Global PV Manufacturing Quality Report 2026

Key risks, defect trends, and supplier performance insights from 2025 inspection data

March 2026

2025 data reveals new quality risks in PV manufacturing

Over 70% of factories were rated in the lowest two tiers (C or D) in 2025 factory audits; none achieved an A+.

Increasing busbar and ribbon counts are making soldering more prone to defects, driving higher defect rates observed at Final EL.

The shift to n-type (TOPCon) is introducing new reliability risks, with UVID emerging as a key concern.

Over the past 9 years, Intertek CEA has conducted over 80,000 inspections in 340+ PV module factories

The following report summarizes our QA data and insights from 2025

Intertek CEA collects data from all stages of quality assurance

1. **Pre-production Factory Audit (findings)**
2. **Inline Production Monitoring (findings)**
3. **Pre-shipment Inspection (defects)**
4. **Container Loading Inspection (findings)**
5. **Batch Testing (test results)**

Findings and defects are classified in three categories by severity:

Severity	Definition
Critical	Findings or defects that may result in severe safety risks and hazardous conditions. They are likely to cause damage to other products or property, trigger non-compliance regulatory issues, and generally constitute a breach of mandatory regulations.
Major	Findings or defects that may reduce the product's functionality or impact safety in the short or long term.
Minor	Findings or defects which do not pose a clear risk of product failure, but rather fall outside the quality requirements.

Pre-production Factory Audit

Before production begins, two auditors visit a supplier's factory to check how well the factory's quality and production processes are working. They examine both the written procedures and how things are actually done on the ground. The goal is to see if the factory can meet the quality standards set by the client and ensure they can consistently deliver products that meet these expectations.

Examples of inspection areas (1000+ items in Intertek CEA's checklists):

A. Change control management
B. Customer complaints management
C. Employee management
D. Material management
E. Production area environment
F. Production process management
G. Equipment management evaluation
H. Quality control
I. Finished product management
J. Loading and logistics management
K. Testing laboratory management

Grading Methodology:

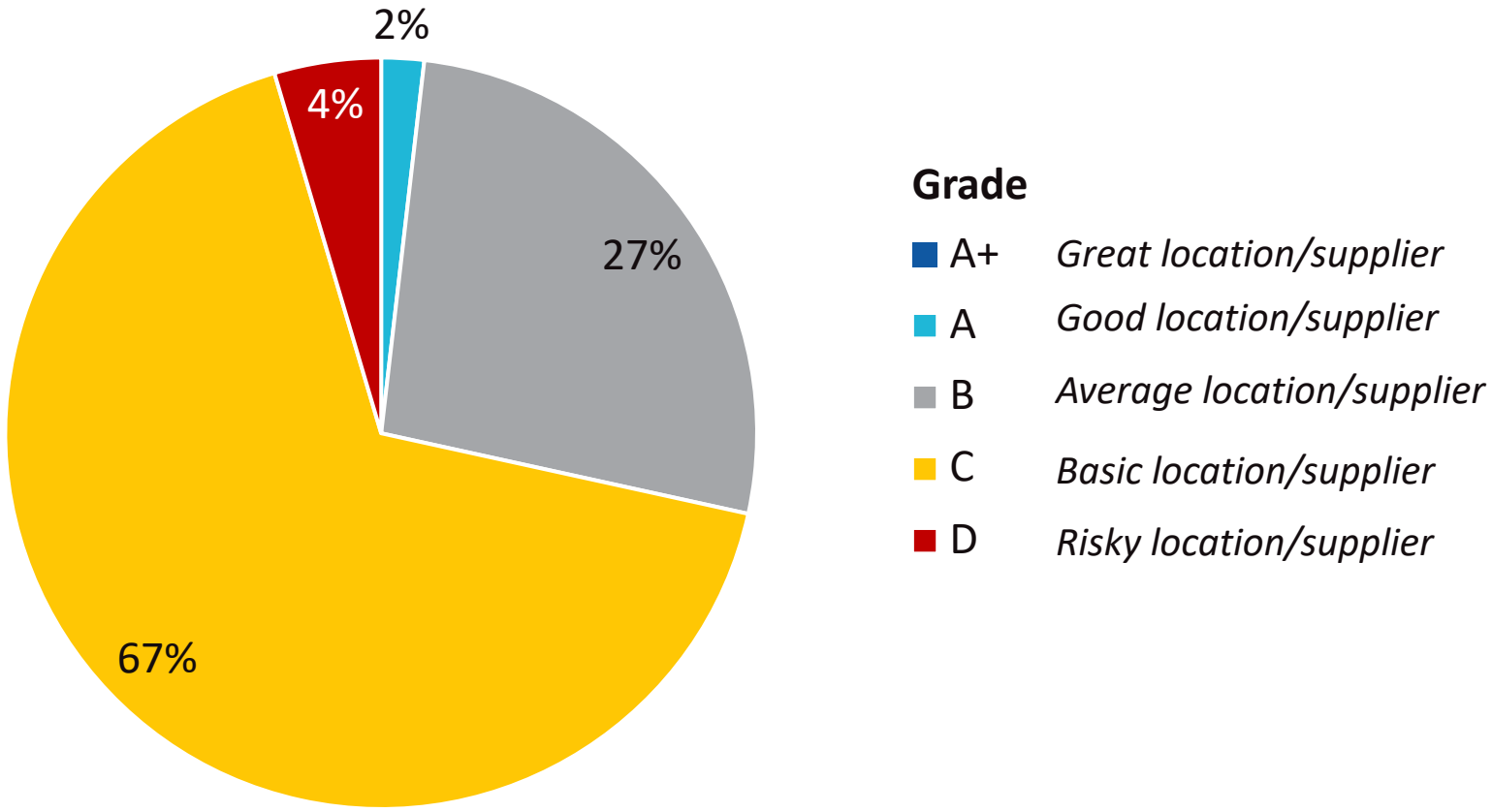
- Findings are scored based on severity (Minor, Major, Critical)
- FA scores are calculated using a risk-based scoring model
- Grades (A+ to D) are assigned based on percentile ranking within the global FA data set
- Grade thresholds are derived from historical data and periodically reviewed

Grade Descriptions:

A+	Great location/supplier
A	Good location/supplier
B	Average location/supplier
C	Basic location/supplier
D	Risky location/supplier

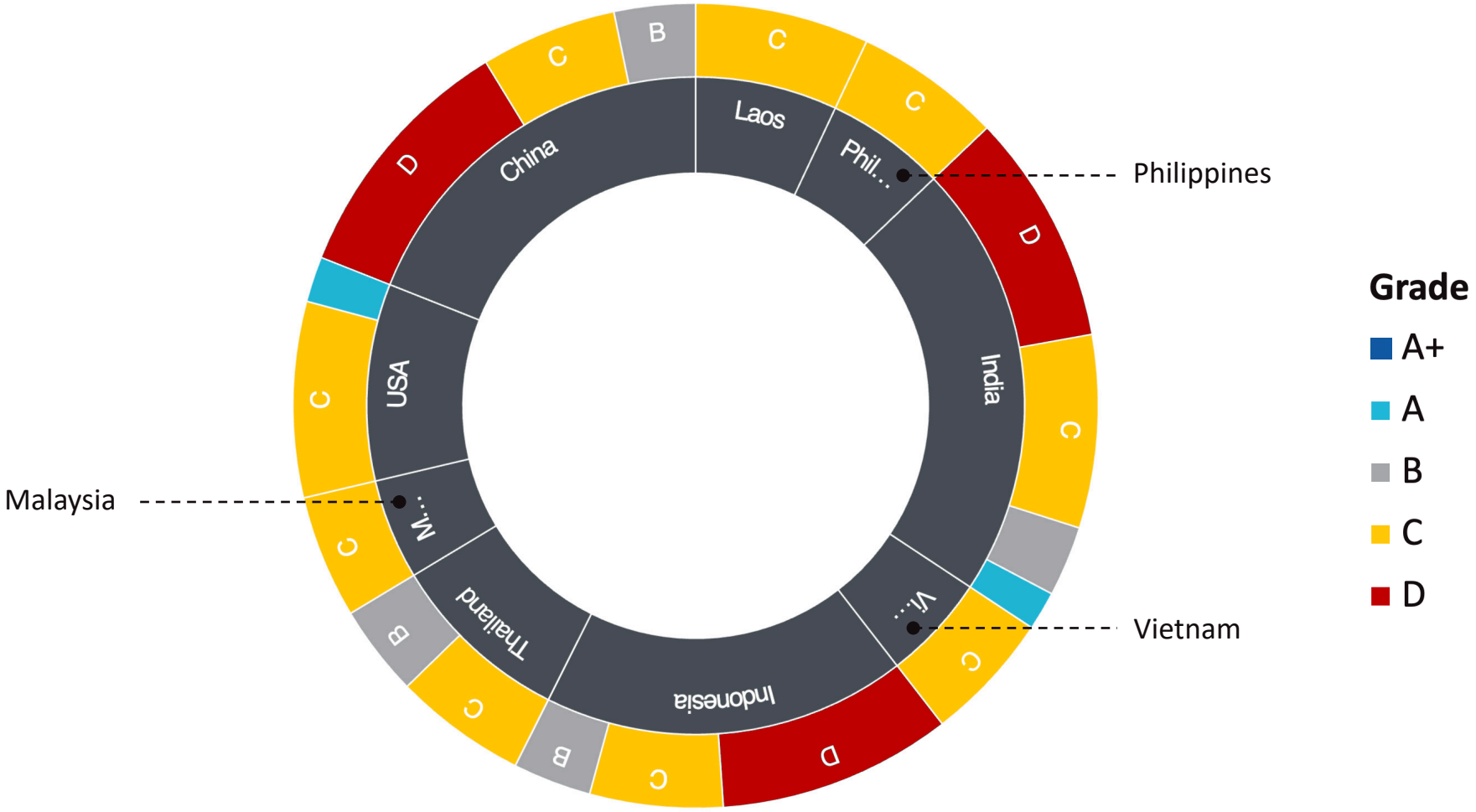
In 2025, more than 70% of factories received a C or D rating, and none achieved an A+

C- and D-rated factories generally exhibited multiple major findings and, in some cases, one or more critical findings



