Visual Inspection of PV Modules

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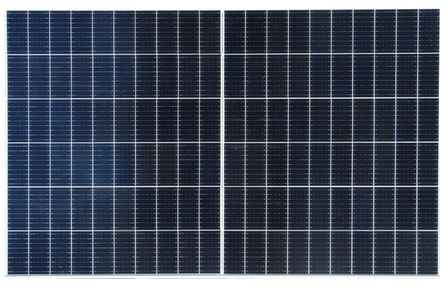
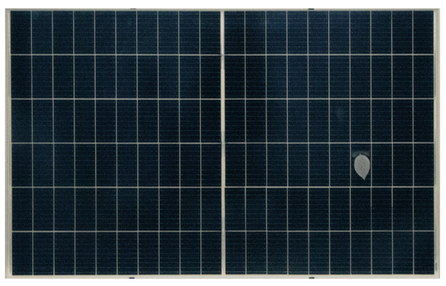
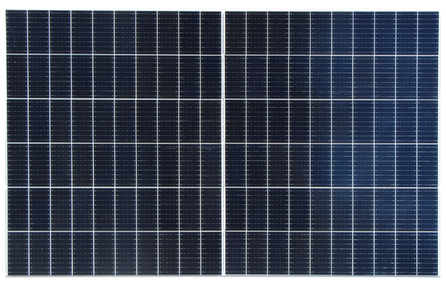
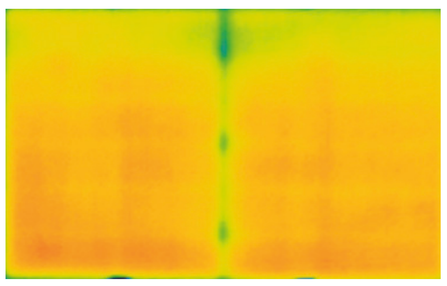
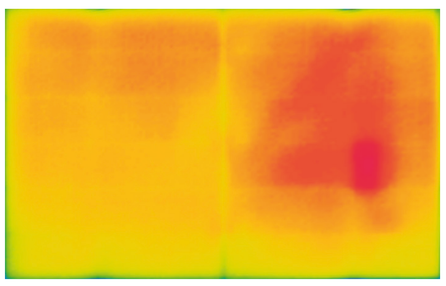
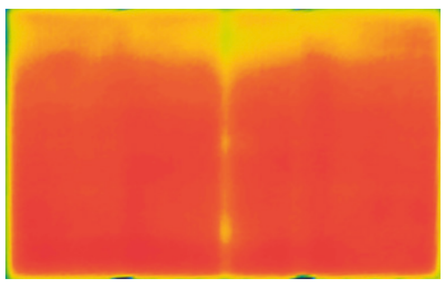
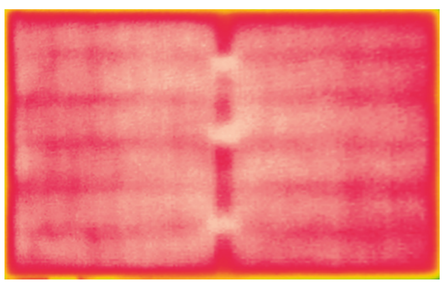
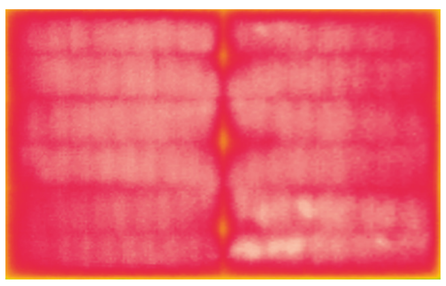
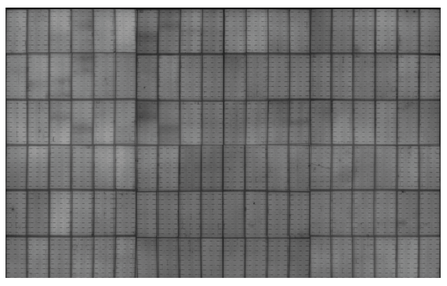
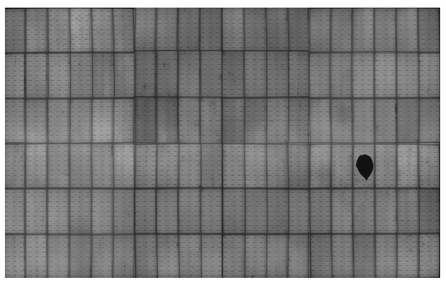
