

How to make the right inspection decisions for solar assets

From the factory to the field

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Company Snapshot



Intertek CEA (formerly Clean Energy Associates), is part of Intertek, a leading Total Quality Assurance provider to industries worldwide, and has a presence in **15 countries**.

Our focus lays on **Solar and Storage**, covering all components from factory to field in its **5 business units**:

- Supply Chain Management
- Quality Assurance
- Engineering Services
- Market Intelligence
- ESG & Traceability

85+

Countries served

280+ GW
65+ GWh

Project experience

350+

Solar/storage factories engaged globally

We are an
intertek
company

12,000+

Auditors, inspectors,
technical personnel

45,000

Employees

340,000+

Inspections and other
technical visits per year

1,000+

Labs and offices



aerial pv
inspection

25 GW+

Drone Inspection

3 GW

PV assets analyzed for EL anomalies

25+

Countries served

1st

To take EL on drones

Aerial PV Inspection GmbH (AePVI) specializes in high-resolution, high-volume electroluminescence measurements in various PV system designs (ground mounted, roof, facade, floating PV) with the necessary sensor platforms such as drones, tripods, multicam systems or cranes/special applications.

Combined electrical and image-based measurements (VI, IR, UV-FL, etc.) using proprietary hardware and AI software applications form the basis for inspecting and analyzing module quality from the factory to the field.

- Evaluation of factory images
- On-site incoming goods inspection
- On-site commissioning
- Damage assessment



+



aerial pv
inspection



Exclusive Partnership

Global Scale + Cutting-Edge Technology

- 85 countries, 350 factories + AI powered inspection innovation

Factory-to-Field Quality Traceability

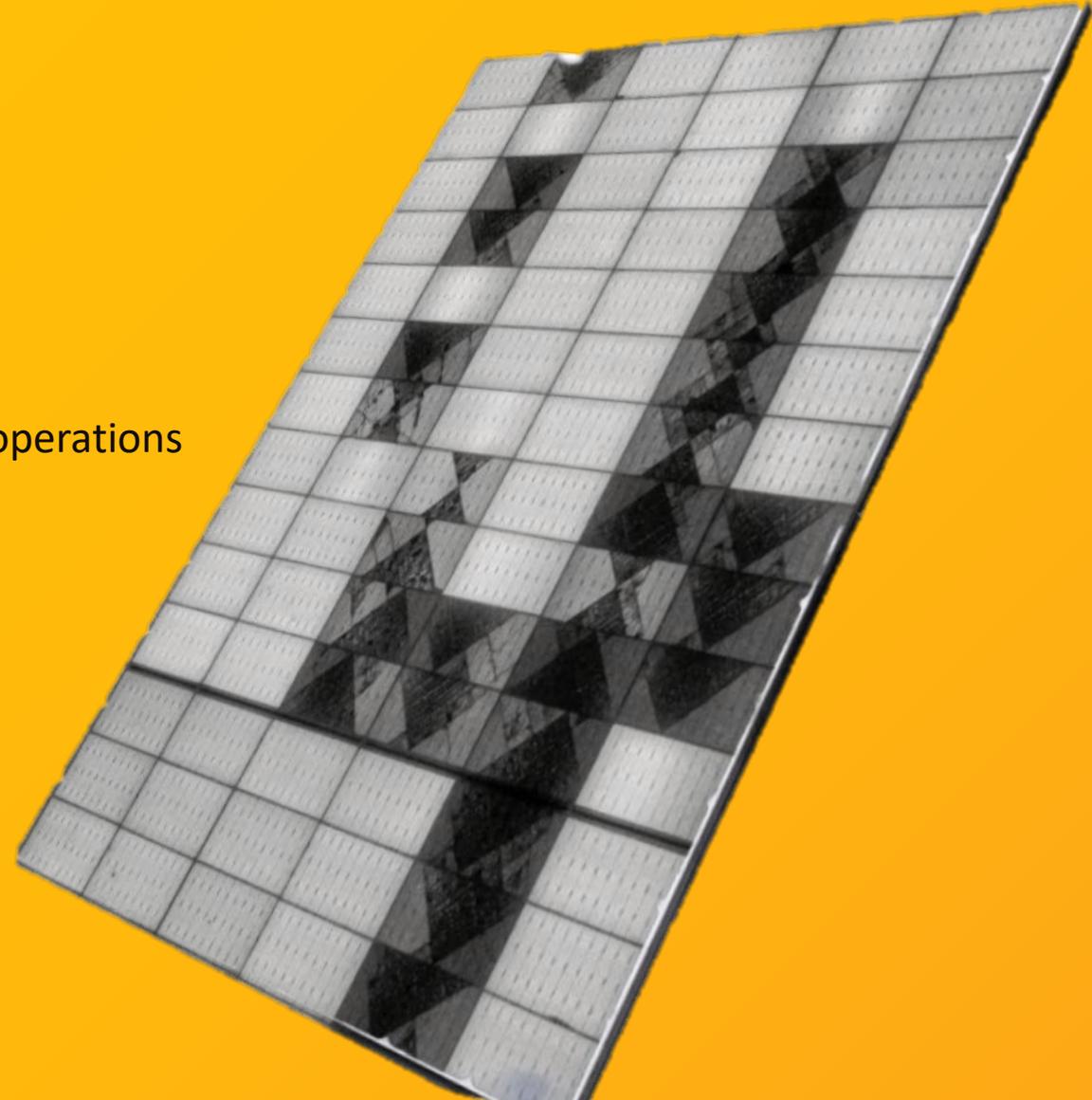
- Complete module lifecycle intelligence from manufacturing to operations

Technology Leadership

- Drone, ground-based, and multi-camera EL systems
- AI-powered image analytics and defect detection

Market-Leading Experience

- 280 GW project QA + 25 GW+ drone inspections
- 25+ years combined company experience



you'll be amazed where you find **intertek**

Market Requirements



Commissioning and Warranty Claims

Compare factory, post-shipment, and on-site EL images to pinpoint responsibility and support claims.



