Outdoor PV Electroluminescence

PV panels can have various defects which result in yield loss. They can originate from production errors, transportation, bad handling during construction or from heavy weather and vandalism.

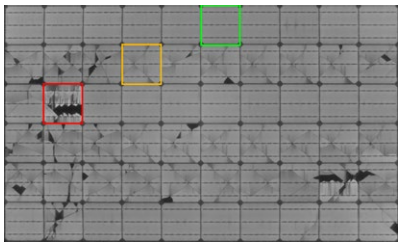
- Some important defects are virtually invisible to **visual** and **thermographic inspection methods.**
- With EL those defects are detected **before leading** to observable **yield losses** in the future and **before potential warranties may expire.**

An outdoor electroluminescence test provides a **meaningful snapshot** or **health record** of the PV modules and therefore offers a reliable solution for owners, EPCs, investors and O&M providers.

What is Electroluminescence?

Photovoltaic (PV) cells are based on semiconductor technology and generate electricity when illuminated. Similar to LEDs known from home-illumination, they emit light when an electric current passes through. This process is called electroluminescence (EL). However, as the emitted light is not in the visible spectrum, but in the near-infrared, this light can only be observed with special cameras.

Depending on the health of the electrical connections, parts of the cells will emit less or even no light. Non-active cell fragments are observed as darker spots and cracks as darker lines. The EL measurement detects otherwise invisible PV defects such as **cell cracks, contact problems, inactive cell parts, early stage PID** and **LeTID**. Often, detection and classification of defects in the EL images are automated using artificial intelligence and even large samples can be analyzed and reports created quickly.

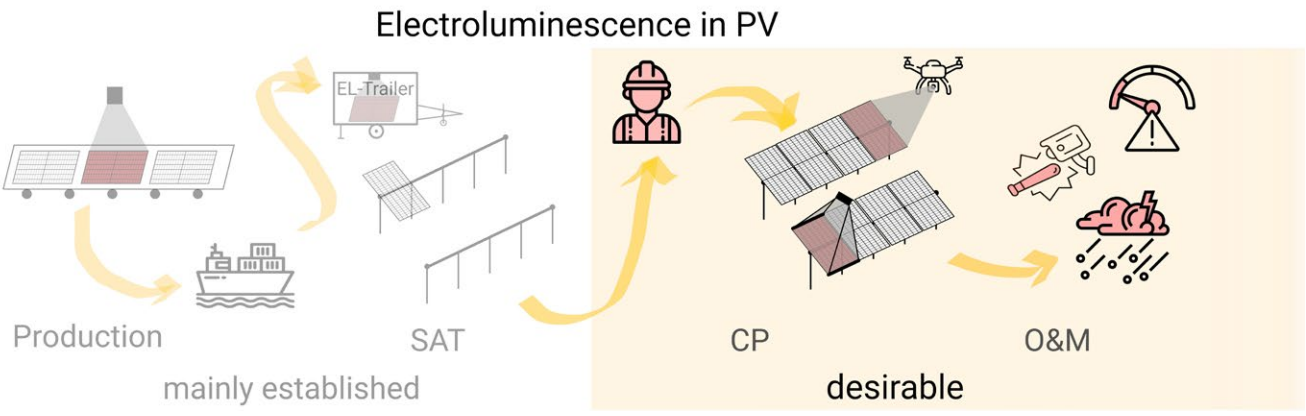


Outdoor EL image of a mono-crystalline module. Marked areas as example: red: non-active area and cracks, yellow: cell-crack, green: healthy cell (© AePVI)

What is special about outdoor EL?

Electroluminescence is the most detailed optical testing method when examining PV module anomalies and their origins. In laboratories and in assembly line quality inspection, EL is the state-of-the-art solution. For new, utility-scale PV projects, samples of the delivered PV modules are checked after arriving on site in a Site Acceptance Test (SAT) based on EL. This is usually performed in a mobile lab, housed in a trailer.

The method described here refers to the so called “on-site”, “in-field” or **“outdoor EL”**. The PV modules are observed after installation and electrical connection in their final position within the power plant. In the past, EL has been done mainly by disassembling the modules from their supports to permit testing in a trailer. This is labor intensive and carries the danger of module damaging in the process with the associated risk that the liable party for the damage cannot be assigned. Thus, outdoor EL is a cheaper and more reliable method to deliver a meaningful snapshot of the power plant’s module health.