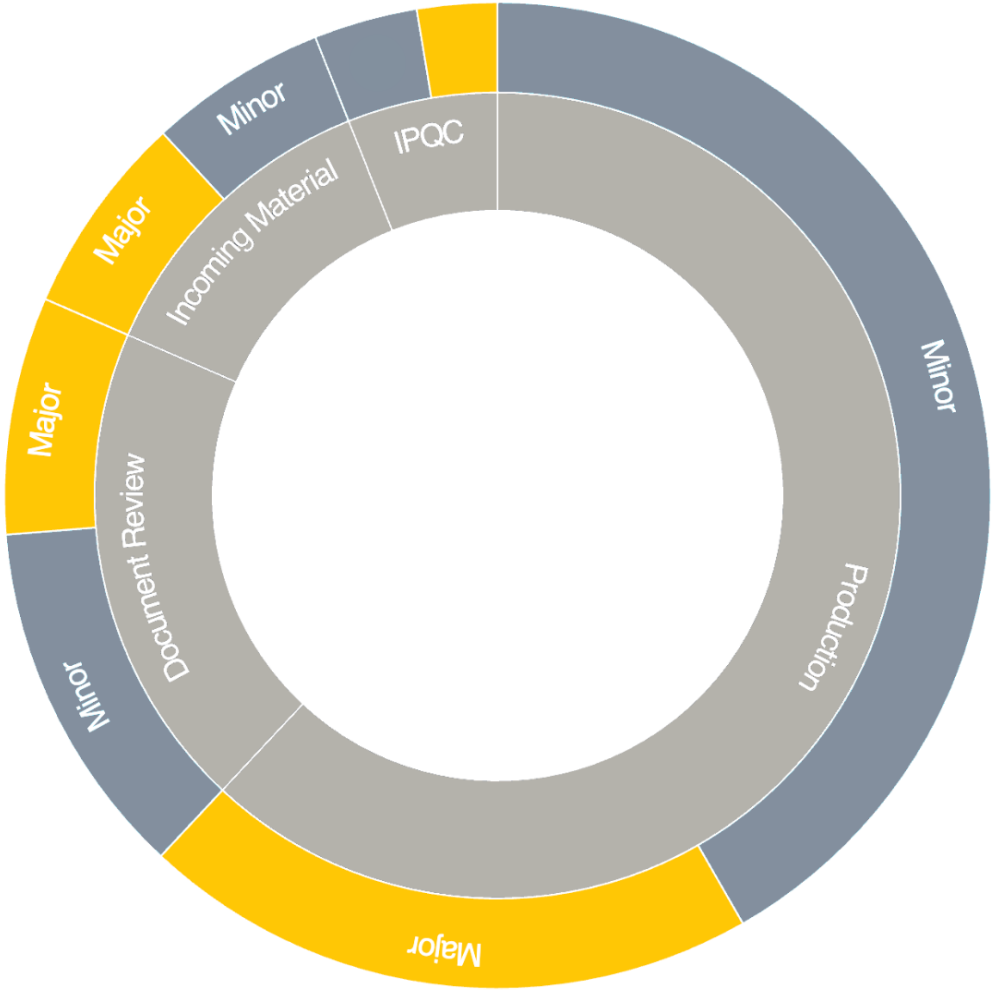
Share of factory average quarterly grades in 2025, based on historical FA percentile thresholds

Significant quality problems were identified in factories in every geography



FA factory quarterly average grade by country 2024-2025

Major issues were identified at every stage of factory operations



Factory Audit findings distribution by severity

Inline Production Monitoring (IPM)

Ensuring Quality Throughout Production

Engineers supervise the production process according to requirements of the customer‘s contract:

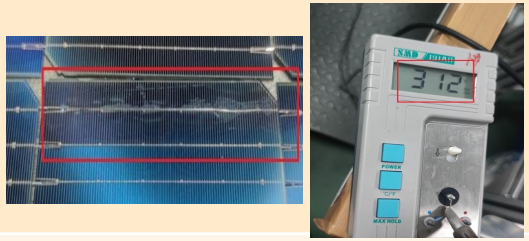
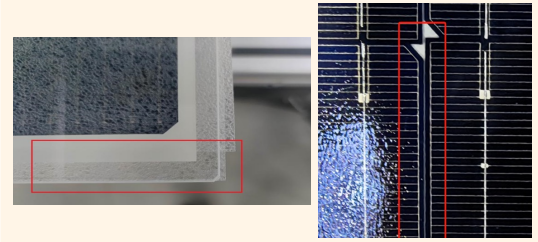
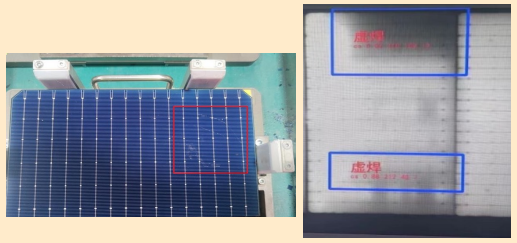
- The Quality Control Engineer (QCE) notes risks in manufacturing quality and monitors the adherence to the supplier's quality system in an objective and fair manner.
- Daily on-site inspections of the production process follow the supplier‘s quality control plan (QCP) and standard operating procedures (SOP) as well as industry best practices.

Examples of inspection areas (checklist of 280+ items):

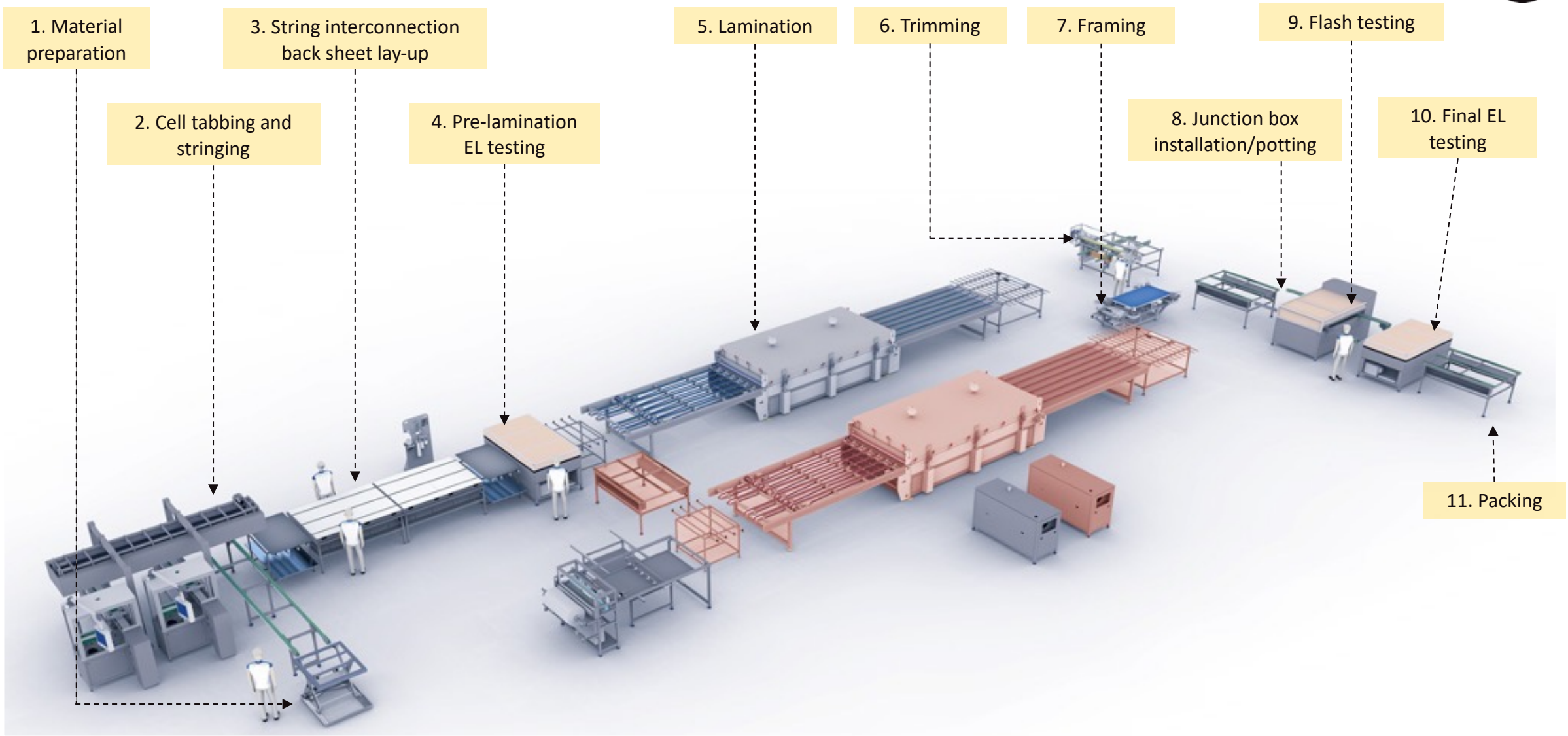
- Incoming materials quality control and inspection
- BOM conformity
- Instrument and production line calibration
- Inline QC monitoring
- Packaging and warehouse inspections

Major risks are escalated directly to the client, while CEA also actively provides recommendations for improvements to the manufacturer.