Due Diligence

Reveal hidden issues before asset acquisition or refinancing. Representative sample of full site inspection.



Insurance Documentation

Capture evidence post storm or hail with precision imaging techniques and reliable classification of the defects. Support warranty disputes with irrefutable evidence.



Degradation Monitoring

Perform repetitive inspections to track defects over time to proactively manage risk.

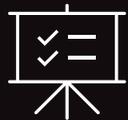


Stakeholders with Different Needs



EPC

Will usually be asked to have some testing done and will do what the contract requires to be done.



Developer

Needs to be assured suppliers and EPC adhere to specifications, warranties and deliver as promised.
Needs to hand over worry-free asset.



Buyer / Investor / Owner

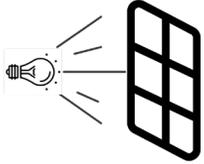
Is interested in performance and safe operation throughout the lifetime or at the time of purchase.
Needs piece of mind.



Insurer

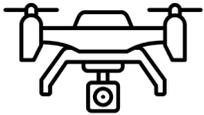
Requires undisputable evidence of damaged goods or assets through.

Providers Propose What They Are Best At



Test Laboratories

Naturally offer testing, sometimes mobile lab solutions, with a focus on performance and accuracy in controlled environment.



Platform Providers

Will typically push for thermal scan (IR testing) as that's what they can scale and easily operate globally.



Electroluminescence Inspection Firms

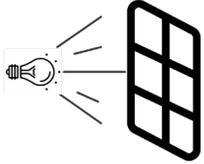
Will propose EL as the tool of choice and often recommend sample sized that fit their methodology.



Electrical Expert

Will offer comprehensive performance review and fault finding through site measurements.

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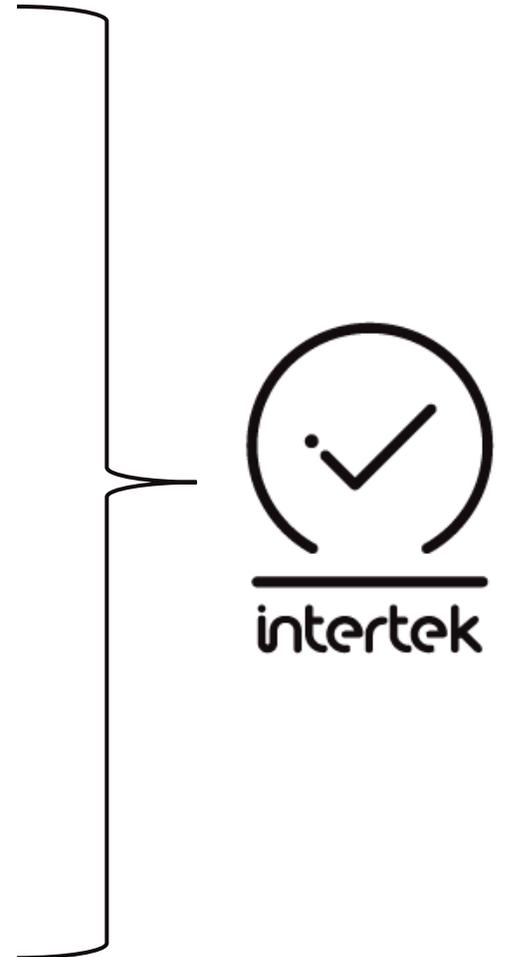
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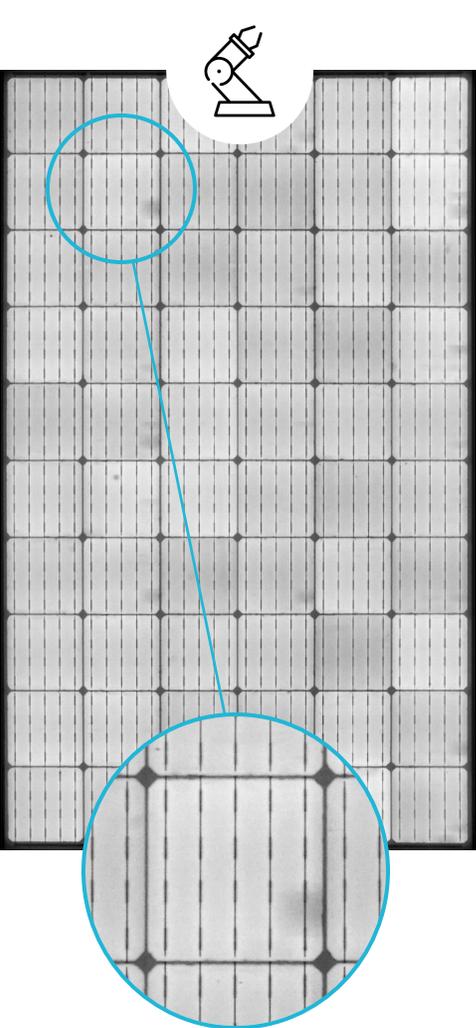
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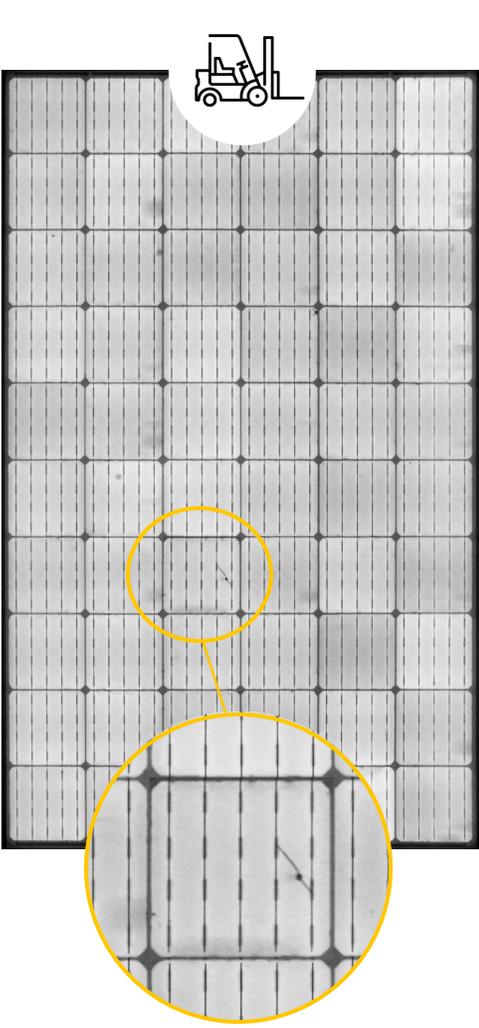
PV Module Stresses



