From Innovation to Investment: Reliability and Bankability of New PV Technologies

Luca Votta – Global Business Sector Leader Energy Transition

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Services for the entire ***Value Chain***

Market Intelligence

Industry leading reports, from analysis of key solar and energy storage components pricing, technology trends, policy updates, as well as custom data and reporting.

Technical Advisory

We support investors, developers, EPC contractors, asset managers procure high quality equipment and optimize PV system performance and efficiency.

Engineering

Complete engineering services for PV plants in order to support investors in the development and construction of reliable assets.

Product Testing

Independent, industry-leading performance testing of PV modules, inverters, trackers, mounting systems, battery energy storage, and other key equipment.

Factory Inspection

Experts in materials, contracting, factory audits, corrective action, production supervision, and pre-shipment inspection to ensure the long-term performance, reliability, and safety of your investment.

Field Services

Assess your project's baseline health at PV module delivery and optimize post-installation performance.

Kiwa Solar & Storage Business
Quick Facts

3 Continents

15 Kiwa Offices involved

5 Labs (China, United States, Germany, Italy)

40 Served Countries

5000+

5000+
Model types tested (PV Modules, Inverters, Batteries)

20+

20+ GW
Of PV Projects consulted and/or visited

1000+

1000+
Factory Audit Conducted

300+

300+ GW
Of PV Production capacity evaluated

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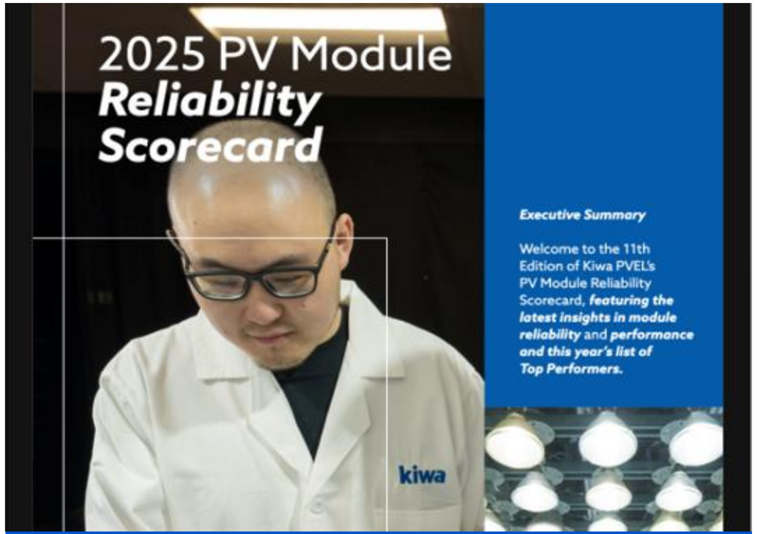
Our ***Market Intelligence*** reports for the industry



Kiwa PVEL Reliability Scorecard

Kiwa PVEL's Product Qualification Program (PQP) is a key tool for mitigating PV module procurement risk by transforming industry-leading bankability testing into procurement intelligence.

PV Modules Manufacturing Quality Report by Kiwa PI Berlin

Key trends, risks, and quality insights shaping the solar energy landscape.

CRU Data, Insight, Strategy & Communities

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The global demand outlook is weakening, while tariff uncertainty continues in the US

In the US, tariff uncertainty will persist until the resolution of the polysilicon Section 232 case – likely late 2025 or early 2026 – while the outlook for availability of AD/CVD-free cells remains tight. In China there is ongoing tension between a soft demand outlook and strong sentiment around government intervention; spot prices have risen, but more concrete actions will be needed to sustain this trend