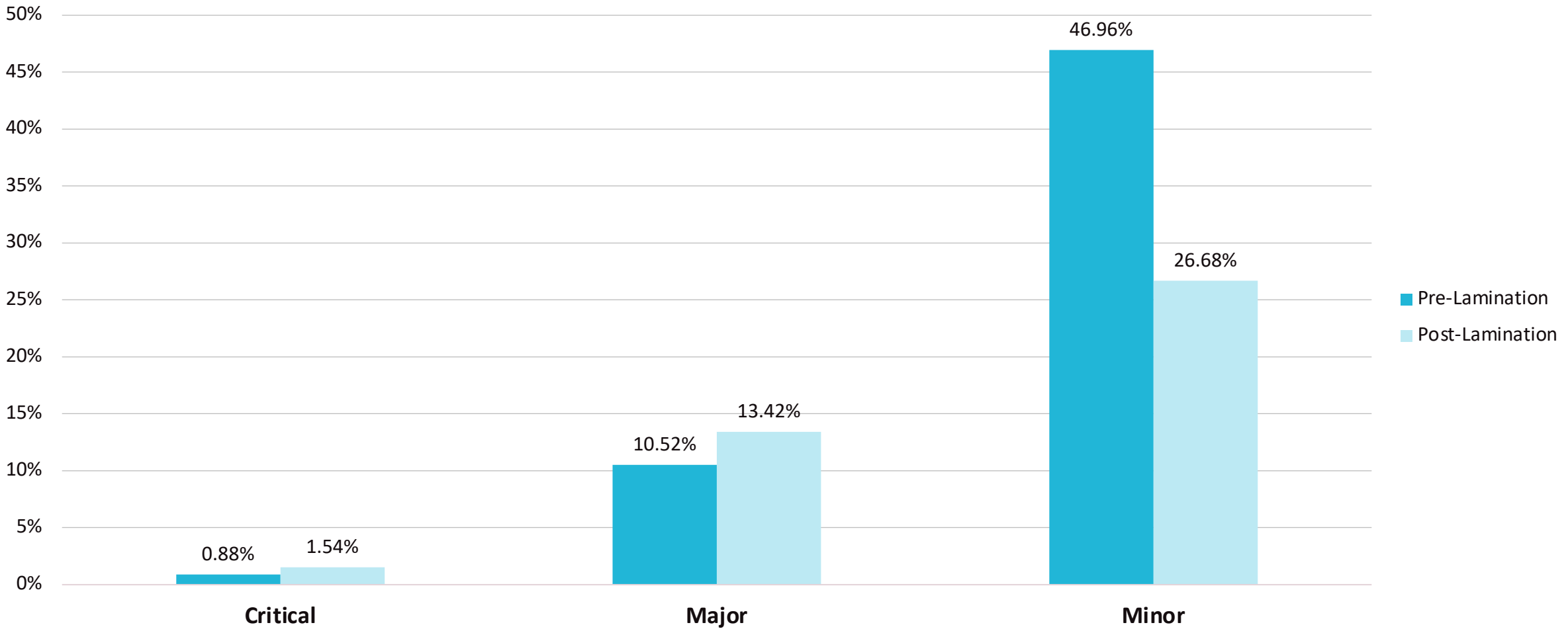
Common finding categories:

Area	Description	Example
Re-work	1. Contaminations after manual re-work 2. Soldering temperature is lower than SOP	
Lay-up	1. Misalignment of encapsulant 2. Distance between the cell strings	
Tabbing & Stringing	1. Scratched cell used 2. Cold soldering	

Understanding the crystalline silicon PV module production line

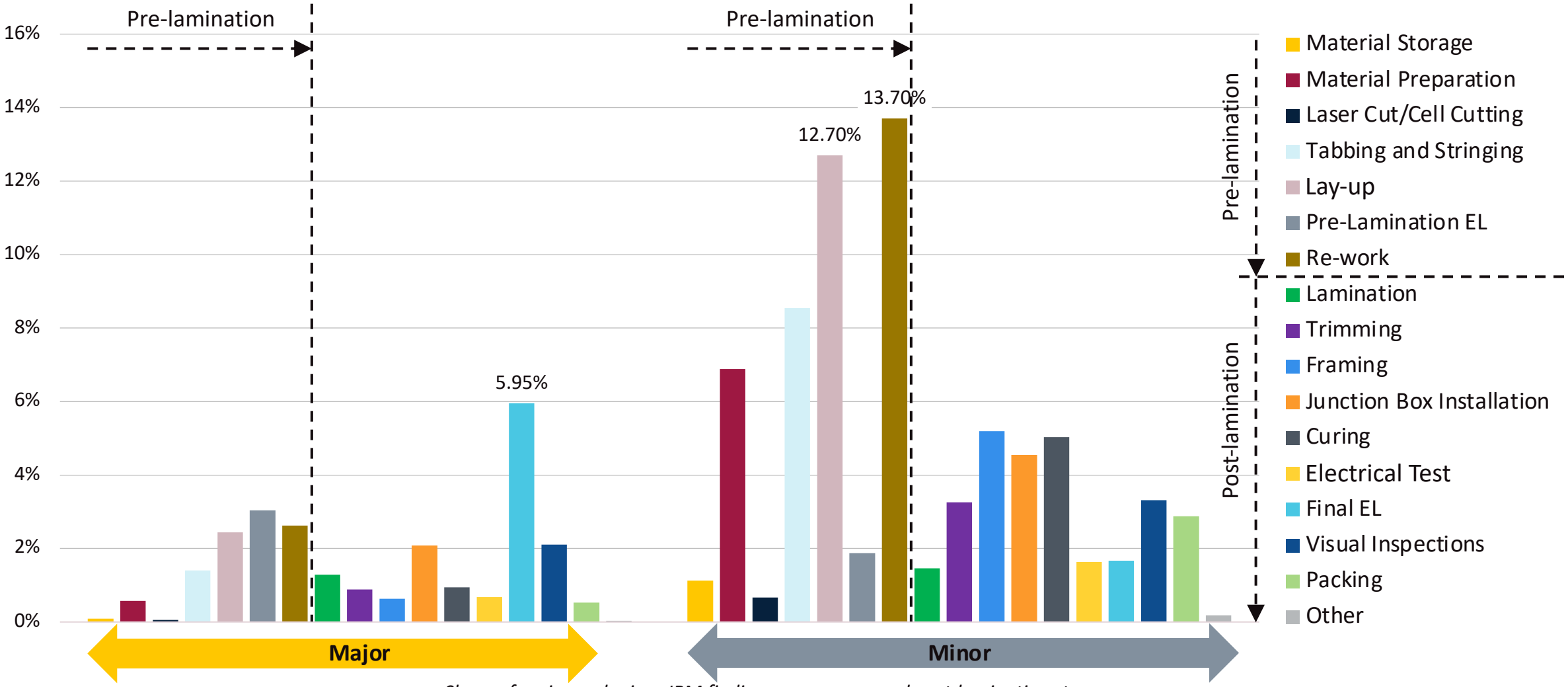


Distribution of IPM findings: Pre- and post-lamination



Share of IPM findings across pre- and post-lamination stages

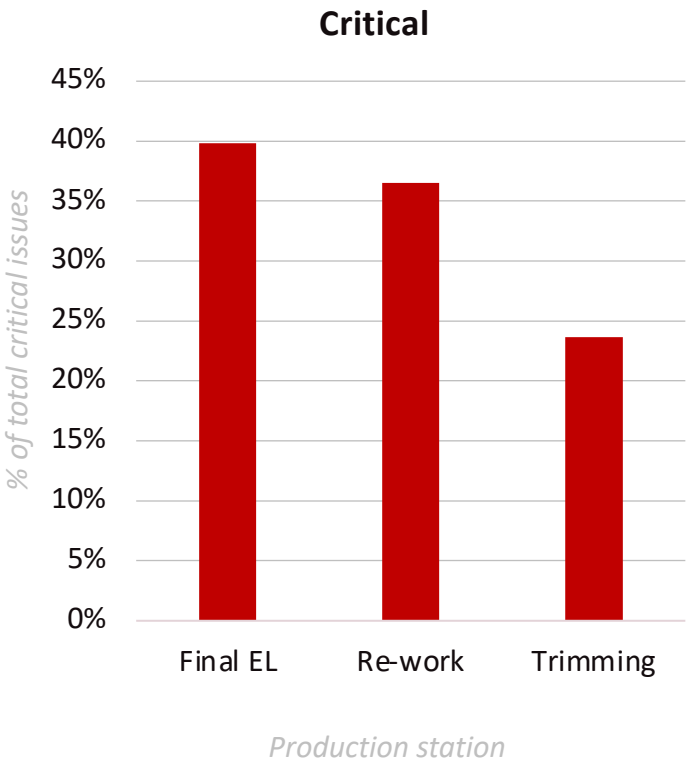
Distribution of IPM findings by production stage

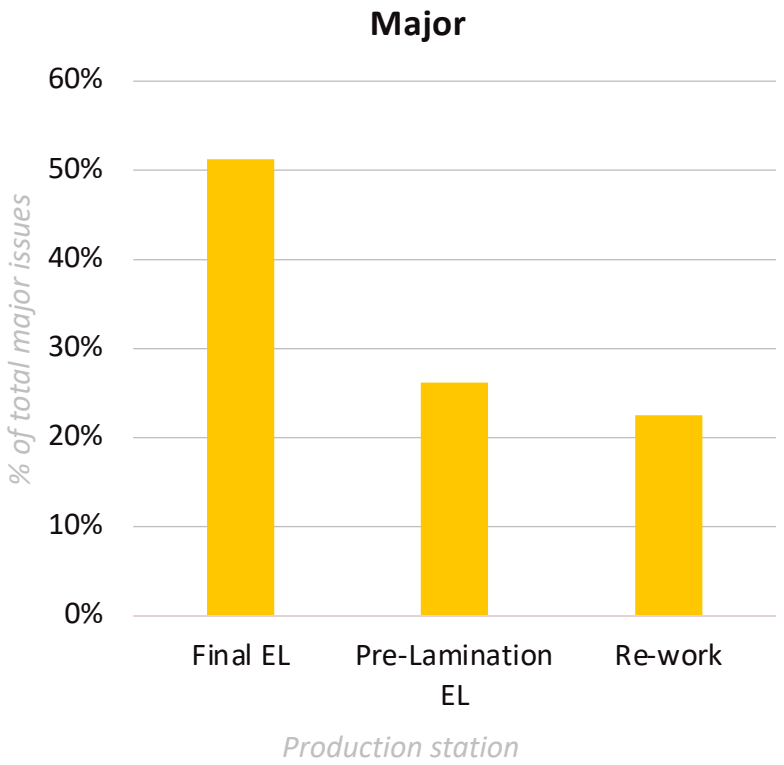


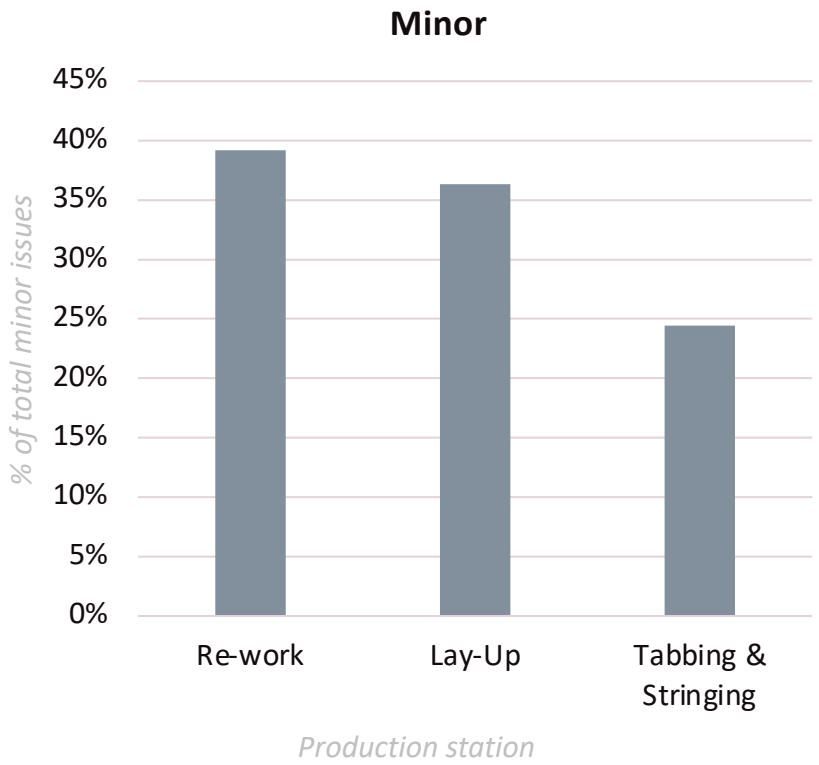
Share of major and minor IPM findings across pre- and post-lamination stages