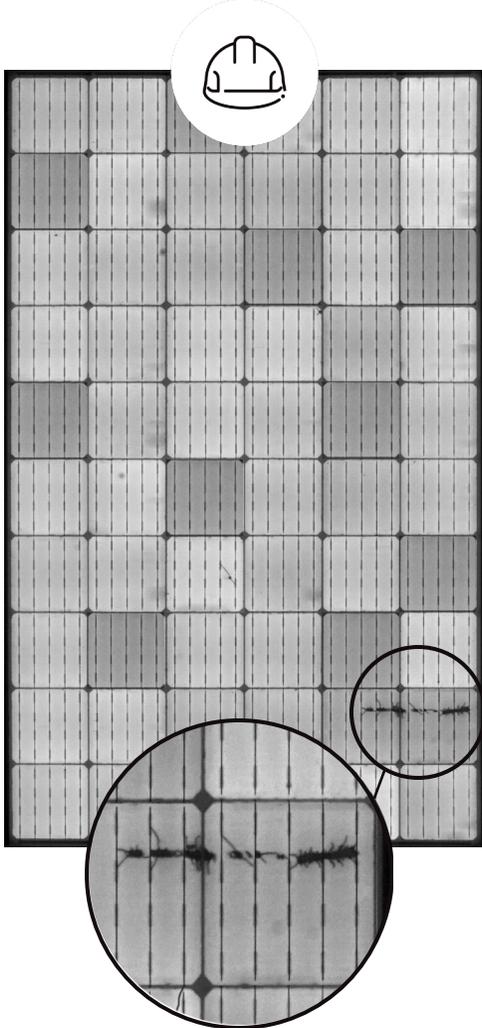
Production



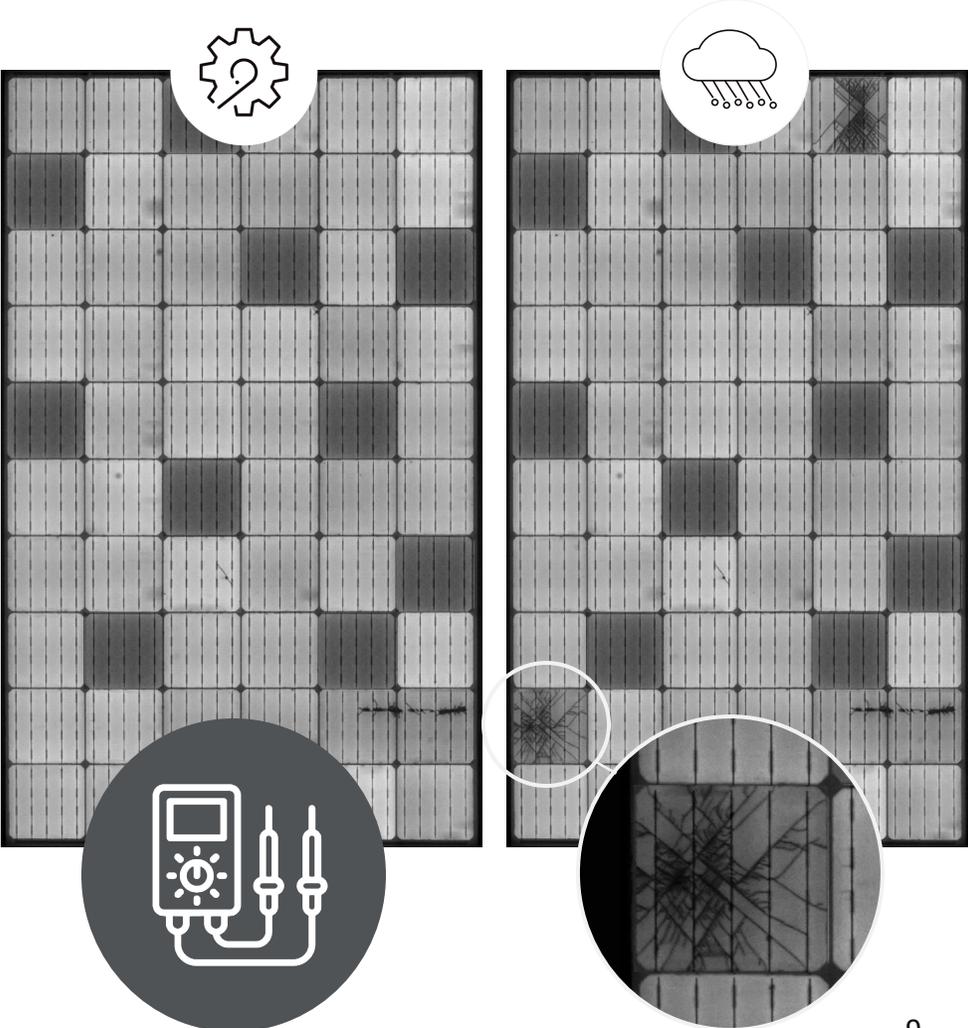
Transportation



Installation



Operation, Maintenance, Event response