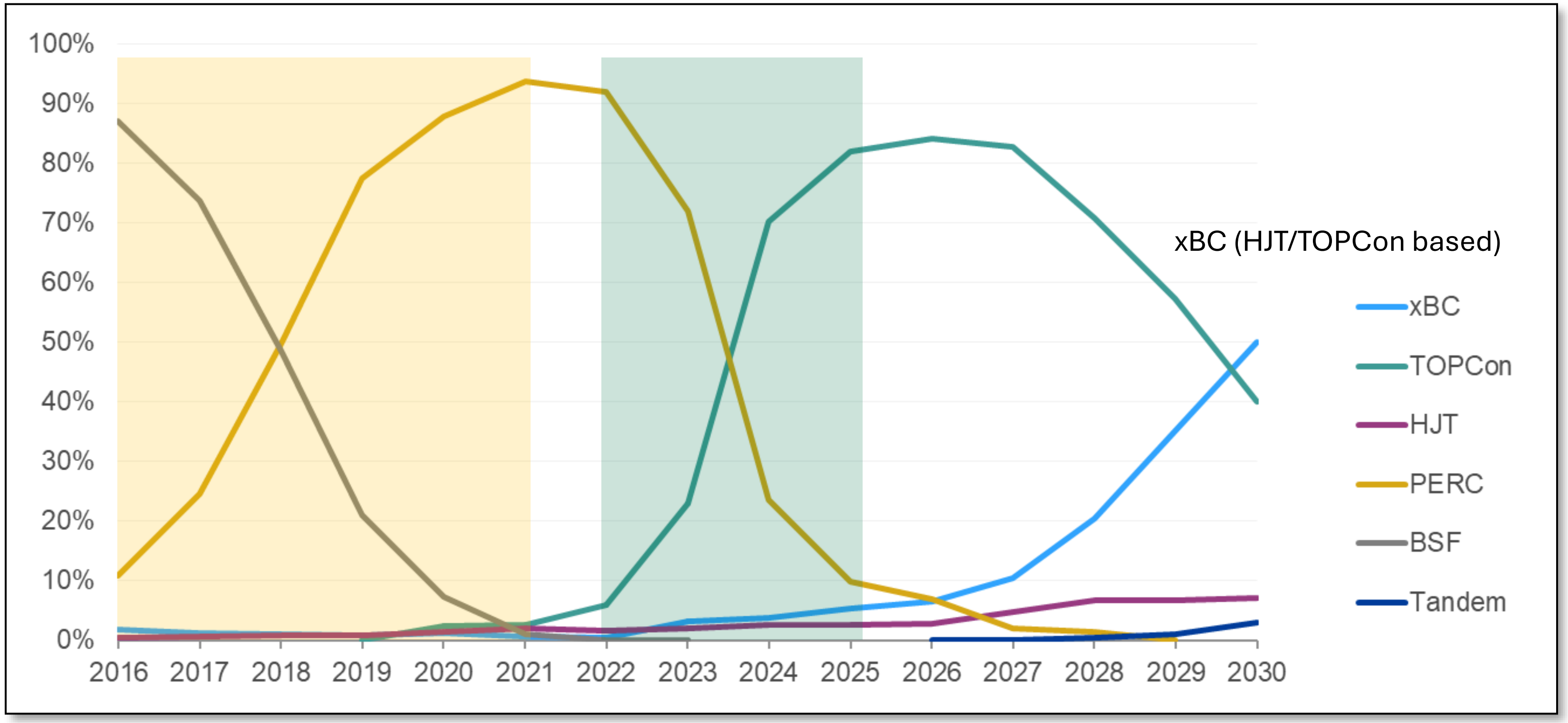
CRU. Independent *expert* intelligence

Solar Technology and Cost Service

Solar Technology and Cost Forecast (STAC) Report

In cooperation with CRU – Independent Expert Intelligence

Cell Technology Advancements



Source: CRU/Kiwa PVEL's Solar Technology and Cost (STAC) Report – Q3'25

Market Shift in PV Cell Technology

- Regulatory policies, new online production capacity, and evolving BOM supply chains result in **constant change** globally for PV module manufacturing.
- Market shift happening very fast toward new cell technologies, **TOPCon** is leading the transition and is projected to dominate the near term; share depends on year and forecast scenario.

Emerging Risks

- **Compressed technology lifecycle** → Higher risk of undetected reliability issues before mass deployment
- **LETID in PERC** modules emerged unexpectedly, causing post-installation performance losses.