Soldering-related defects are increasing; most are detected at final EL testing

As busbar and ribbon counts increase, smaller contact areas make soldering more prone to defects; these issues are most visible at the Final EL



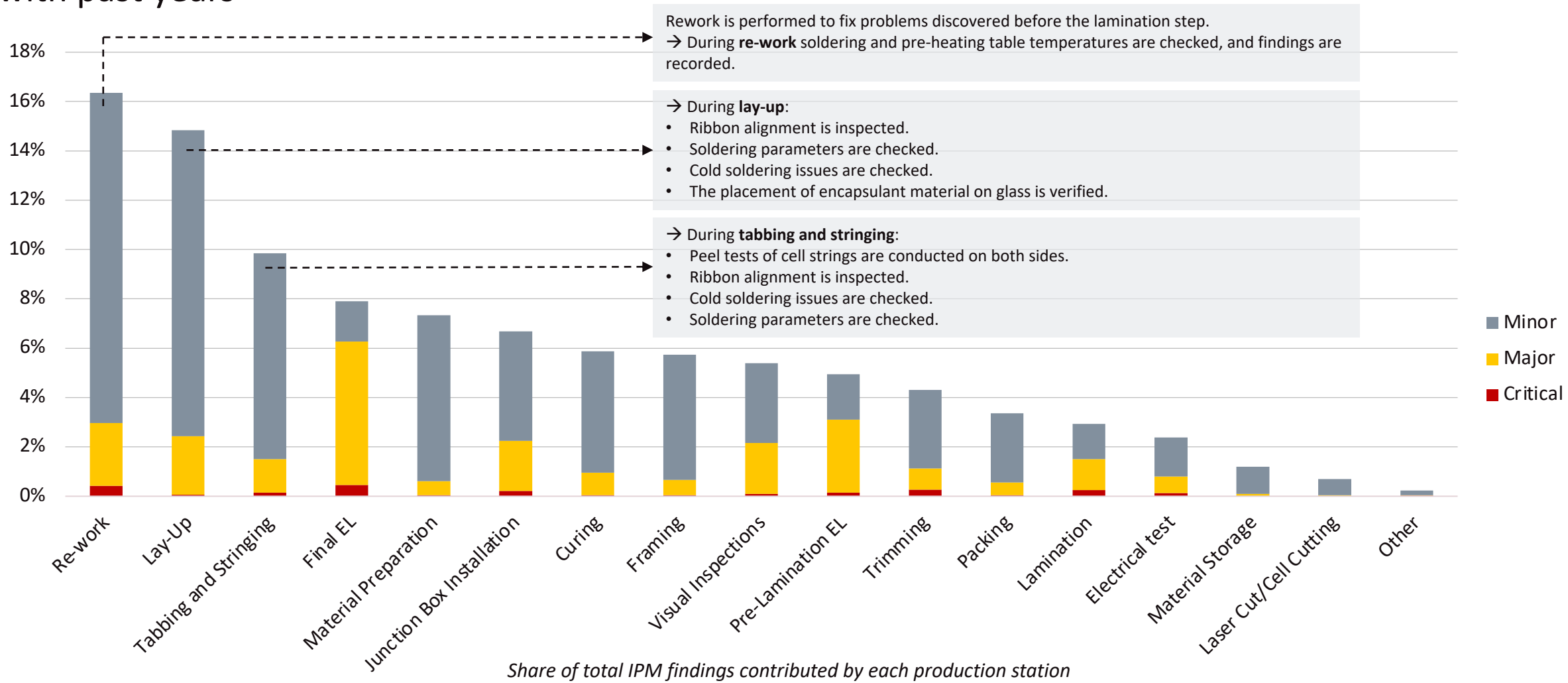




Top 3 contribution by categories for each severity

Same production stages continue to drive most IPM findings

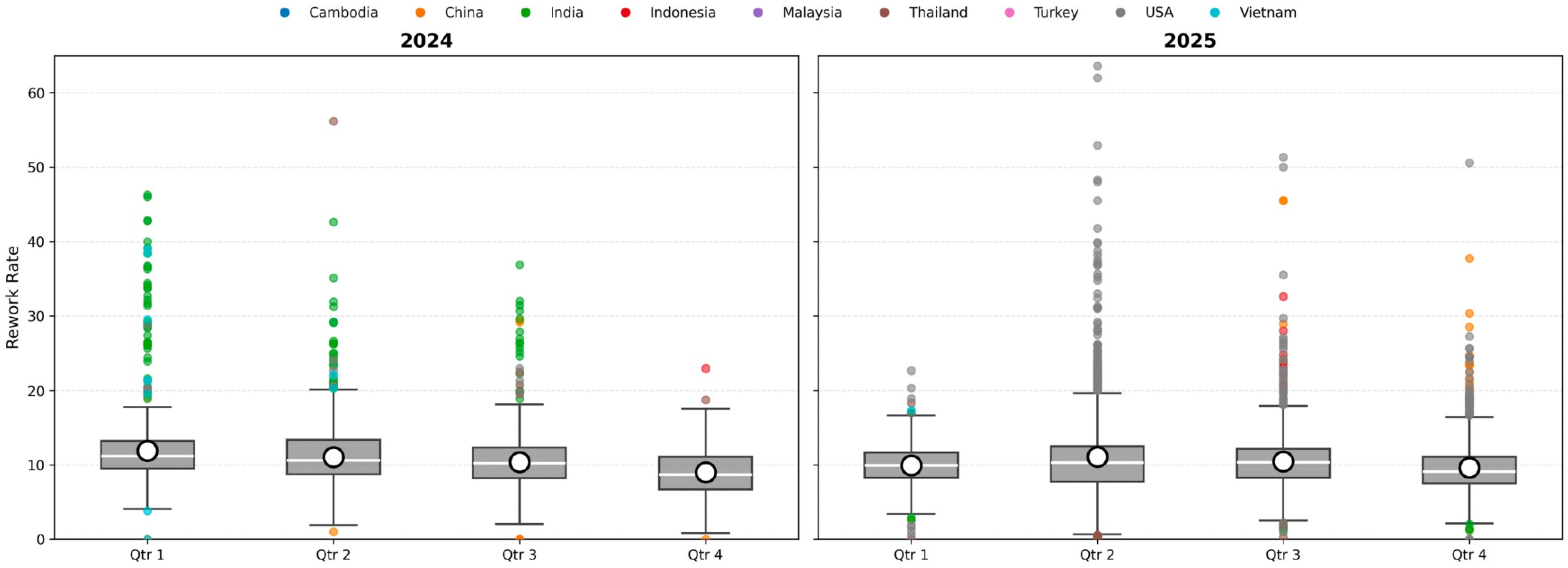
Re-work, lay-up, and tabbing & stringing remain the primary sources of findings, consistent with past years



Share of total IPM findings contributed by each production station

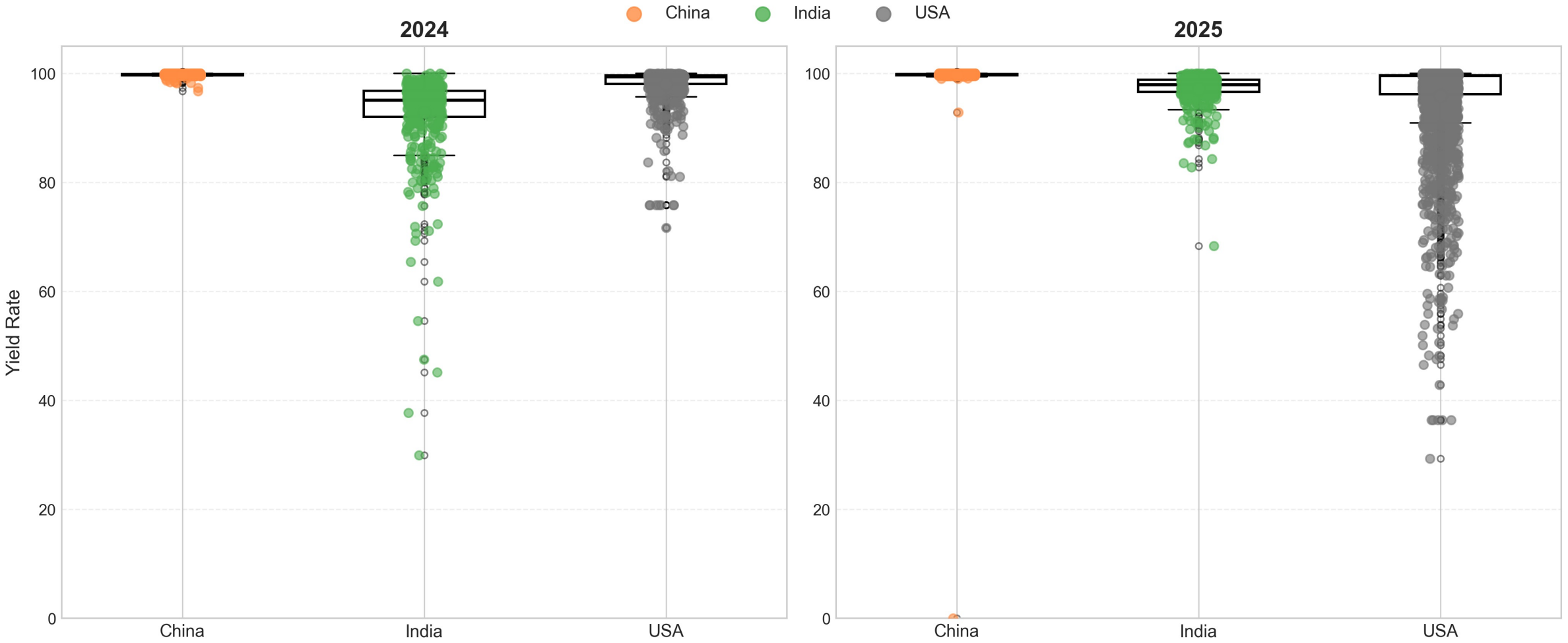
Stable average re-work rates mask significant factory-level variability