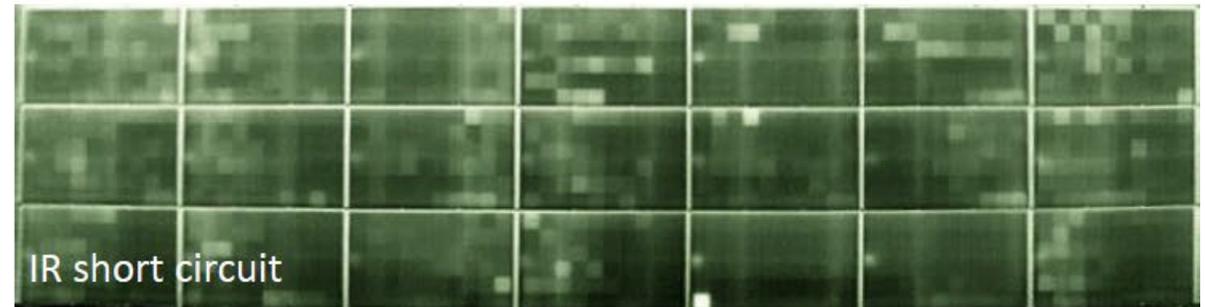
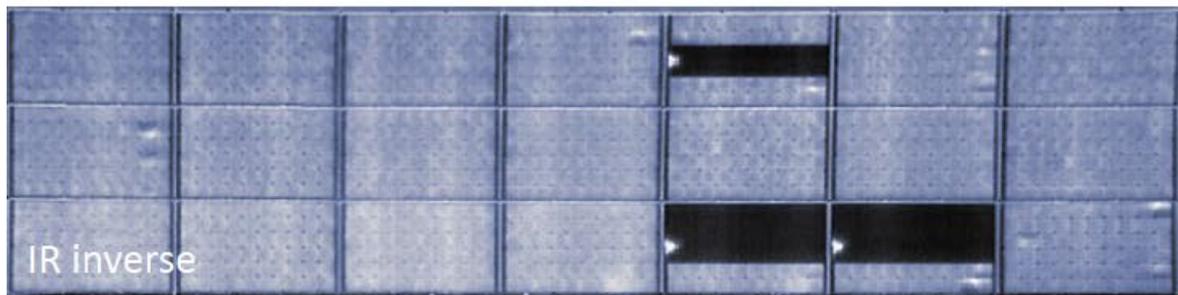
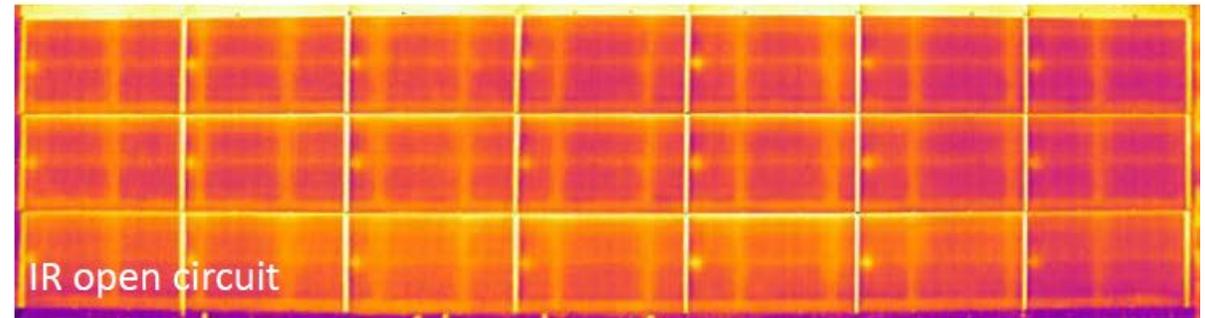
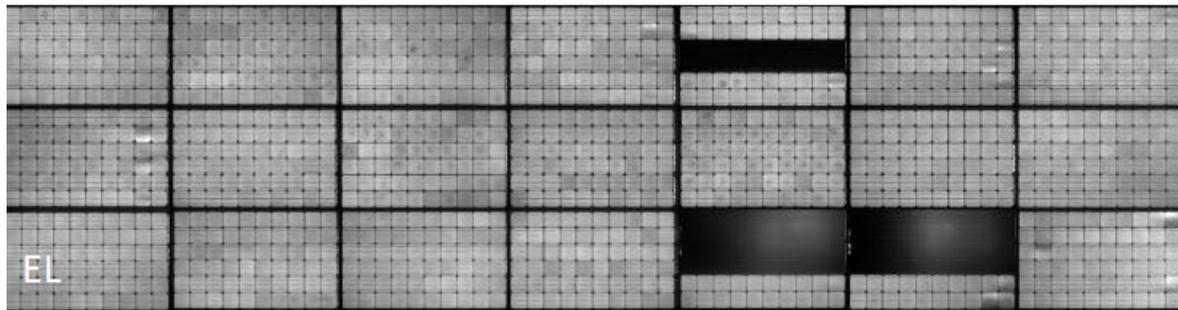
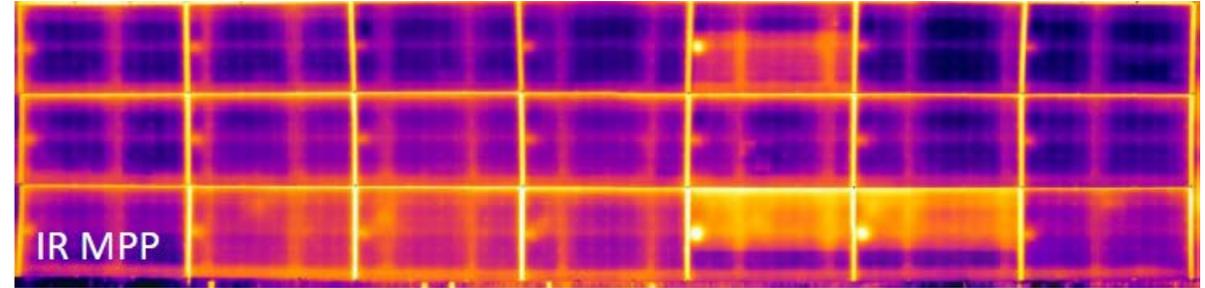