Managing Quality **Over Time**

- **Kiwa** maintains a **decade-long findings & defects database** covering 125+ manufacturers, enabling industry-wide benchmarking of PV module manufacturing quality.
- Graph reflects consolidated defect ratios across all inspected factories, providing a year-over-year view of **manufacturing quality trends**.
- Rising BOM-related quality issues are also evident in **Kiwa's PQP/lab testing,** where there is a clear uptick in BOM PQP failures.

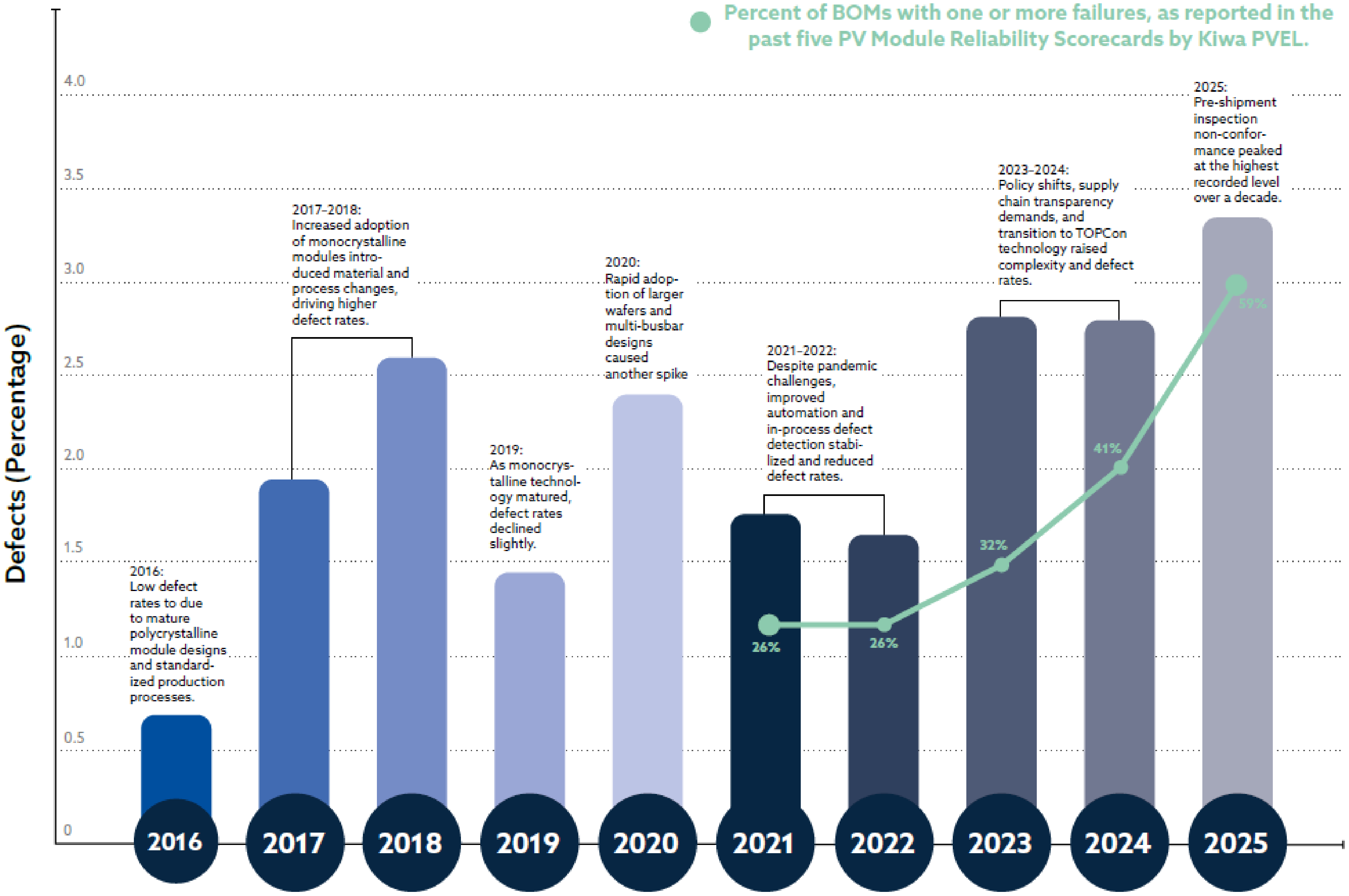


Figure 1: Manufacturing Quality Over Time

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Managing Quality
Over Time

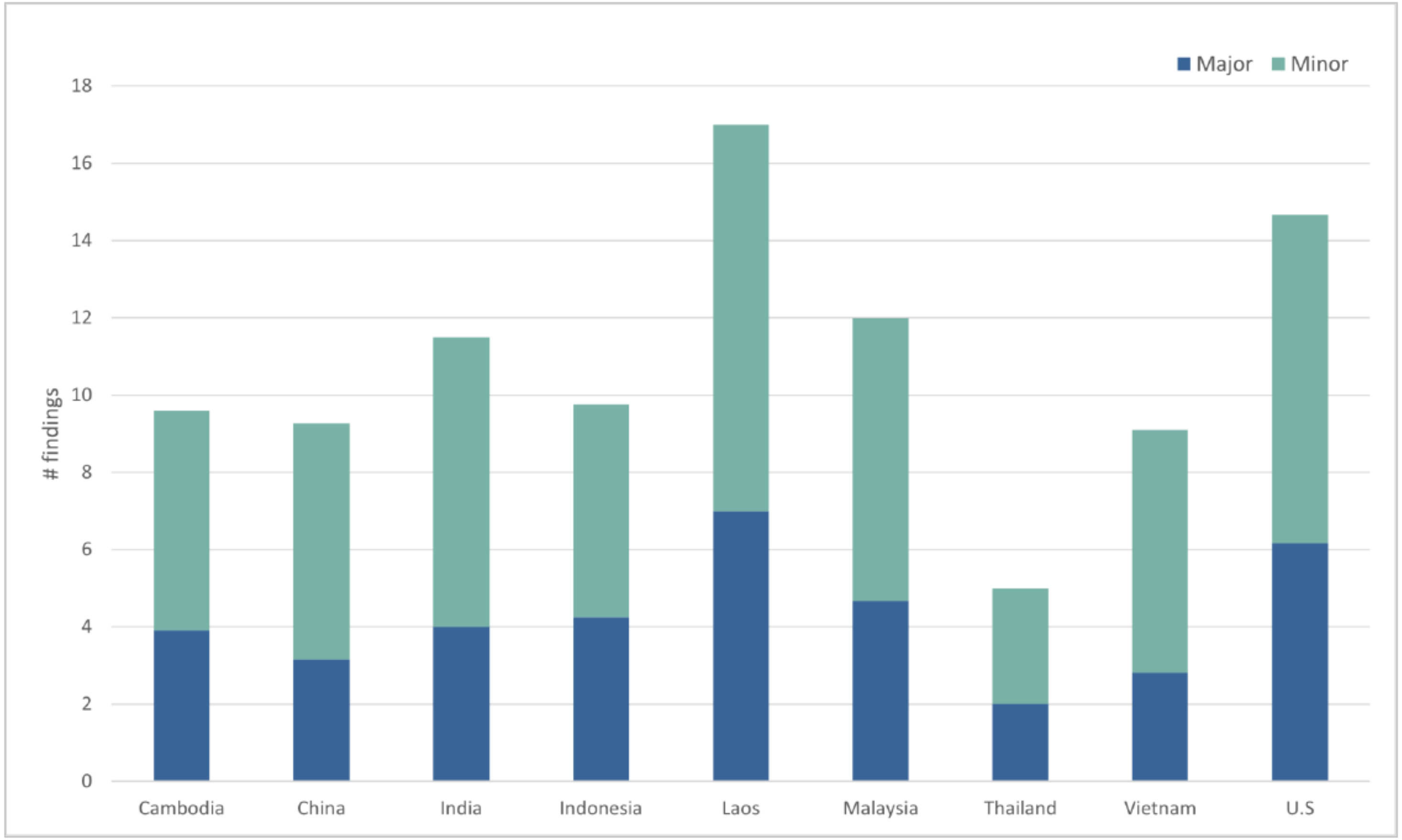
- **Kiwa** maintains a **decade-long findings & defects database** covering 125+ manufacturers, enabling industry-wide benchmarking of PV module manufacturing quality.