While typical rates remain around 10-15%, large deviations persist during ramp-up and capacity expansion



Factory ramp-up drives most low yield rates in 2025

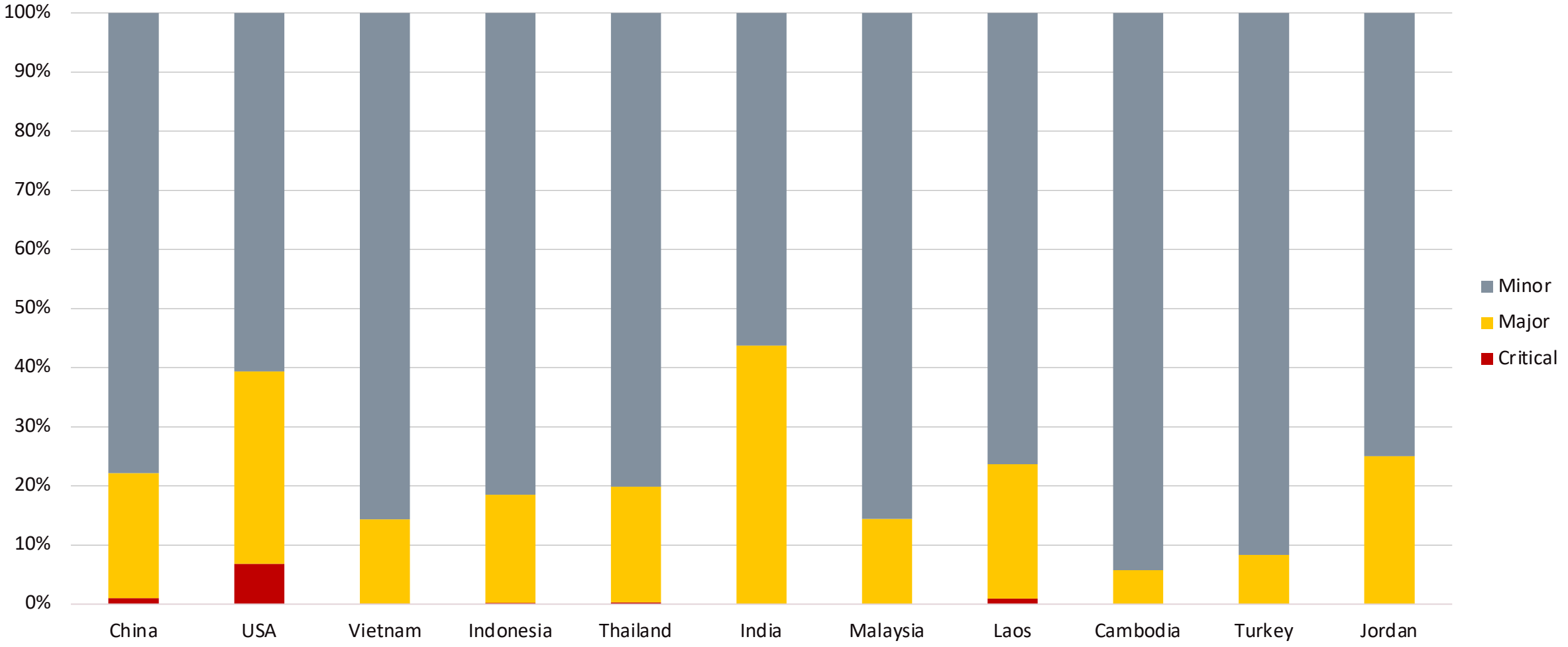
In contrast, mature suppliers maintain stable, high yields



Daily average production yield rates of suppliers on country basis

U.S. capacity expansion is exposing early-stage execution risks

Critical issues observed during ramp-up reinforce the need for strong QA oversight



Distribution of IPM issues by severity across countries

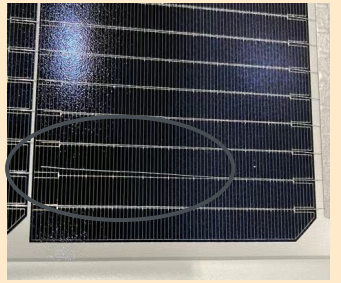
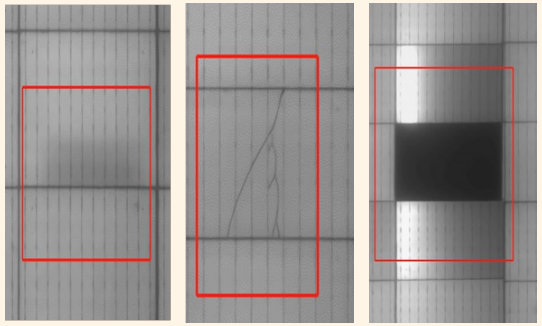
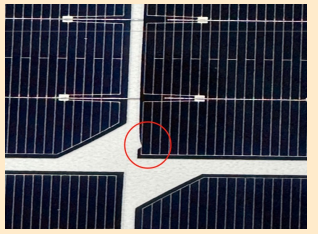
Pre-Shipment Inspection (PSI)

A pre-shipment inspection involves selecting a statistically significant number of samples based on the Acceptable Quality Limit (AQL) method to check product quality at the manufacturing facility, following pre-defined criteria from the procurement contract, with potential shipment rejection or rework if standards are not met.

Main Inspection points:

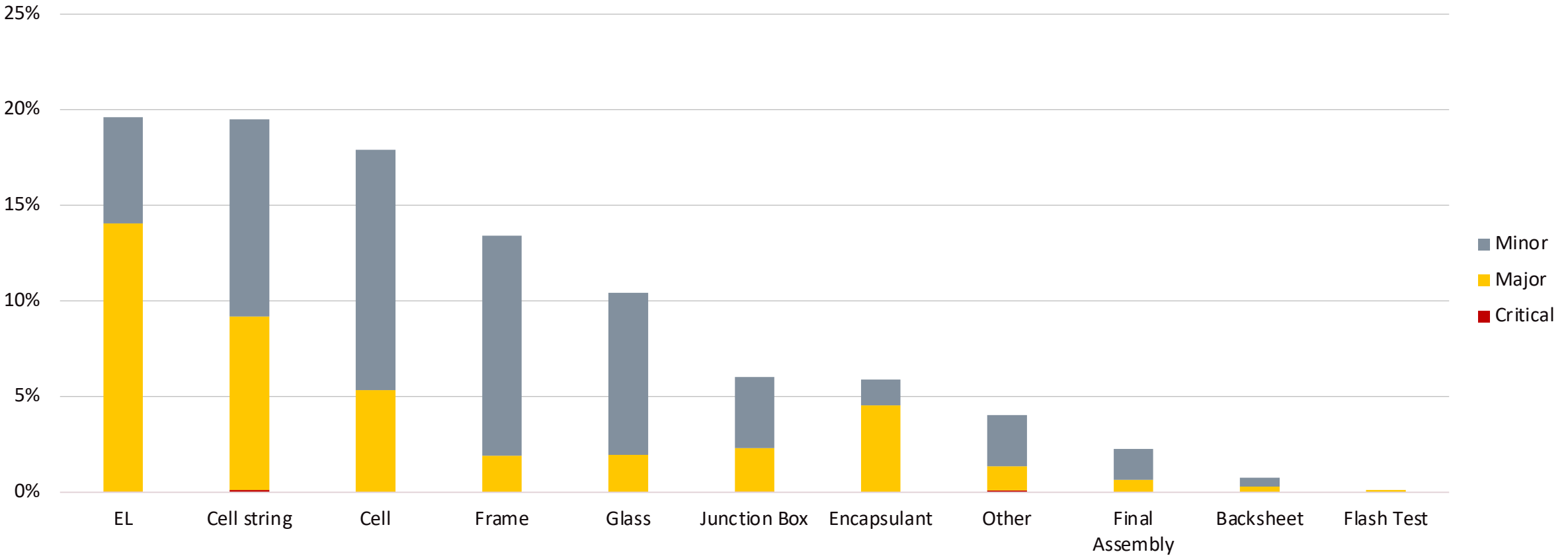
- Visual inspection
- Functional and performance testing (EL imaging and IV tracing)
- Safety testing (hi-pot test, ground test)
- Certification and nonconformance inspection
- Rejection protocols

Defect Categories:

Category	Description	Example
Cell string	Misalignment of string is the most common defect in this category	
Electrolumi-nescence (EL)	Defects identified under EL category are cold soldering, microcracks, and dark cell	
Cell	Cell cracking and cell chipping visible to naked eye come under this category	

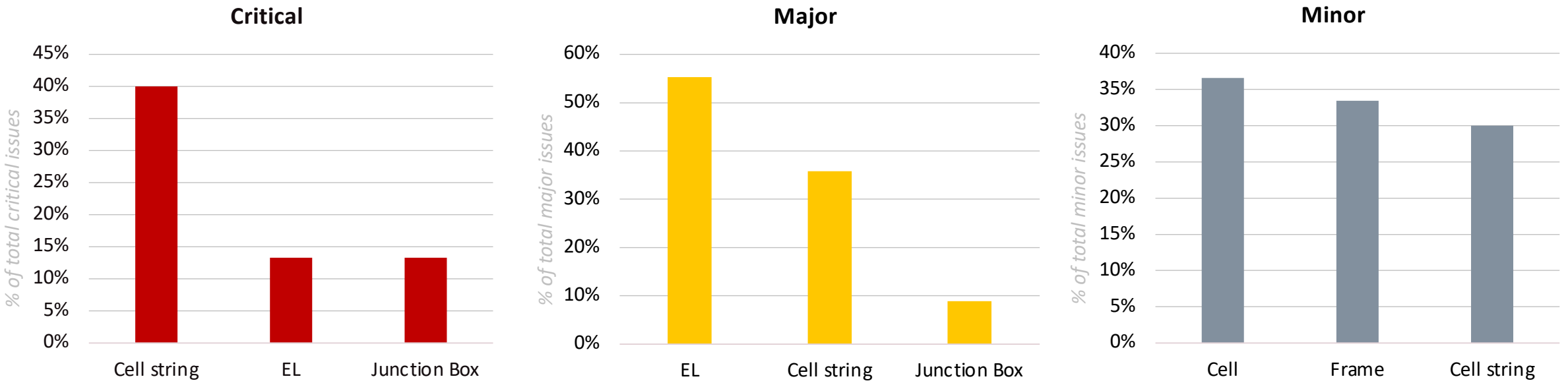
EL imaging, cell strings, and cells continue to account for the majority of defects