What Inspection Method is the Right one?



Video

What Inspection Method is the Right One?



Choice of the Correct EL Platform



EL Tripod

- Single module recordings
- Up to 200 modules per night
- Flexible and lightweight; easy to take on a plane



EL Multi-Camera System

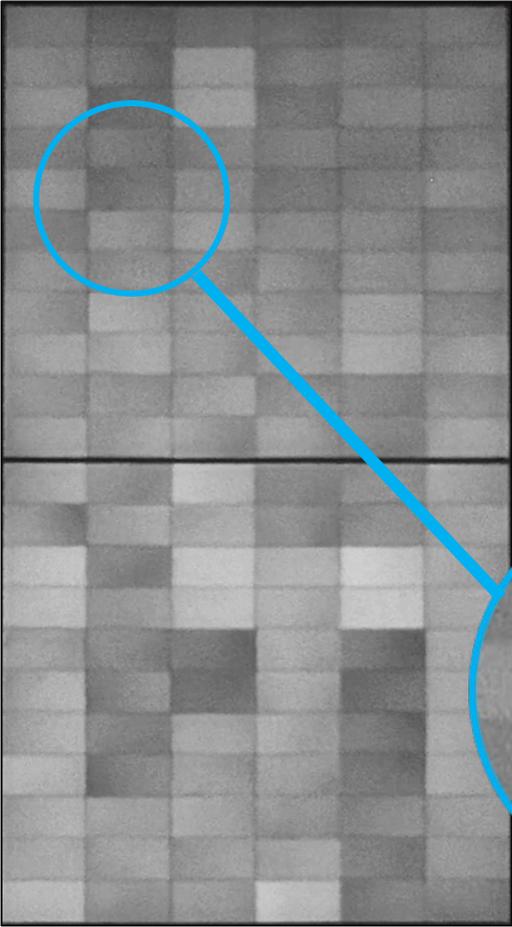
- Parks with more than one module row
- Up to 10 cameras
- Highest resolution / image quality
- Thousands of images per night