Kiwa PV Module Testing Labs
- Napa (California)
- Berlin (Germany)
- Suzhou (China)

2025 Audits

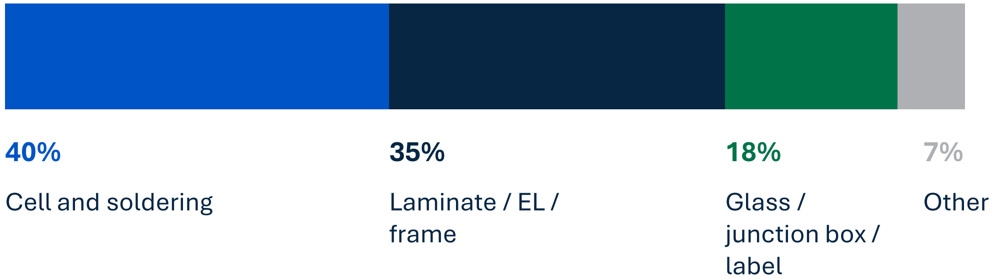
Previous years Audits

Results Vary by Time & Place

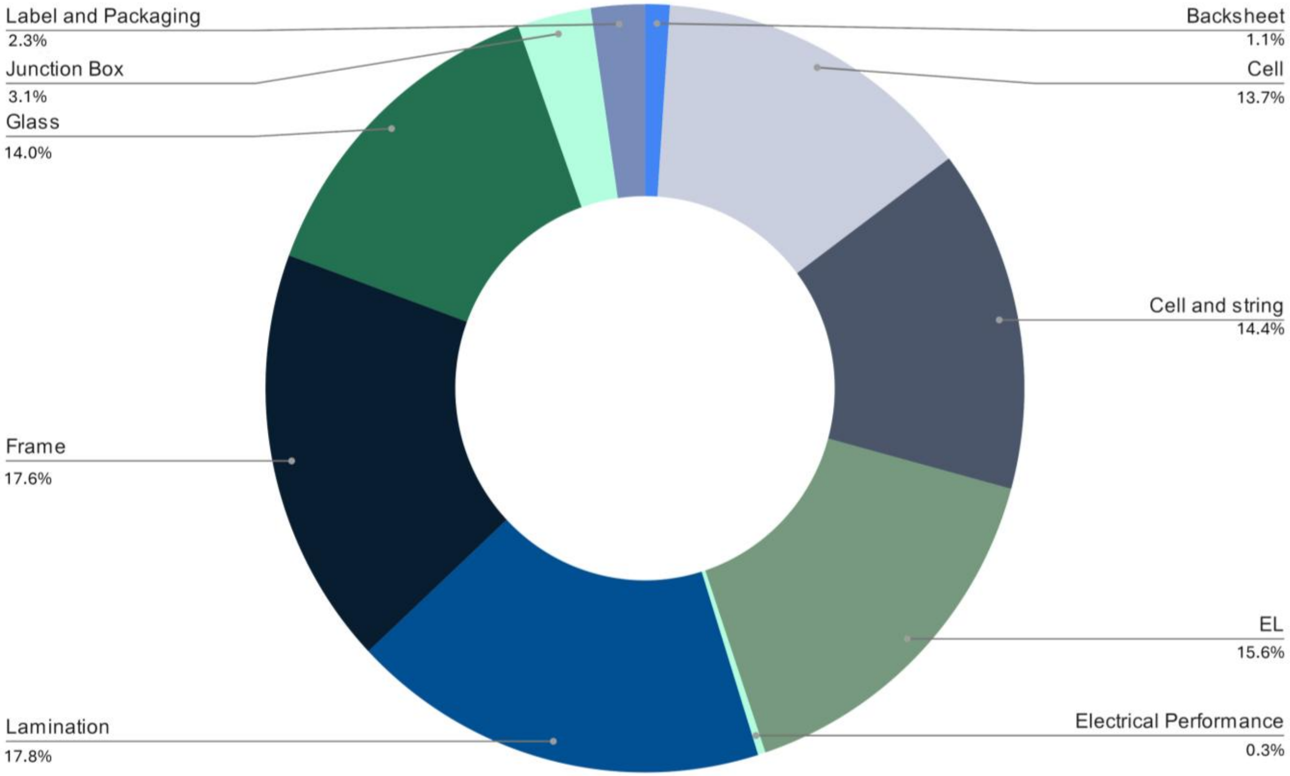


- Higher number of findings in factories located in **recently developed PV manufacturing hubs**, such as the U.S, Laos, and India.
- Common quality findings identified in these factories include insufficient training for the equipment operators, poor equipment conditions, material mishandling.
- **Significant variation among different factory locations**. While the overarching QMS framework is consistent, the implementation of quality control measures can vary significantly. This variation underscores the importance of assessing each facility.