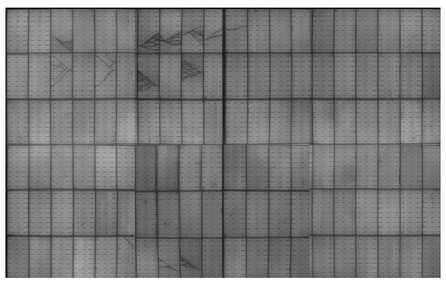
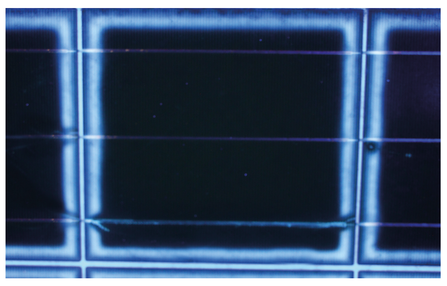
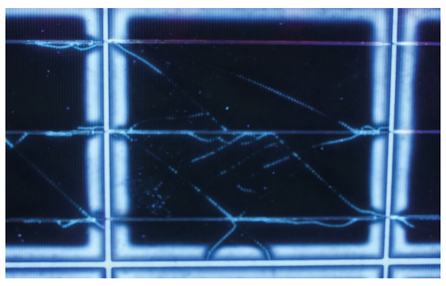
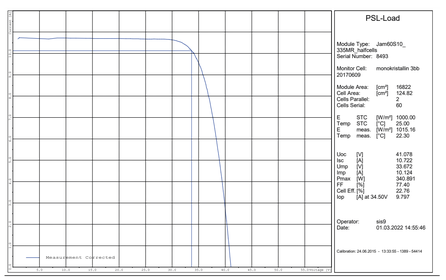
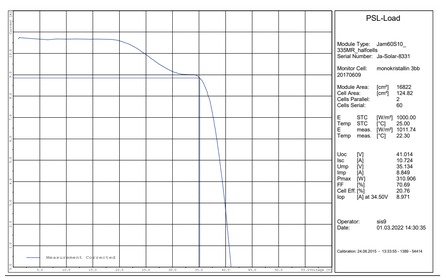
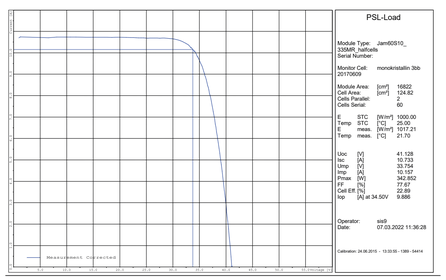
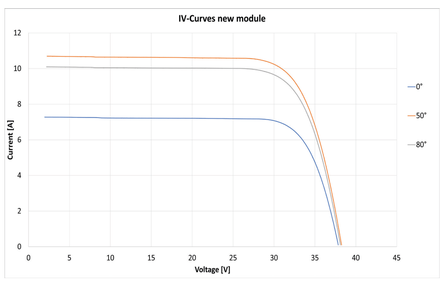
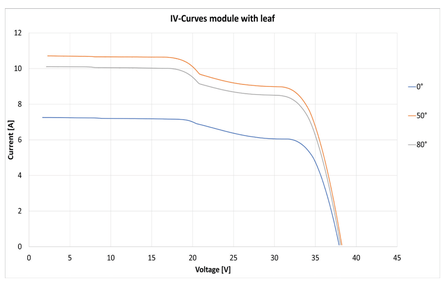
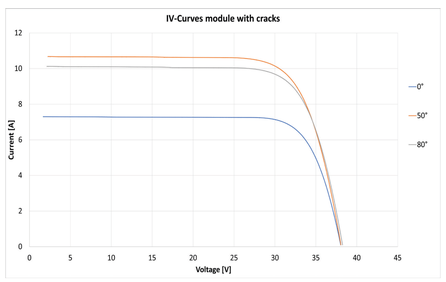
Matthias Burri, Sina Spring and Prof. Dr. Christof Bucher, Bern University of Applied Sciences, PV Lab