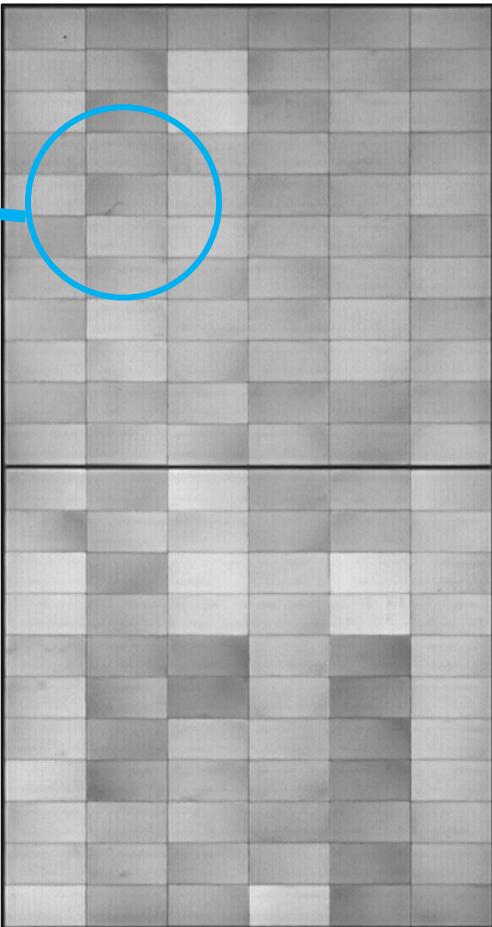
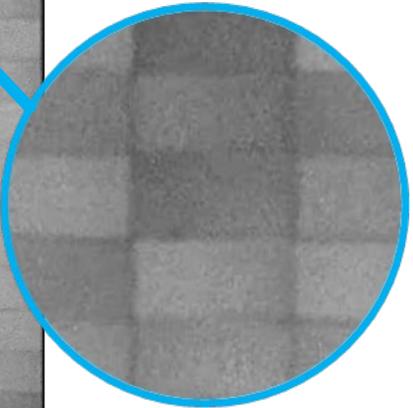
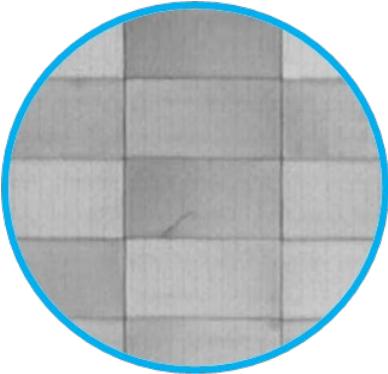
EL Drone

- Roofs, facades or floating PV
- Flight permit is required
- Weather dependent (temperature and wind)
- Higher altitude flights for overview

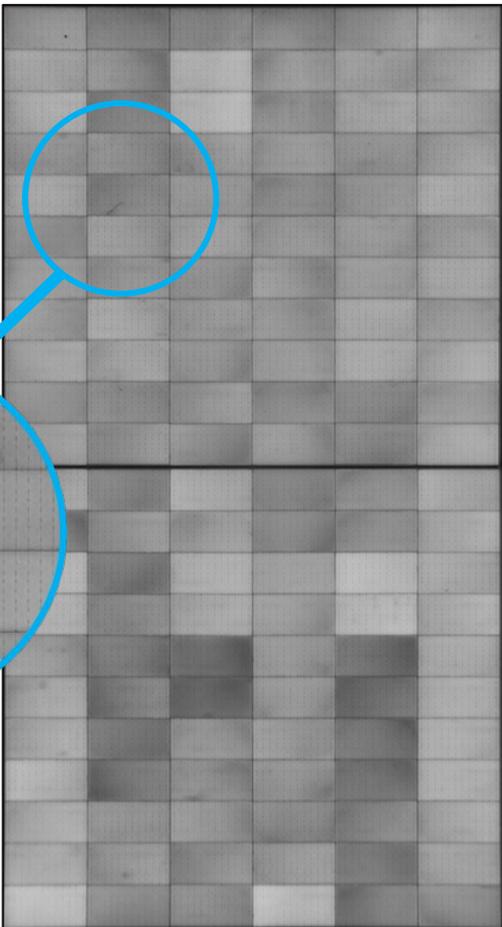
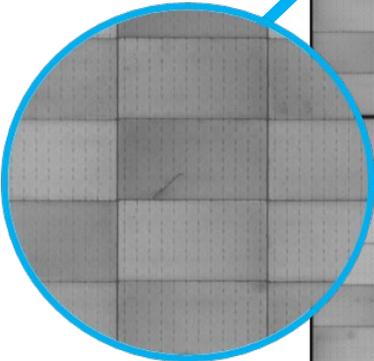
EL Image Quality



EL- Fast Scan*



EL- Drone*



EL- Tripod*

*The quality may vary depending on the module type and measuring conditions.