Mechanical stress on cells, string misalignment, and cold soldering are the major contributors to these defects



Share of total pre-shipment inspection defects by defect category

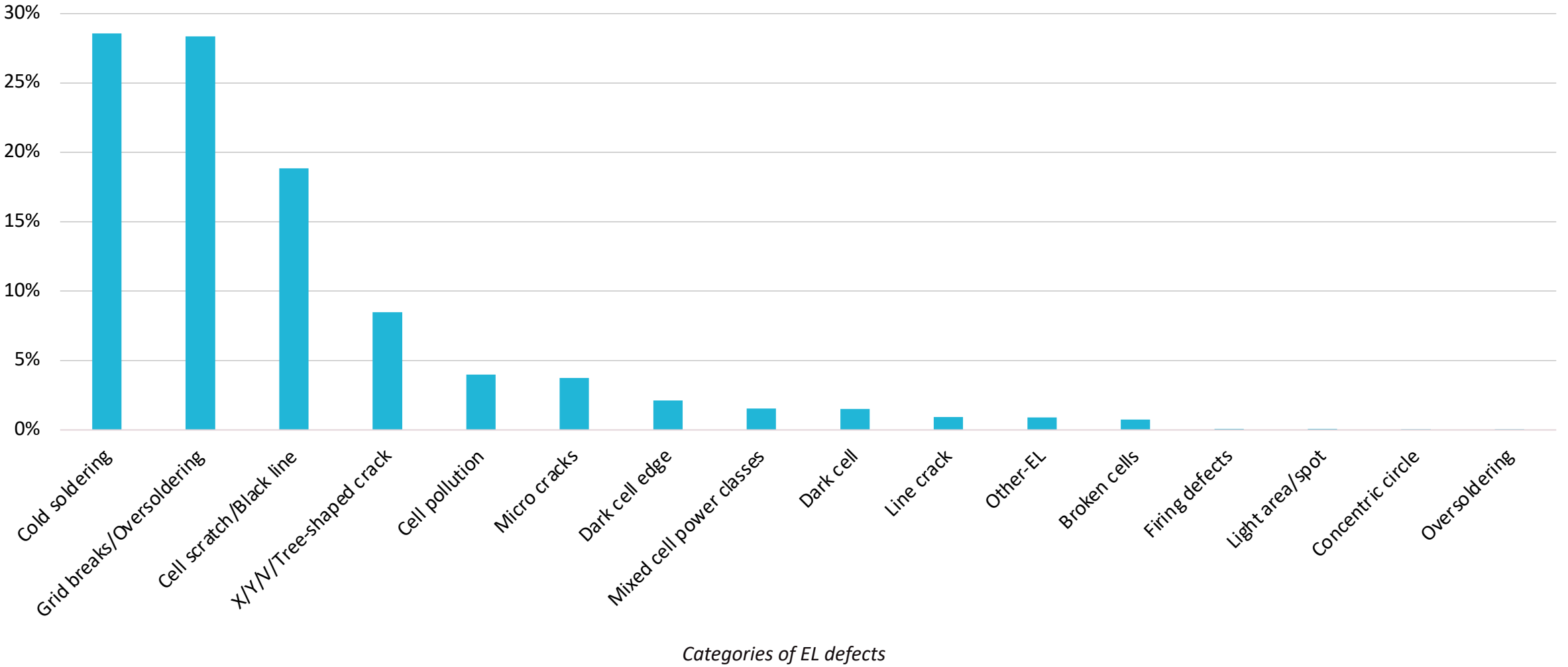
Cell string defects represent the highest risk, while EL testing continues to reveal major issues missed by visual inspection



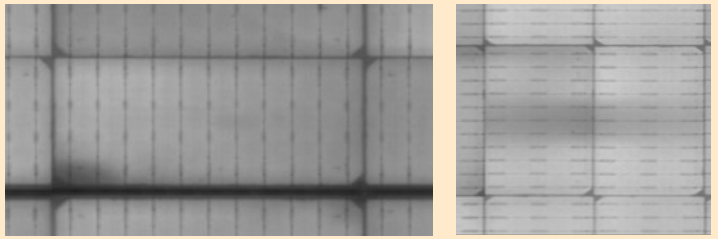
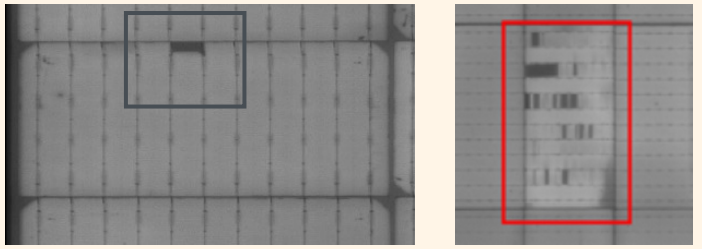
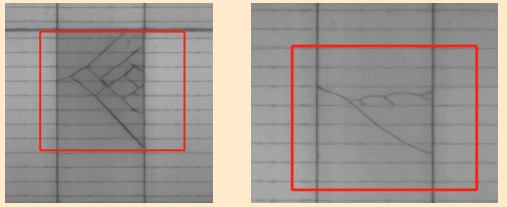
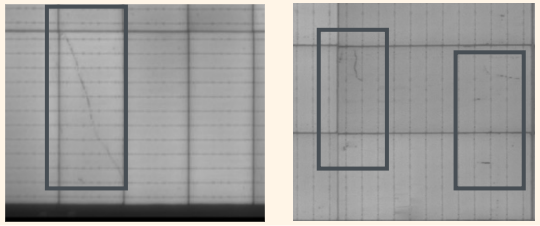
Top 3 contribution by categories for each severity

Cold soldering, grid breaks, and scratched cells are top EL defects

Mechanical stress, soldering issues, and handling errors are the primary drivers



Common EL defects: Descriptions and examples

Defect	Description	Example
Cold soldering	Occurs due to poor electrical contact between the cell and the ribbon during soldering. Higher resistivity leads to dark areas.	
Grid breaks	Defective metallization during screen printing of cell fingers causes higher resistivity areas where the metallization is lacking. These areas appear darker.	
Microcracks	Cracks in the cell cause electrical discontinuity and loss of active area leading to dark lines appearing. Stresses can cause the cracks to grow and branch.	
Cell scratch	Scratched cell surface causes lower efficiency and leads to dark lines appearing.	

Container Loading Monitoring (CLM)

Container Loading Monitoring (CLM) is executed at the supplier's warehouse. It is the final control point at the supplier site after IPM & PSI. Engineers verify the module data and monitor the whole process of module pallet loading into the containers.

CLM Checklist:

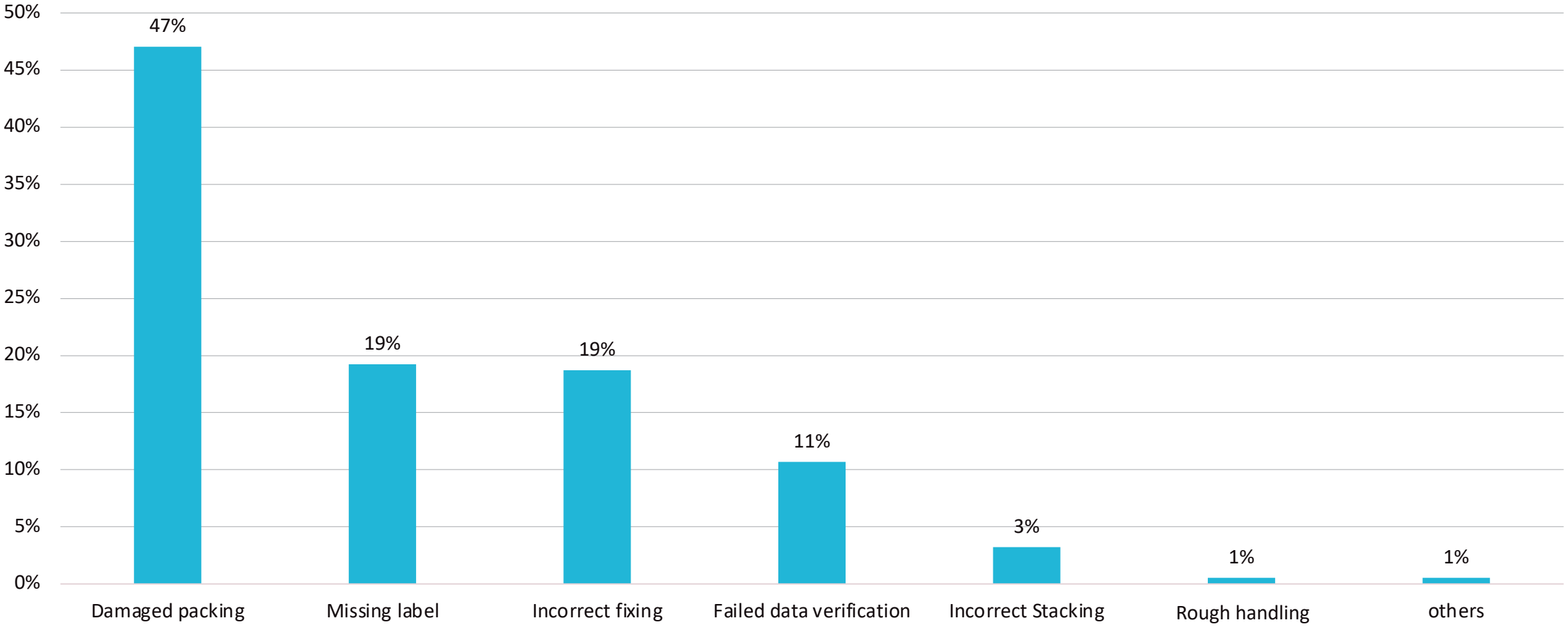
- Check consistency of shipped product against the purchase order in terms of product specification and quantity.
- Verify the shipped goods are the ones qualified during IPM & PSI and not mixed with unqualified products.
- Make sure the packing and stacking / loading method of pallets are consistent with the client's requirements.
- Monitor container loading process is compliant with supplier’s SOP.
- Ensure packing material is complete and not damaged.
- Verify containers are in good condition.
- Record of the container number and seal for tracking.