The state of health of a PV module can be assessed using various methods. Electroluminescence (EL), indoor and outdoor infrared (IR), UV luminescence, current-voltage-curve measurement (IV) and visual inspection are some of them. This poster compares these methods and shows the advantages and disadvantages of each.

	New module	Shaded module	Module with cell cracks
Visual			
Outdoor IR			
Indoor IR		←*Test module, intact cells* *Test module, cell cracks*→ Indoor IR imaging won't show shading, since the heat registered isn't produced by incident light but instead by the current running through the module.	
Indoor EL			
Indoor UV		←*Monocrystalline module, intact cell* *Monocrystalline module, cell cracks*→ UV fluorescence doesn't show recent cell cracks. These images show old PV modules.	
Indoor IV curve			
Outdoor IV curve			

Visual

Visual inspection of a PV module.

Advantages:
- No specialized equipment needed
- Mechanical defects with no electrical implication visible

Disadvantages:
- Most electrical defects not visible
- Not quantifiable

Outdoor IR

Thermographic imaging of a module in maximum power point (MPP) operation.

Advantages:
- No system manipulation required
- Identifies energy relevant failures
- Measurement can be done for a full system
- The modules do not have to be dismantled.

Disadvantages:
- Weather influence
- Poor accessibility to panels
- High temperature ≠ defect
- Cell cracks not necessarily visible

Indoor IR

Thermographic imaging of a module in laboratory conditions under rated current.

Advantages:
- Identifies shunts, hot spots, moisture, installation failures
- More reproducible than outdoor

Disadvantages:
- Not representative for MPP operation
- High temperature ≠ defect
- External power suppy necessary
- Low shunt and high series resistance not easy to distinguish

Indoor EL

Electroluminescence imaging of a module in laboratory conditions under DC current.

Advantages:
- High-Resolution
- Identifies cell cracks, microcracks, shunts, layer defects, diode failure, disconnected cell regions, soldering defects

Disadvantages:
- Defect origin not identifiable
- Defect influence on performance not identifiable
- xpensive laboratory equipment needed
- Modules must be dismantled

Indoor UV

Photographic imaging of UV fluorescence of a module under ultraviolet light.

Advantages:
- Shows chronology of cell cracks (photo-bleaching)
- High-Resolution
- No power supply necessary
- Modules do not have to be dismantled
- indicates thermal history of cells

Disadvantages:
- Doesn't work well on newer modules and new defects
- Defect influence on performance not necessarily identifiable
- Complete darkness needed

Indoor IV curve

IV curve tracing under laboratory conditions.

Advantages:
- Shows (partial) shading, soiling, degradation
- Shows series resistance, shunts
- Short test time
- Reproducible results

Disadvantages:
- Expensive laboratory equipment needed
- Modules must be dismantled
- On-site effects (i.e. partial shading) not visible

Outdoor IV curve

Mapping relationship between current and voltage from open circuit to short circuit electrical load in actual use.

Advantages:
- Real usage (e.g. shading) shown
- Modules do not have to be dismantled.
- Measurement can be done on module level or for a full system

Disadvantages:
- Results not fully reproducible
- Temperature correction needed
- Correction with irradiance data needed

Berner Fachhochschule

Technik und Informatik

Labor für Photovoltaiksysteme | Jlcoweg 1 | 3400 Burgdorf | Schweiz
bfh.ch | christof.bucher@bfh.ch