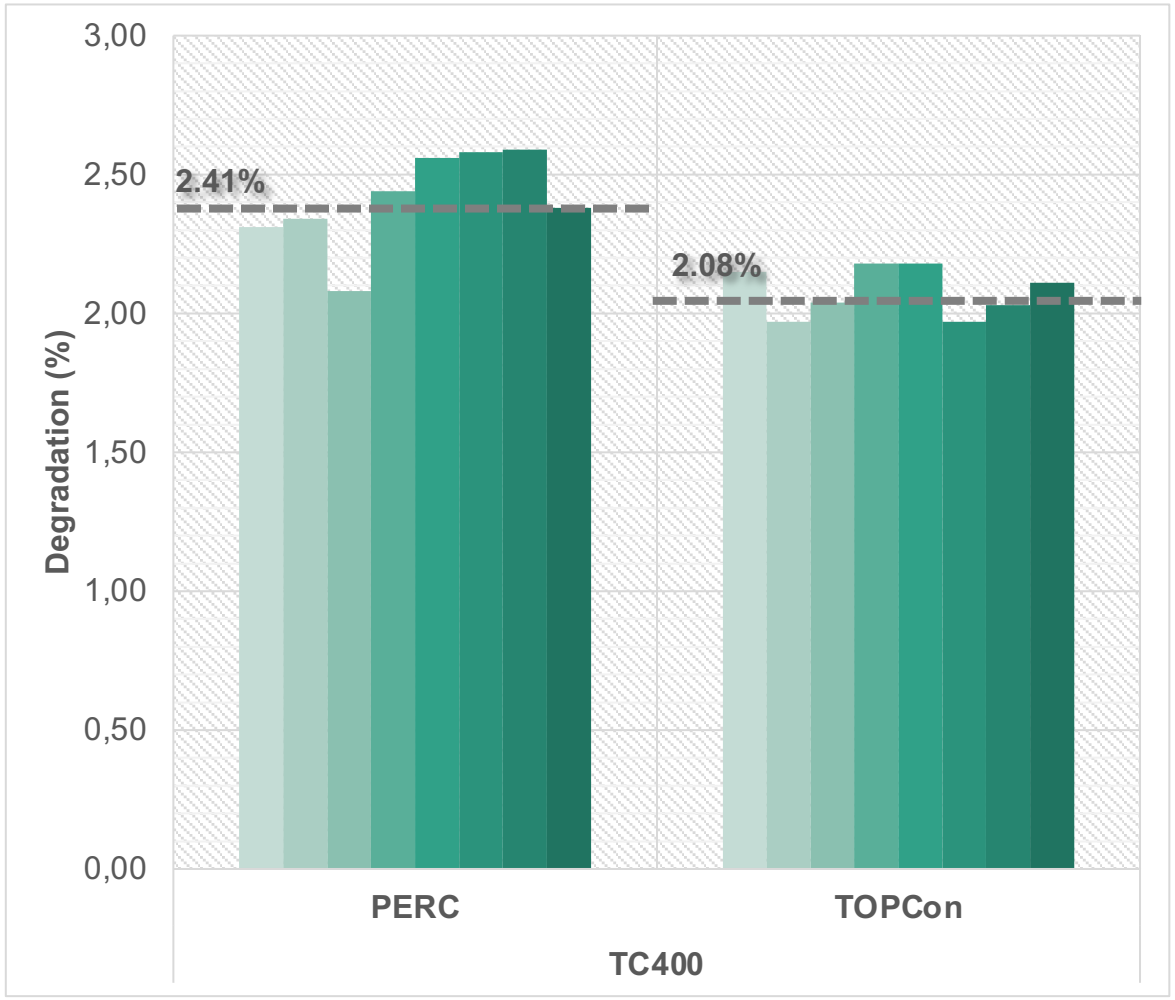
Different Cell Technology

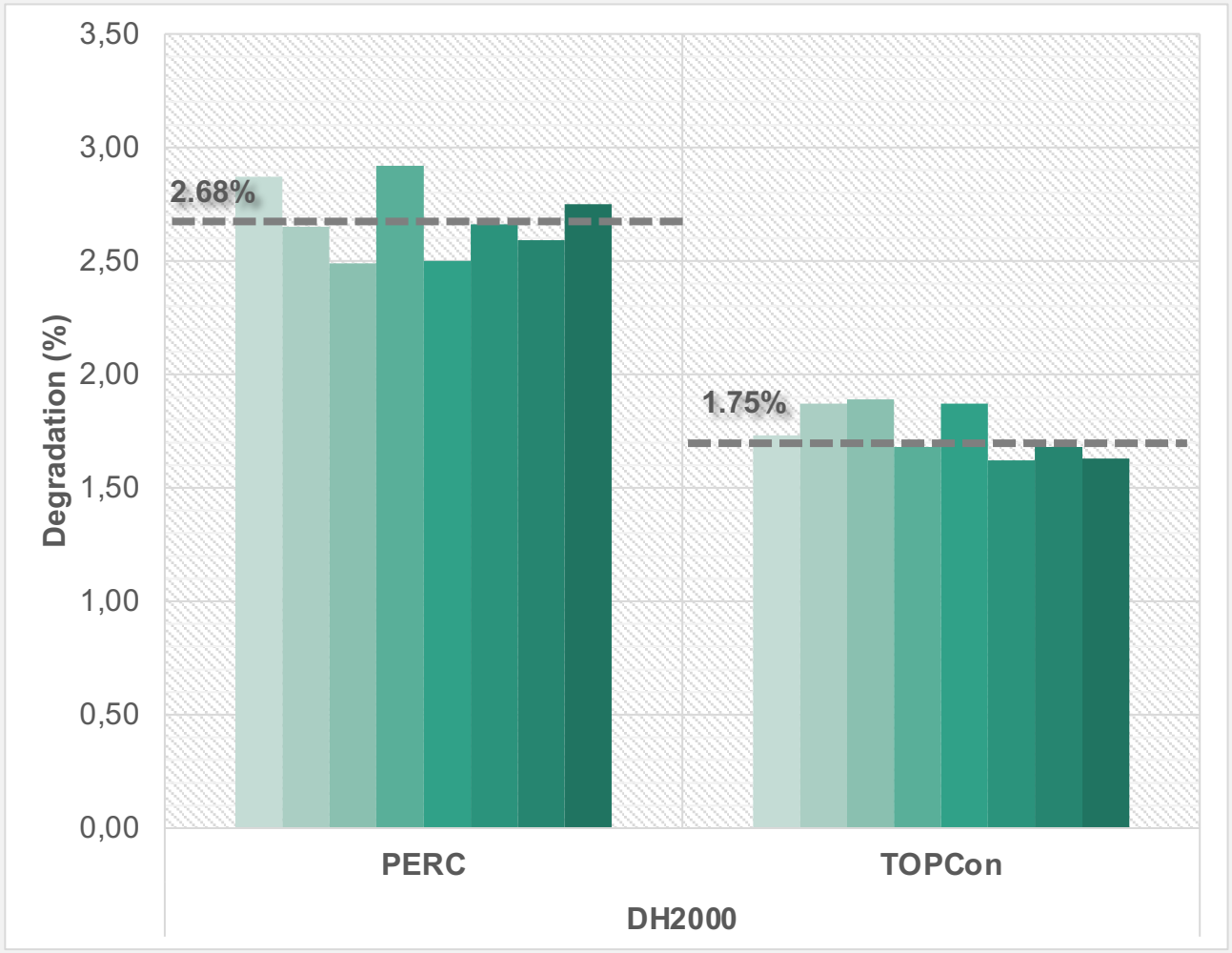
Different Cell Doping

Tiger Pro
Bifacial Dual Glass 72 cells
P-Type PERC

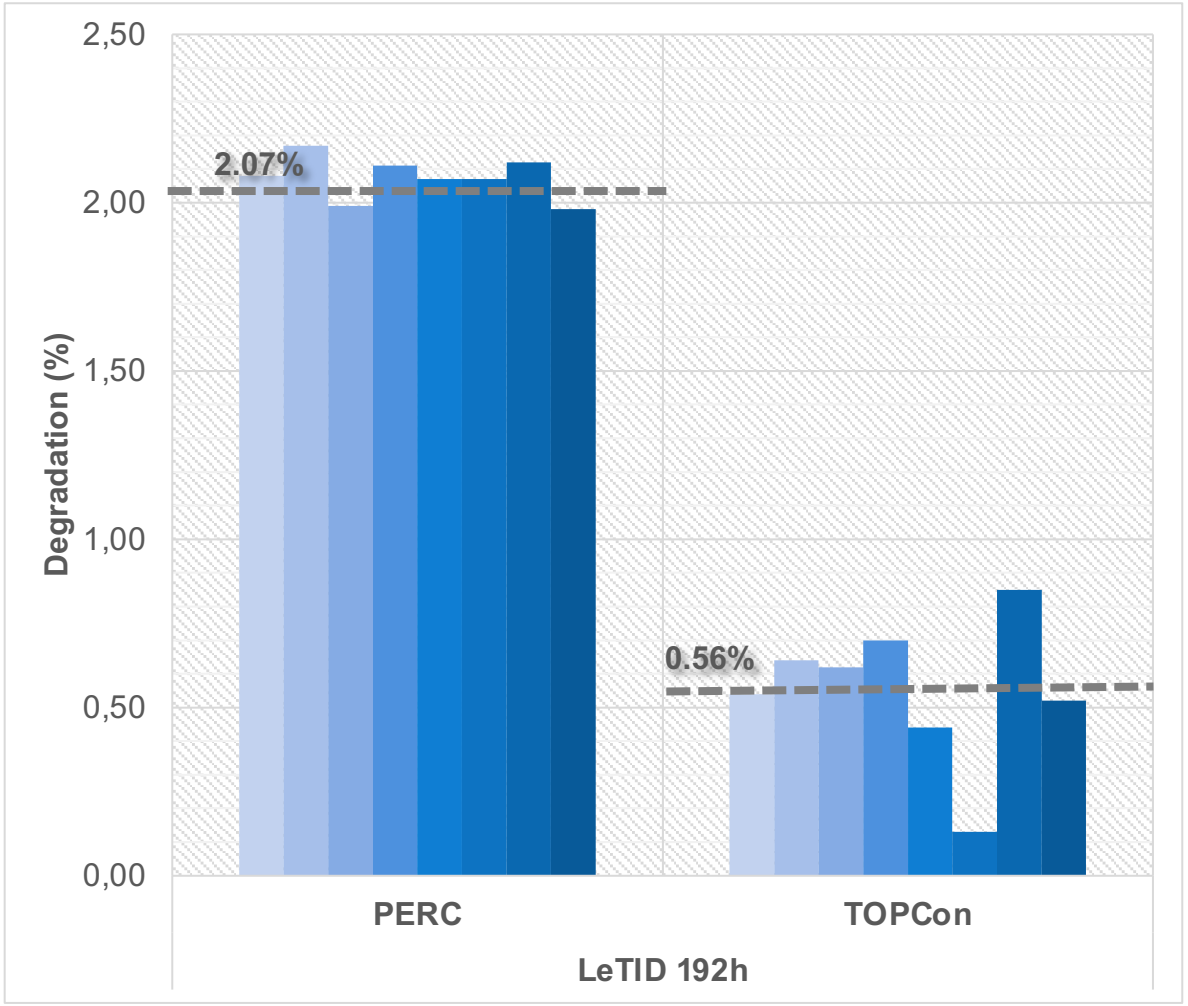


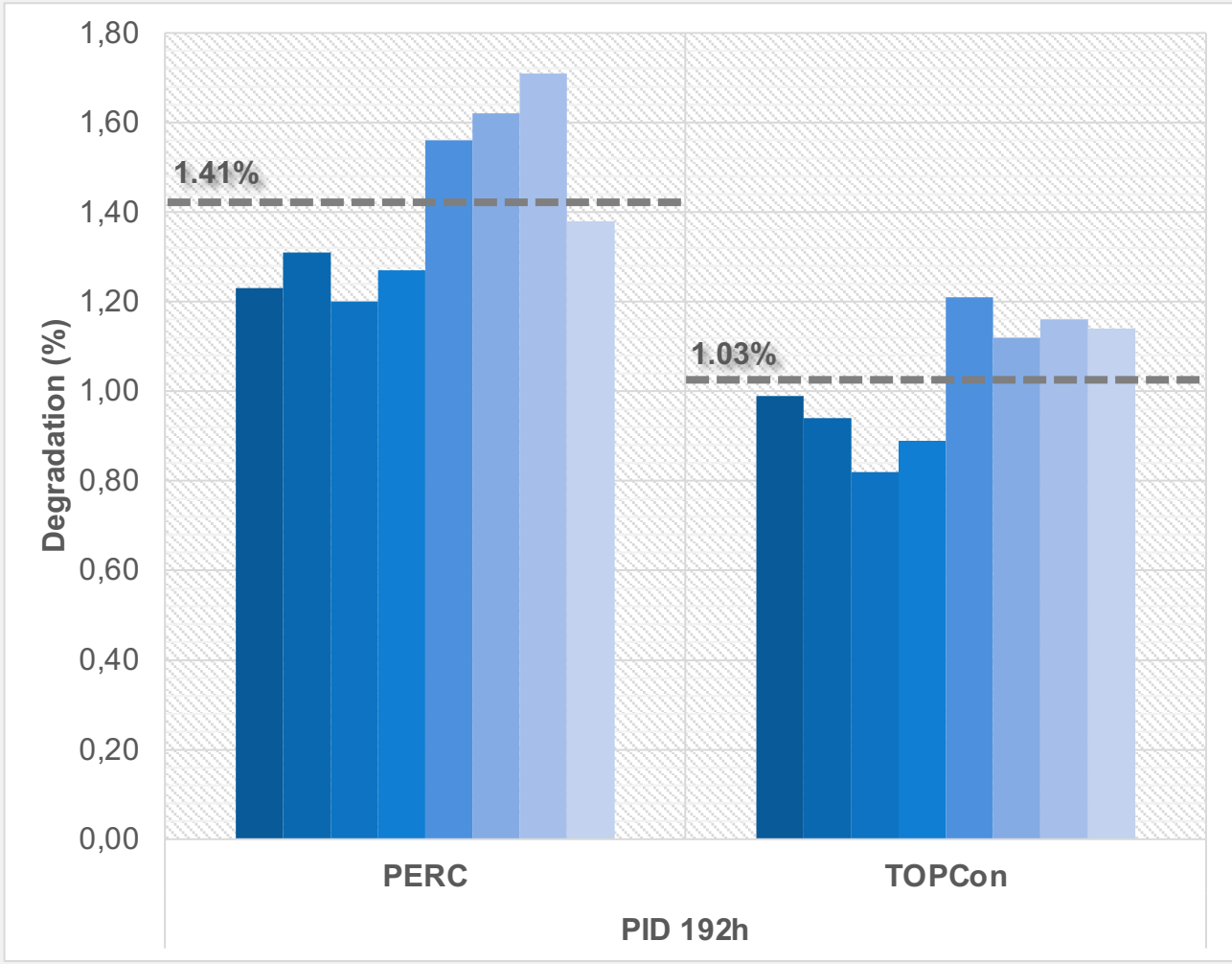