Findings during CLM:

Description	Example
Damaged packing	
Torn fixing tie	
Damaged outer wood shingling	

Damaged packing is the most common finding during CLM

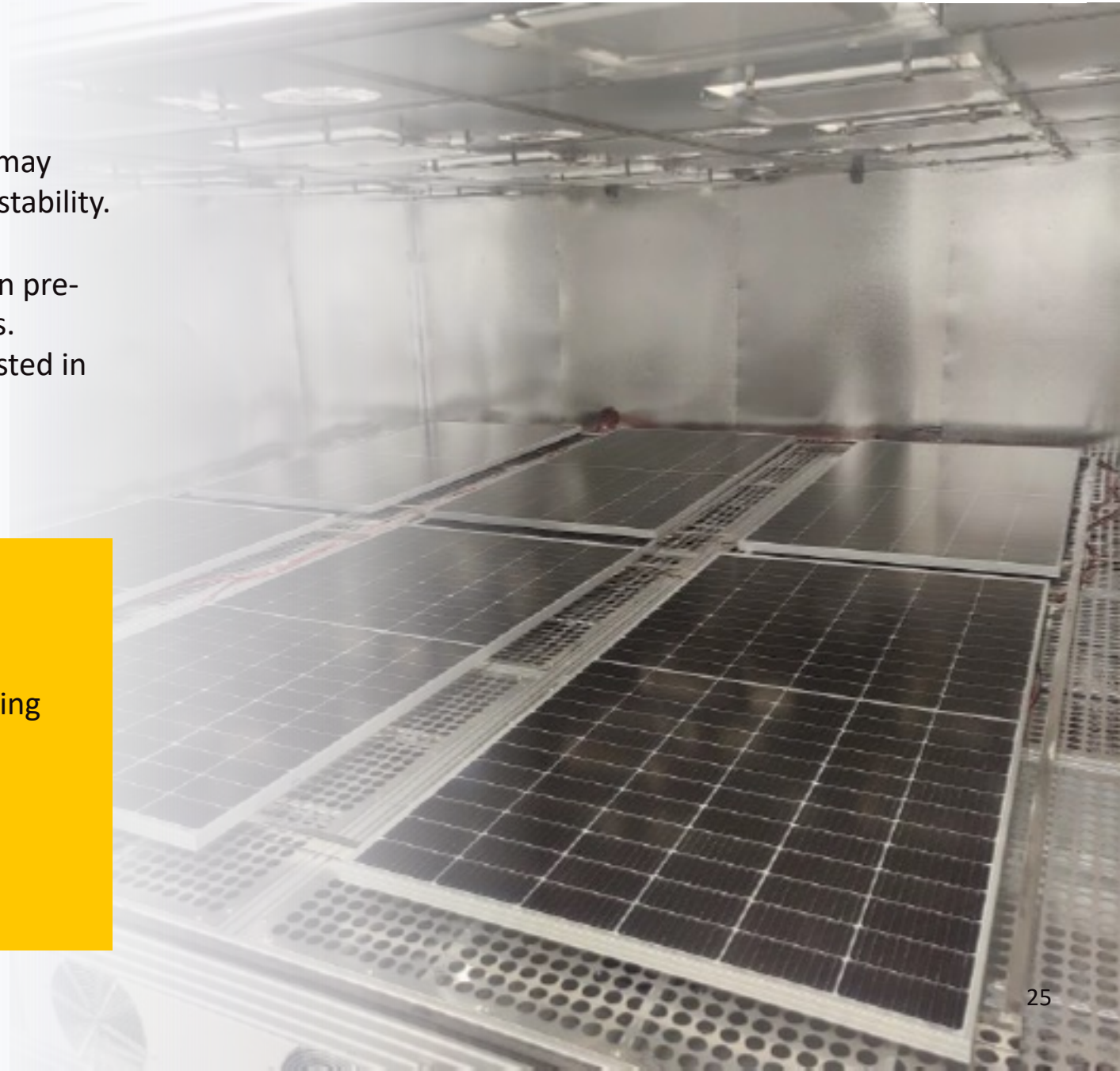
Includes carbon box damage, pallet damage, torn fixing ties, and other packaging issues



Frequent defects during Container Loading Monitoring

Batch testing

PV manufacturers use multiple sources of raw materials that may have variations. Production processes may also suffer from instability. Batch testing is important for controlling any deviations in performance of a production batch before shipment, based on pre-agreed pass/fail criteria and representative sampling methods. Sample modules are selected from a production batch and tested in an internal or external lab, such as Intertek, to verify their performance and quality.



Tests that are typically conducted in a lab:

- Potential Induced Degradation (PID) Testing
- UV Induced Degradation (UVID) Testing
- Light and Elevated Temperature Degradation (LETID) Testing
- Light Induced Degradation (LID) Testing
- Hail Impact Testing
- Mechanical Stress Testing
- Special Tests Specific to Project

Some important module degradation modes

Potential-induced Degradation (PID)

PID is a type of module degradation caused by the high voltage between the PV cells and the glass surface, which is grounded via the substructure of the cell or the frame. PID affects the PV cells, causing a potentially irreversible efficiency loss.

Light and Elevated Temperature Induced Degradation (LeTID)

LeTID is a form of solar cell degradation due to a combination of irradiance exposure at high temperatures. It typically takes 1-2 years to manifest. LETID may self-reverse, but at a very long, 10+ year timescale.

Light Induced Degradation (LID)

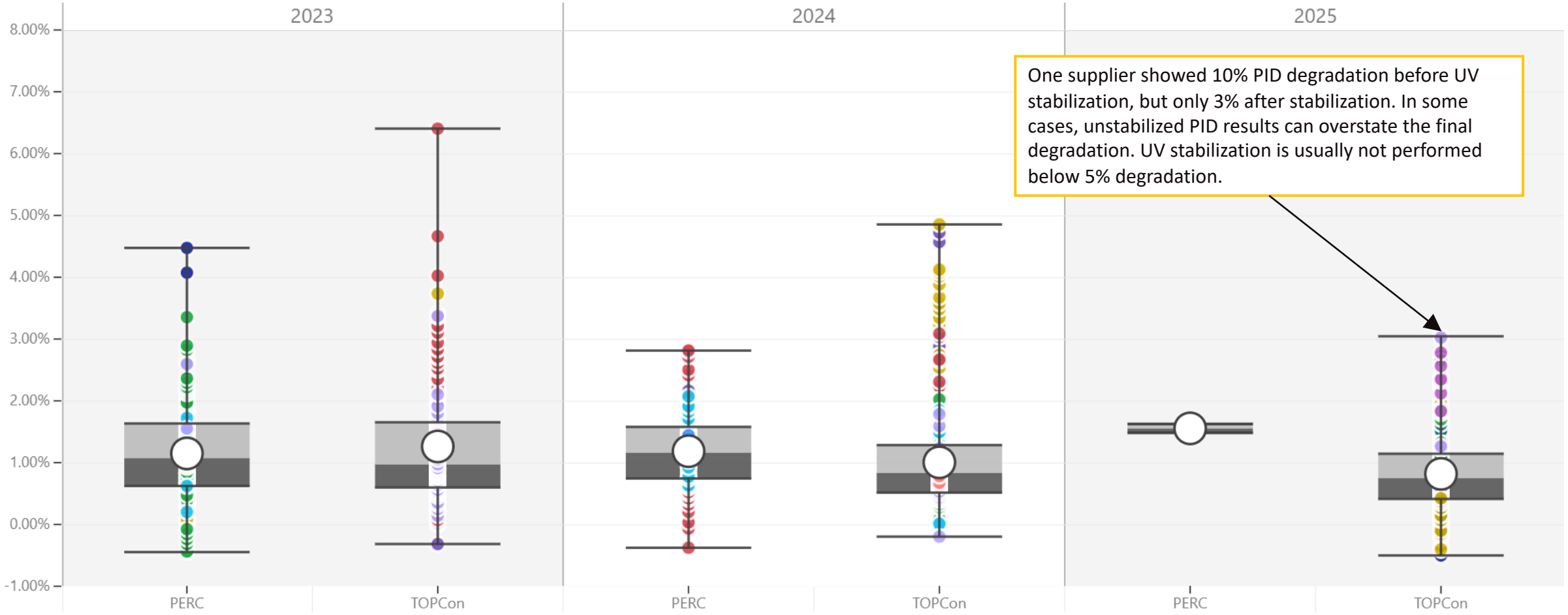
LID is a loss of efficiency of the PV cells which happens in the first hours of exposure to the sun. The cell efficiency loss is typically permanent.

UV Induced Degradation (UVID)

UVID is degradation caused by UV exposure in sunlight, where high-energy photons damage cell passivation. Some of the loss may recover with further light exposure, but part can remain permanent.