Defects Distribution
during factory Inspections



- **Nearly 40%** of defects are related to **cell processing** and **soldering**.
- The ratio of these findings has **increased** due to the **introduction of new cell and module technologies**.
- Earlier Kiwa data showed higher **TOPCon** defect rates than **PERC**, especially in soldering, rework and layup.
- More recent 2026 data indicate that **TOPCon** lines are improving as process control and production experience matures.
- Challenges with Emerging Technologies



Overall defects distribution during factory inspections

Defects Distribution
during factory Inspections

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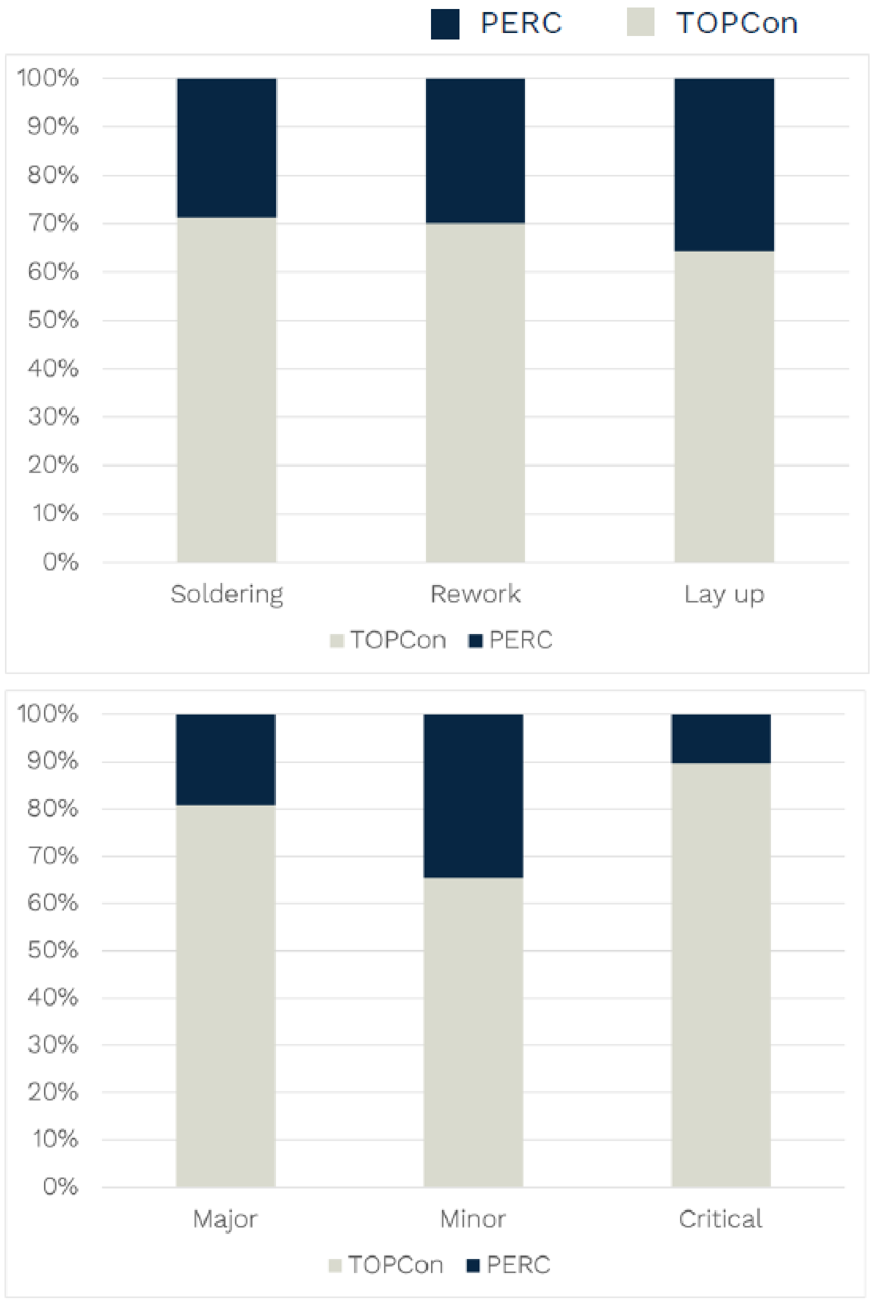