Powering Up The Modules / Strings



Module-level Power Supplies

- Light-weight at 70V/15A
- Easy and safe to operate
- Adjustable for each module, if needed



String-level Power Supplies

- Operational before inverters or transformers are on site
- Independent of equipment type (inverter, combiner box type)
- Enables additional testing (e.g. Lost Bypass Diode, insulation test)

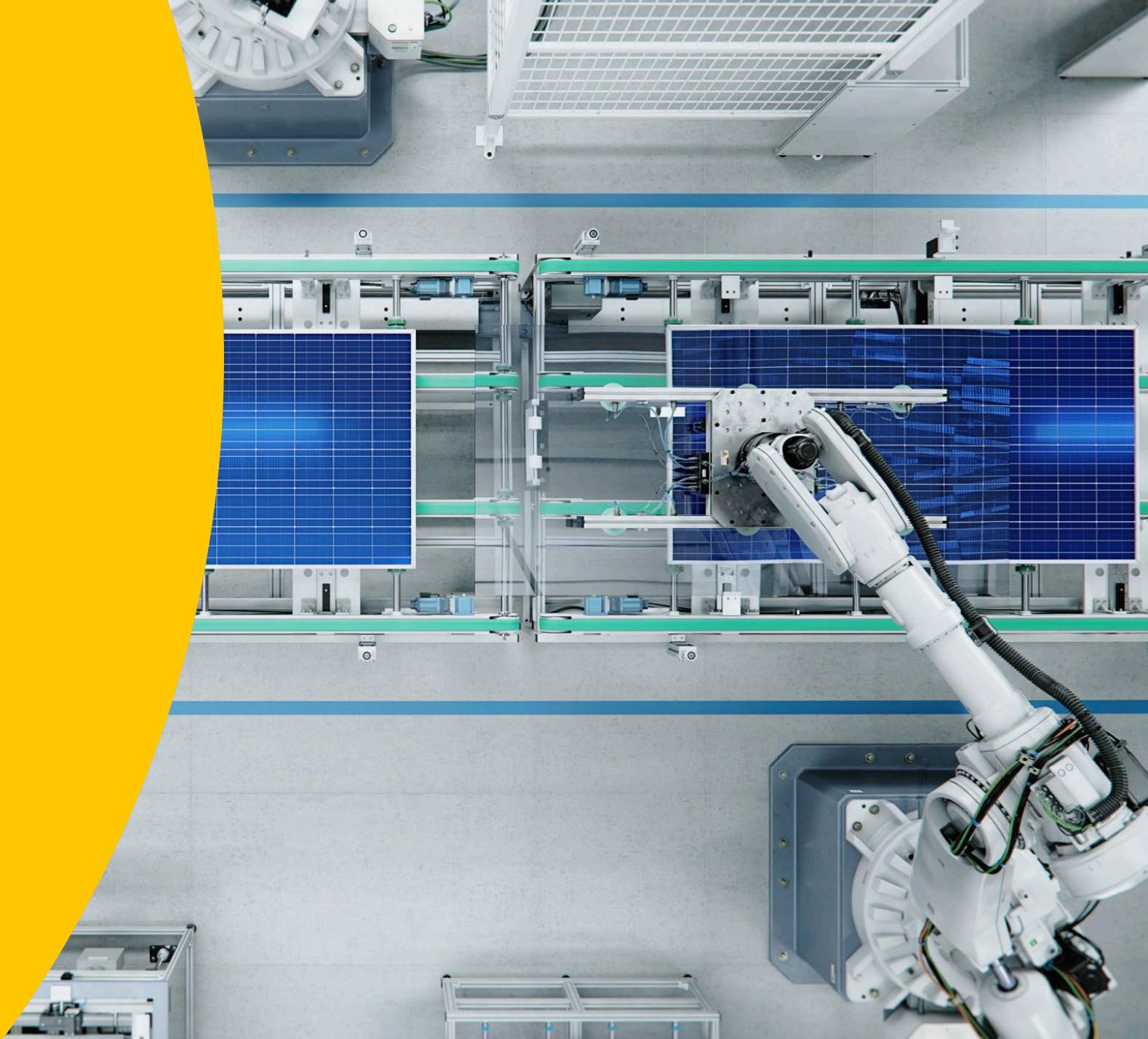


Inverter Back-feeding

- Few new type inverters have back-feeding functionality
- Requires $>1,500\text{ V} / 10\text{ A}$
- Very fast and efficient way, but limited to new assets with certain hardware

Factory

Pre-Shipment Inspection (PSI)



Pre-Shipment Inspection

Purpose: 3rd party verification of modules meeting specifications (sample based)

Industry practice:



Flasher / IV curves



Visual inspection



Electroluminescence testing



Hi-Pot or insulation test



ISO 2859 AQL level sampling based on pre-agreed acceptance criteria

Consider:



100 % independent factory EL image review powered by AI



Soldering Issues

The Weak Point in every PV Module

Industry standard:

- 100 % inline inspection through AI powered camera systems.
- 100 % IV-curve and EL testing.

The problem:

- Neither EL testing nor power testing in the factory will identify a solder joint that is imperfect.
- If the contact is there, current will flow.
- Very small failure rates (e.g. $< 0.1\%$)
- No currently applied inline test method that will find bad soldering connections that come loose over time.

Result:

- Remaining risk for thermal events in several modules per MW.



Field

Post-Shipment Inspection (SAT)

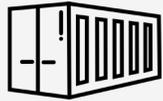


Site Acceptance Testing (Incoming Goods)



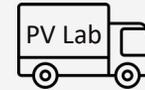
Purpose: Verify factory products and checking for transport damage

Industry practice:



Dark room / container EL test on site

Sometimes:



Mobile lab with EL/IV testing



Insufficient for power warranty claim due to uncertainty and supplier acceptance

Best practice:



Visual inspection and serial number scan



High resolution EL image



AI analytics tool for fault detection



Electrical inspection (LBPD test)



High precision lab testing in case SAT shows issues



Accurate documentation of transport damage and comparison with factory images possible.