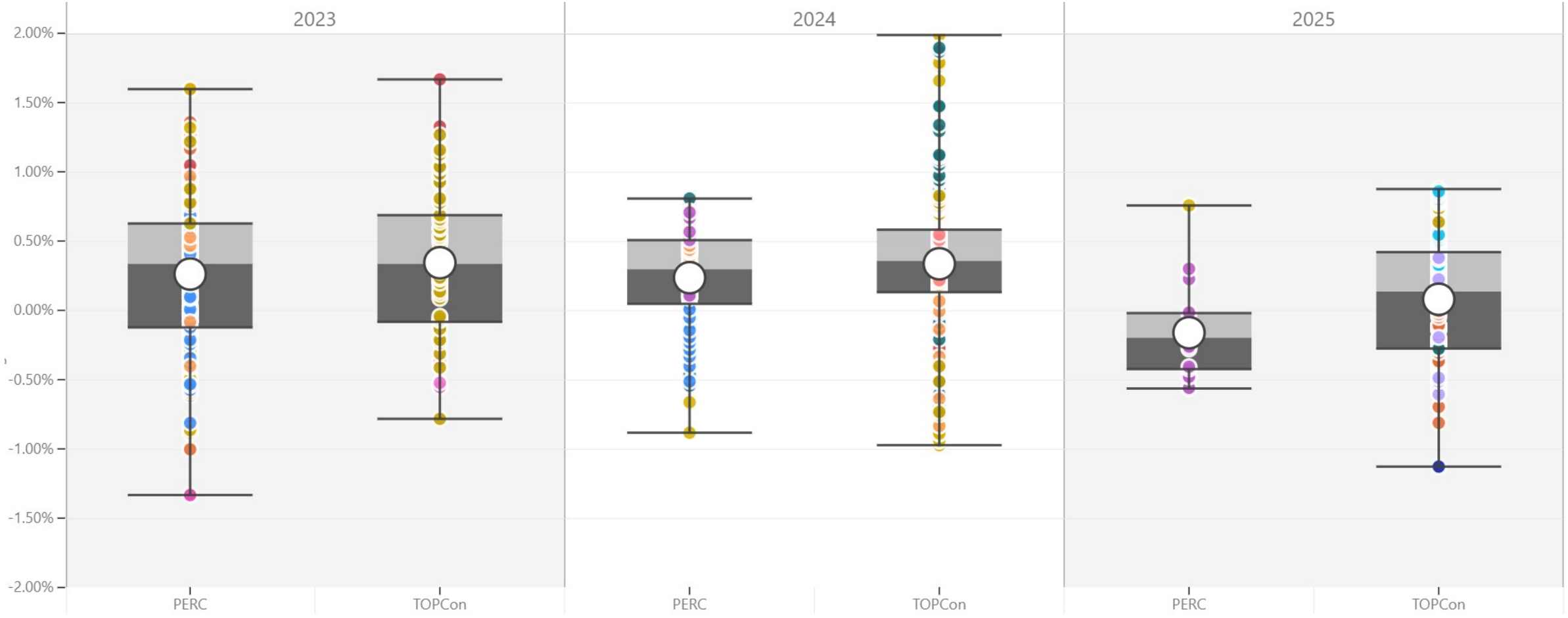
No UV-stabilized samples exceeded 3% PID degradation in 2025

As the industry shifts toward TOPCon, PERC represents a much smaller share of the PID dataset



Intertek CEA batch testing data, multiple labs (PID at 85°C/85%, RH/96h). Different colors indicate different suppliers. Potential Induced Degradation (PID). PID testing is not always realistic with respect to actual field conditions as it is done in a dark chamber. UV stabilization is sometimes applied to mimic the effect of actual field conditions and the regenerative effect of light on PID.

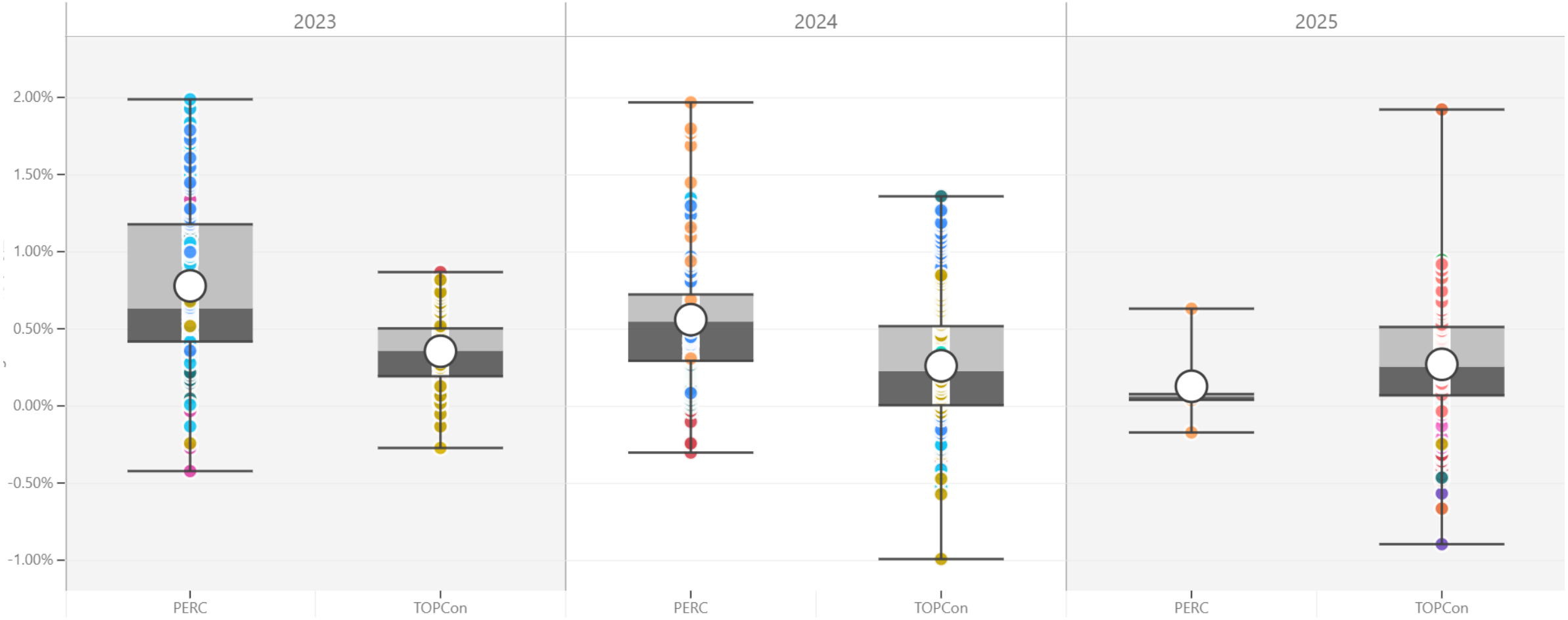
LeTID risk has largely been mitigated in mature PERC and TOPCon manufacturing



Intertek CEA batch testing data, multiple labs (LETID 1x or 2x (Isc-Imp), 162/168 h, 324/336 h). TOPCon data from nine suppliers. Light and Elevated Temperature Induced Degradation (LETID).

TOPCon demonstrates consistently low LID

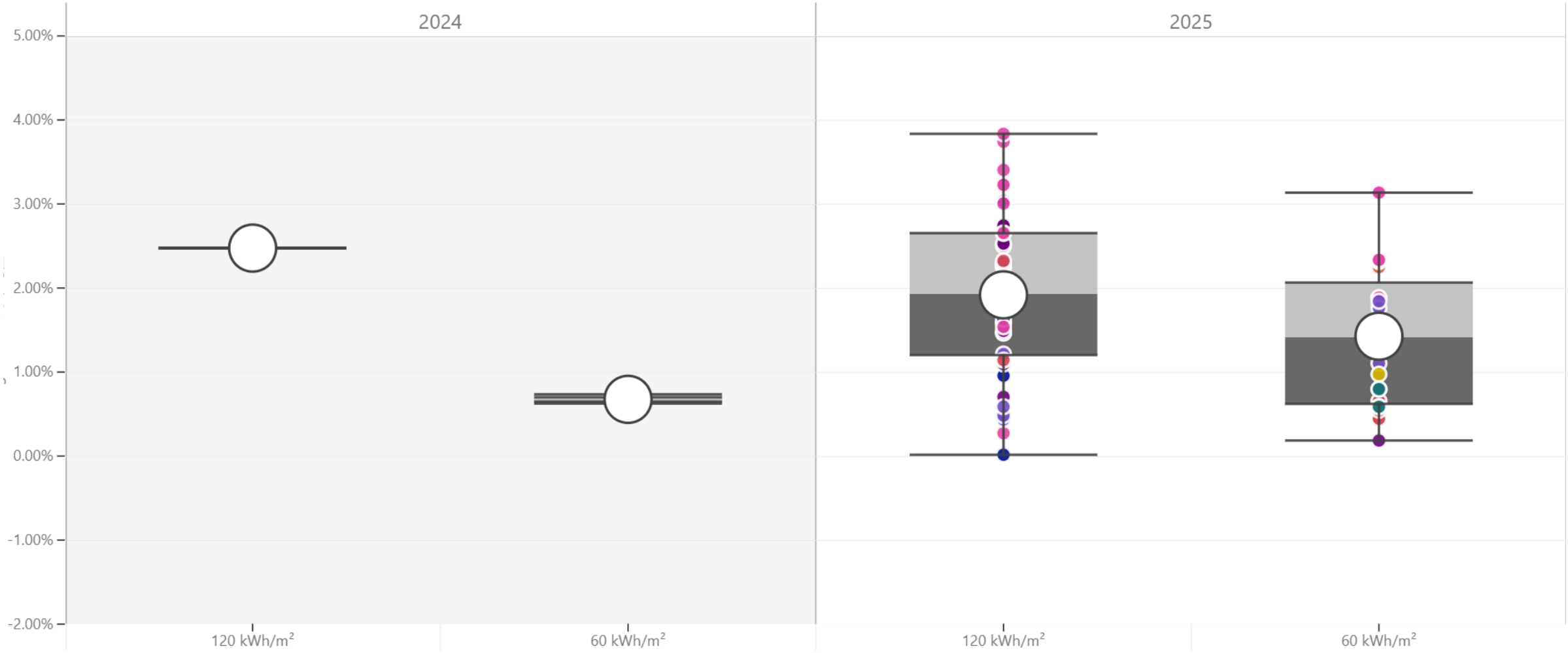
Rare outliers still occur, with no clear root cause identified to date



Intertek CEA batch testing data, multiple labs (LID at 20 – 80 kWh/m²). Light-Induced Degradation (LID)

UVID is a key quality risk for TOPCon modules

2025 data shows significant supplier-to-supplier variation in UVID performance



What can you do to ensure the long-term financial health of your PV assets?

Golden Standard

Closing the Gaps: We review your procurement contract, project requirements, product specifications and quality assurance plans to ensure your PV modules perform well and safely, preventing any surprises.

Early Detection: We identify risks in the supplier's inspection criteria and product qualification tests early on, to save costs and extend your system's operational life.

Expert Check-Up: Our experts verify adherence to key safety and performance standards for reliable PV modules.

Negotiation Support: We support you in negotiating and adjusting the technical exhibit deviations.

Factory QA

Factory Audit (FA): Engineers check factories with a 1,000+ point checklist, assess risks, and recommend fixes.

Inline Production Monitoring (IPM):
Engineers monitor production in real-time using a 280+ point checklist to ensure quality, spot issues, and suggest corrections.

Pre-Shipment Inspection (PSI):
Engineers inspect and test a random sample of finished products, record findings, and advise on improvements.

Container Loading Monitoring (CLM):
Engineers verify module data and oversee the entire process of loading the pallets into containers.

Batch Testing: Sample modules are selected from a production batch and tested in a lab to verify performance and quality.

Contact us for a consultation!

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www.intertekcea.com