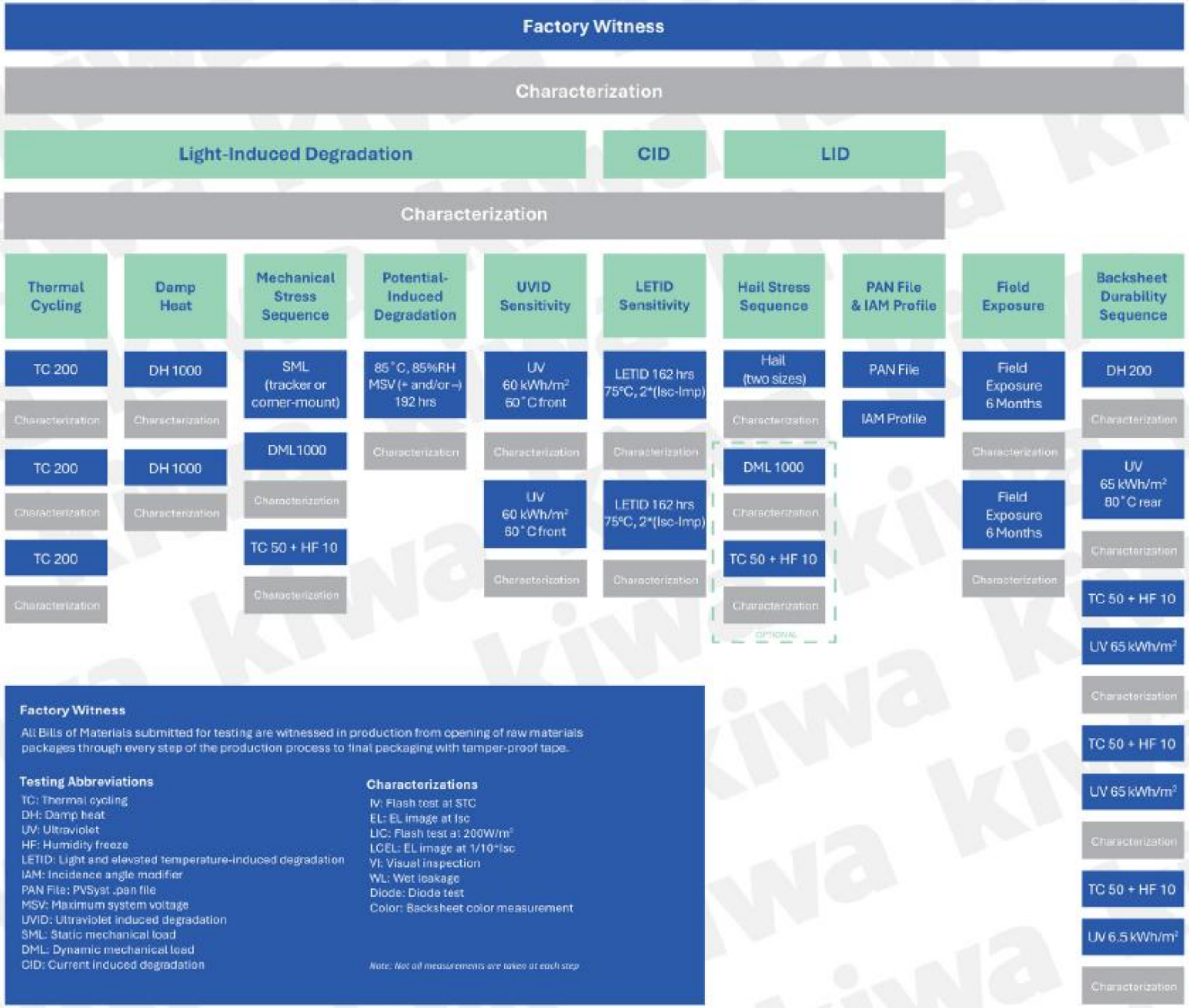
Defect ratios by cells type

Risk Mitigation Actions

- Tight soldering recipe control
- Machine-condition monitoring and calibration
- Operator training and rework discipline
- Facility-specific assessment before approval

Product Qualification Program

- **Kiwa PVEL's Product Qualification Program (PQP)** and **Scorecard** are the global solar industry's trusted resources for PV module reliability and performance data
- To earn Top Performer status, model types made from unique sets of bills of materials (BOMs) need to meet or exceed the stated criteria for that particular PQP test.



TOP PERFORMER 2025
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PV MODULE RELIABILITY SCORECARD

PQP architecture: from BOM definition to reliability intelligence

Top Performer status is BOM-specific: unique bills of materials must meet or exceed the criteria for each PQP test.

TC	DH	MSS	HSS	PID	LID	UVID	PAN
Thermal Cycling	Damp Heat	Mechanical Stress	Hail Stress	PID	LID + LETID	UVID	PAN Perf.

1. **BOM definition**
   Unique material set
2. **Factory witness**
   Build verification
3. **Lab stress tests**
   Extended stress sequence
4. **Scorecard intelligence**
   Procurement action

TOP PERFORMER 2025 kiwa PV MODULE RELIABILITY SCORECARD

2025 reliability outcomes
Failures are not isolated edge cases

Not all modules perform equally; failures increased across manufacturers and BOMs.

83%
Manufacturers had at least one test failure

59%
BOMs had at least one test failure

19%
BOMs experienced power-loss-related failure

20%
BOMs experienced failure in mechanical load testing

Failure modes

DH 2000	10% of BOMs; 19% of manufacturers
Hail	15% of BOMs failed
PID	9% of BOMs failed
J-box	~1/3 of manufacturers had at least one junction-box-related failure
UVID	UVID is an emerging BOM-specific risk for n-type technologies; validate it through extended qualification testing, not certification alone.

Failure composition

Visual inspection major defects	60%