Set aside modules for reference strings/tables ("Golden Rows")

Field

Commissioning





Commissioning / Repeat Inspection

Purpose: Detecting of production and installation damages / degradation effects (LeTID, UVID, ...)

Varying customer requests:



100 % thermography, AQL level sampling or even 100 % EL inspection

Best practice:



100 % thermography



1 % - 10 % Sample high resolution EL inspection plus serial number scan



Lost Bypass Diode (LBPDP) tests on the sample modules / strings



AI analytics tool for fault detection and verification against factory EL images



For repeat or end-of-warranty inspections involve monitoring data for targeted inspection

Measure reference strings/tables (“Golden Rows”) and compare with random samples

Field

Event Response



Event Response



Purpose: Detecting damaged modules

Customer initial request:



100 % thermography or recently 100 % EL inspection

Best practice:

The inspection needs to match the damaging event

Comparison to reference strings/tables (“Golden Rows”)



Hail: 100 % EL fast scan of the damage area



Unclear yield loss: 100 % thermography and 1 % - 5 % EL inspection, possibly IV-curve tracer and lab



Lawn mowing or cleaning robot damages: 1 % - 5 % high resolution EL inspection

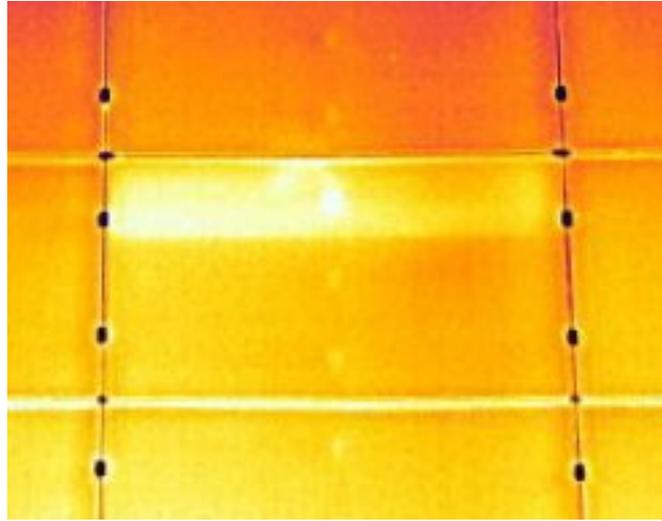
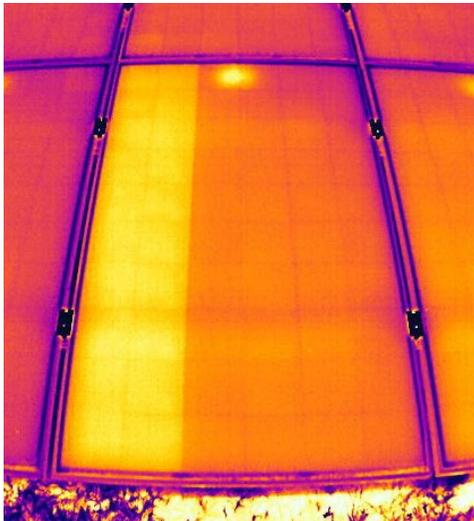


Thermal event: 100 % thermography and visual inspection plus Lost Bypass Diode and Lost Substring test

Current Faults in PV Systems

Lost Substring

- Defective or missing connection to the substring
- Loss of power
- Can be detected with thermography (IR MPP) and/or EL



Lost Bypass Diodes

- Defective or missing connection to the bypass diode
- Only showing in case of shading, not caught on standard thermal scan
- The module may start to burn
- Detect effected strings through feeding current through diodes





Questions to Ask Your Inspection Provider

Before You Commission an EL Inspection:



Define Your Objective

What's the purpose? Commissioning | Due Diligence | Warranty Claim | Post-Event Damage | Routine O&M



What Are You Looking For?

Defect type determines resolution needs:

High-res required: Manufacturing defects, microcracks, cell issues → Commissioning/baseline

Low-res acceptable: Large cracks, hail damage, PID, UVID, LeTID, obvious failures → Fast screening



System Design / Status / Timing / Location

Modules on a rack? → *1P vs. 6H has huge impact on matching inspection method*

Grid-connected? Inverters installed? → *Impacts powering method*

Weather/seasonal constraints? → *Affects scheduling & feasibility of technology choice*

Location constraints? → *Rooftop, Ground-mount, flood zone, no-flight zone*



Questions to Ask Your Inspection Provider

Before You Commission an EL Inspection:



Sample Size

100 % coverage or representative sampling? → Ask: "What's statistically valid for my objective?"



Provider Capabilities

✓ *"What technology will you use and why?" (drone, tripod, multi-camera, single module test, mobile lab)*

✓ *"How do you power strings on systems like mine?"*

✓ *"Can you compare to factory baseline data?"*

✓ *"What's included in the deliverables?"*

✓ *"How do you ensure quality and defensibility for claims?"*

✓ *"What do I have to organize?" → hidden cost*



The Bottom Line: *The right questions lead to the right inspection method—saving time, cost, and ensuring actionable results.*

Thank you!



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