Thermal and Humidity Tests



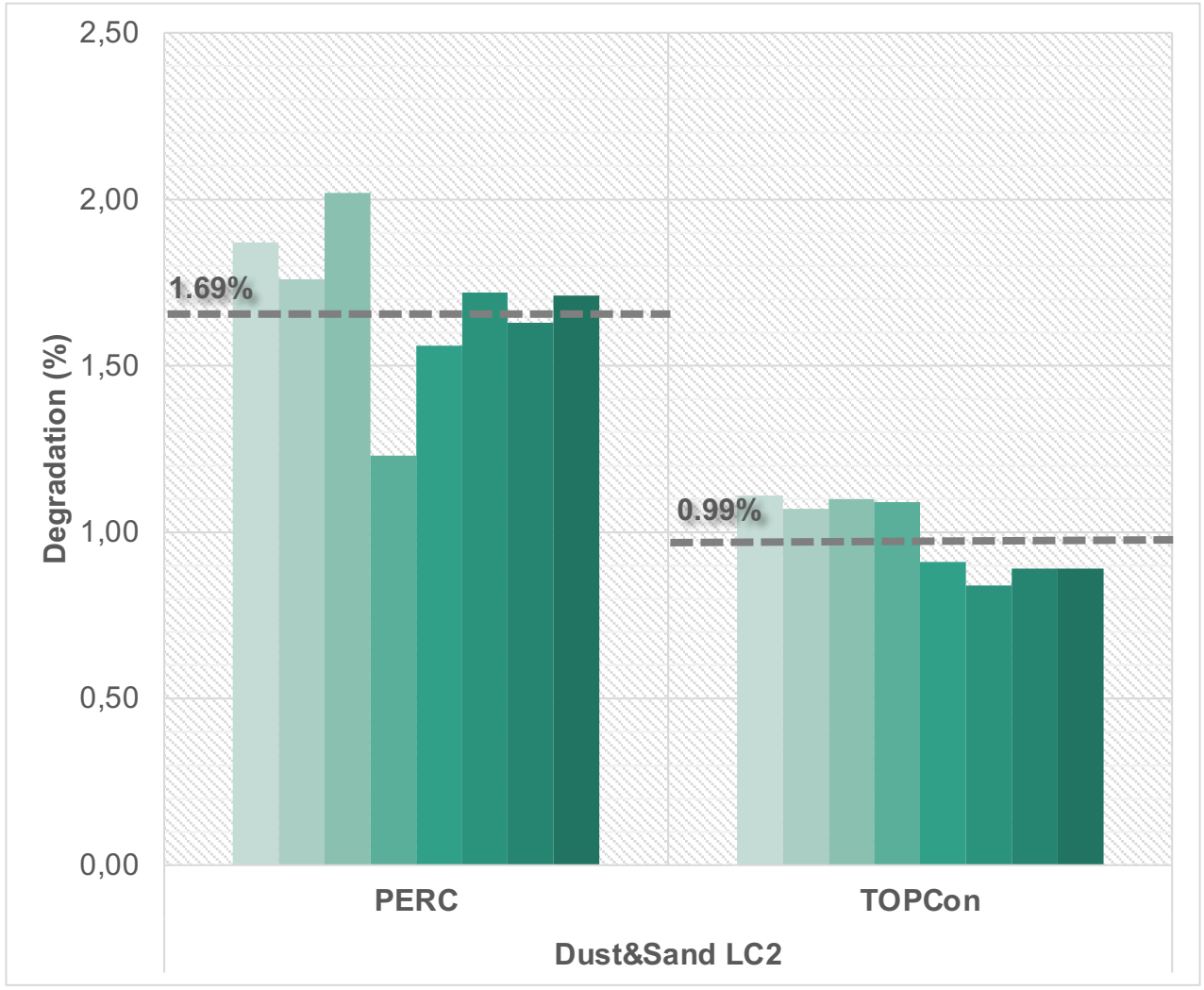


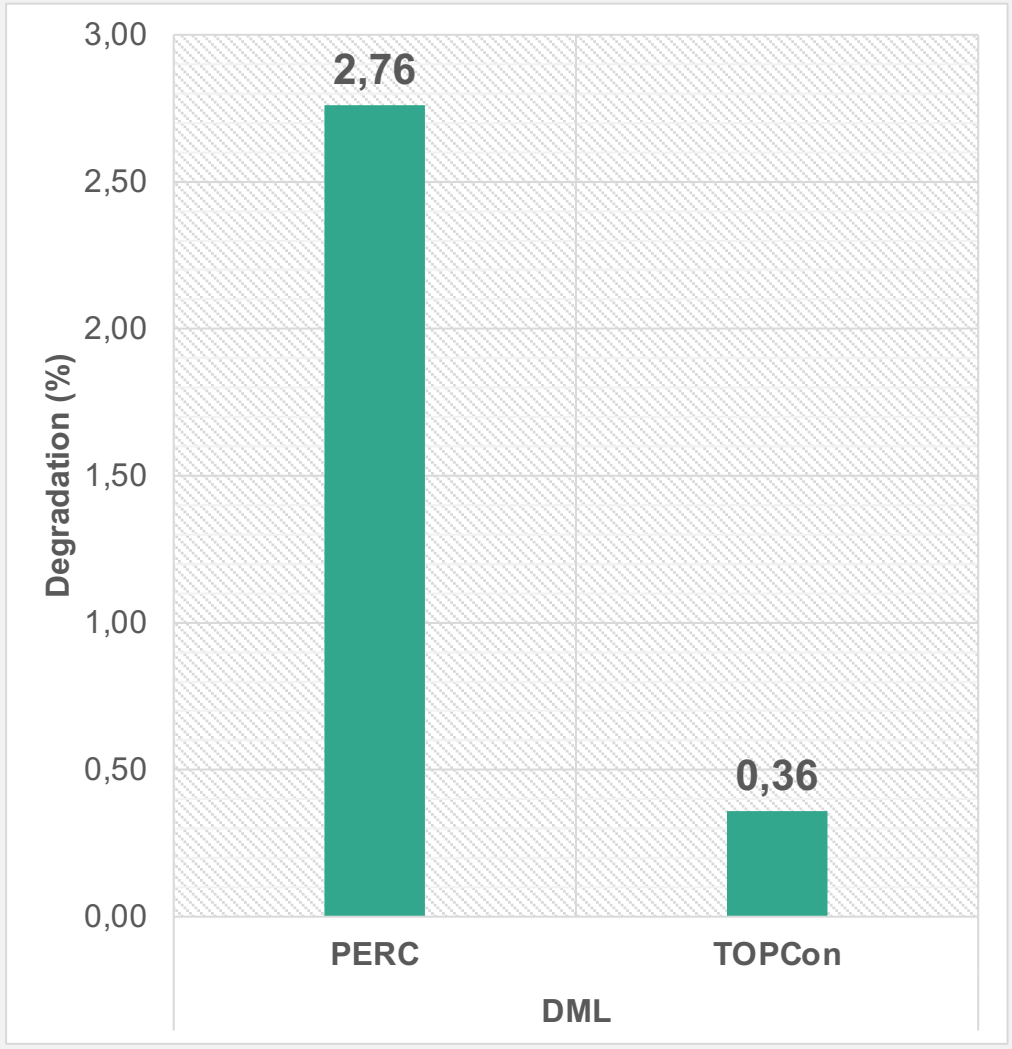
Performance Degradation Tests





Mechanical Tests





Summary

- **MENA region has the potential to be the biggest solar market globally, and due to its high solar irradiance, any smallest improvement in technical specs will result in considerable improvement in generation which will lead to lower LCOE.**

- **TOPCon technology can enhance the PV module performance in harsh weather conditions due to their lower cell temperatures compared to PERC.**

- **N-doping will improve the PV module resistance to induced degradations such as LID, LeTID & PID.**

	TC400	DH2000	LeTID 192h	PID 192h	D&S LC2	DML
PERC	2.41%	2.68%	2.07%	1.41%	1.69%	2.76%
TOPCon	2.08%	1.75%	0.56%	1.03%	0.99%	0.36%
Improvement	**13.69%**	**34.07%**	**72.95%**	**26.95%**	**41.42%**	**86.96%**

Thank You!

Building Your Trust in Solar

Mohammed Saady Dweik

Mohamed.saady@jinkosolar.com

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Demonstrating durability in n-type modules

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4:00 pm – 5:00 pm | GST, Dubai
3:00 pm – 4:00 pm | AST, Riyadh
1:00 pm – 2:00 pm | Morocco

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Thank you for joining today!