Power degradation failures	21%
Safety / wet leakage failures	7%

Technical interpretation

The dominant failure category remains “visual inspection”, driven by breakages and mechanical defects; power-loss failures are increasing with UVID inclusion and PID/TC/DH/MSS mechanisms.

2026 PV Module Reliability Scorecard

12th edition · coming soon

The new Scorecard will bring updated evidence on module quality and reliability under real-world stress conditions.

Launching May 27, 2026

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What to watch next

UVID & metastability

Emerging BOM-specific degradation risk for n-type technologies; validate through extended qualification testing, not certification alone.

Delamination & lamination

Track moisture- and process-driven defects linked to encapsulant selection, lamination recipe and edge stability.

Mechanical robustness

Treat glass breakage, frame damage and hail response as bankability issues under field-relevant loads.

Conclusion

Bankability controls for fast-evolving PV technologies. Kiwa’s publications converge on a control stack: qualify the BOM, audit the facility, control changes, and verify performance.

1. Define procurement envelope

Require BOM-level qualification, not generic product-family qualification.

2. Verify factory execution

Perform facility-specific audits, corrective action tracking and pre-shipment inspection.

3. Control changes

Treat BOM changes, production relocation and new lines as risk triggers.

4. Test independently

Use PQP / lab tests to validate reliability under stress conditions.

5. Monitor in field

Confirm baseline health at delivery and optimize post-installation performance.

Continuous Quality Assurance*

***NOTE:** Pre-Shipment Inspection, Acceptable Quality Limit-based sampling, and batch testing bridge factory QA and shipment acceptance, confirming that the approved BOM and production process are consistently delivered before the realization of the project.


Let's work together
To make it happen.