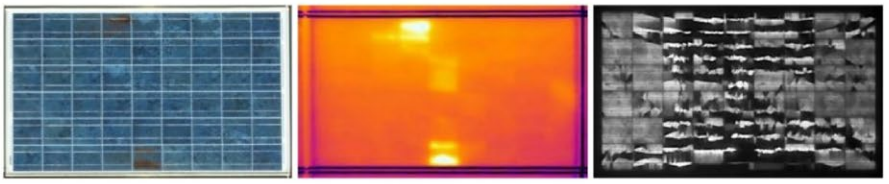
Electroluminescence quality checks after the site acceptance test (SAT) in the commissioning phase (CP) and during operation and maintenance (O&M) of the plant. Events causing defects are best investigated by outdoor EL inspections.

Electroluminescence – know the health of your assets!

Why is it important?

State-of-the-art drone-based inspection methods using standard visual and thermographic observations have made it possible to investigate large areas of PV plants in short time and at low cost. Especially thermography is a great tool to spot major faults such as lost substrings, inactive modules or hot spot pattern. However, some defects like cell cracks, contact problems, inactive cell parts, early stage PID and LeTID are almost invisible to those methods and the detection of hot spots often fails to reveal their cause. This lack of information makes standard thermography a less appropriate tool for insurance claims or commissioning measures where reliable statements are mandatory. Undetected defects may surge over time and performance losses may stay undetected during the plant's warranty time.

Currently possible
Possible in future
Not possible

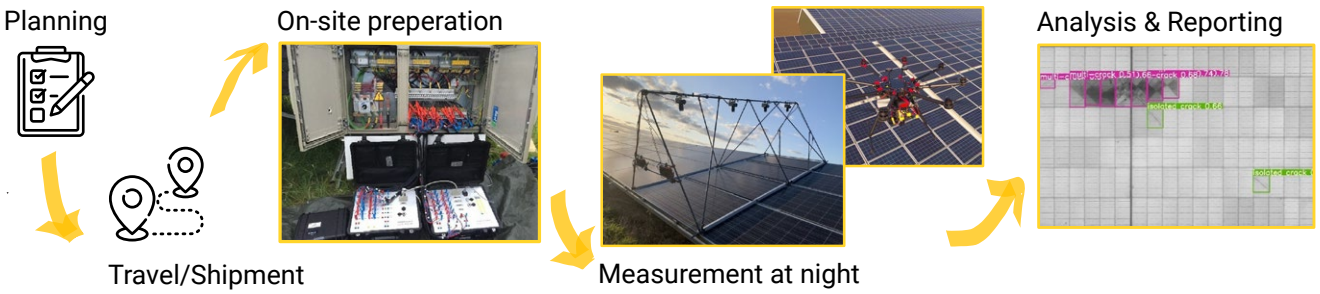


Fault	VIS	IR	EL
Glass breakage, shading and soling			
Delamination and discoloration			
Substring, module and string failure			
Cell and finger faults			
PID (also in the initial stages)			
LID and LeTID			
Cell fractures and isolated areas			
Micro cracks			

Summary of the defect detection capabilities of different inspection methods. The pictures show the same PV module seen by the three inspection methods. Where the thermographic image just shows three potential hot spots, EL unveils that actually one third of the cell area will not participate significantly in the power production (© AePVI).

How is it done in the field?

In order to offer a valuable service, it is important to analyze and adapt the measurement scope to the specific project needs. For some customers a simple thermography might be sufficient, for others a full outdoor EL is advisable. The procedure can be broken down into the following steps:



1. **Planning:** Clarification of details regarding plant design and desired scope of investigation in order to define the implementation methods and costs. Decisive factors include: plant location and size, modules, mounting and inverter technology, depth of investigation from spot testing to 100% control.
2. **Travel/Shipment:** Hardware may be shipped upfront or brough directly in the measurement trip.
3. **On-site:** Experienced staff sets up the electric current supply to power the PV strings. Since EL measurements are performed at night, they are less weather sensitive as thermography and don't interfere with production during the day.
4. **Measurement:** Performed after sundown either with tripod system or by drone.
5. **Analysis & Reporting:** The collected images are processed with an AI-based software that automatically detects and labels the faults. Results are supplied as report and/or on a digital platform.

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