Task 13: Reliability and Performance

Overview of PV Module Repair Procedures

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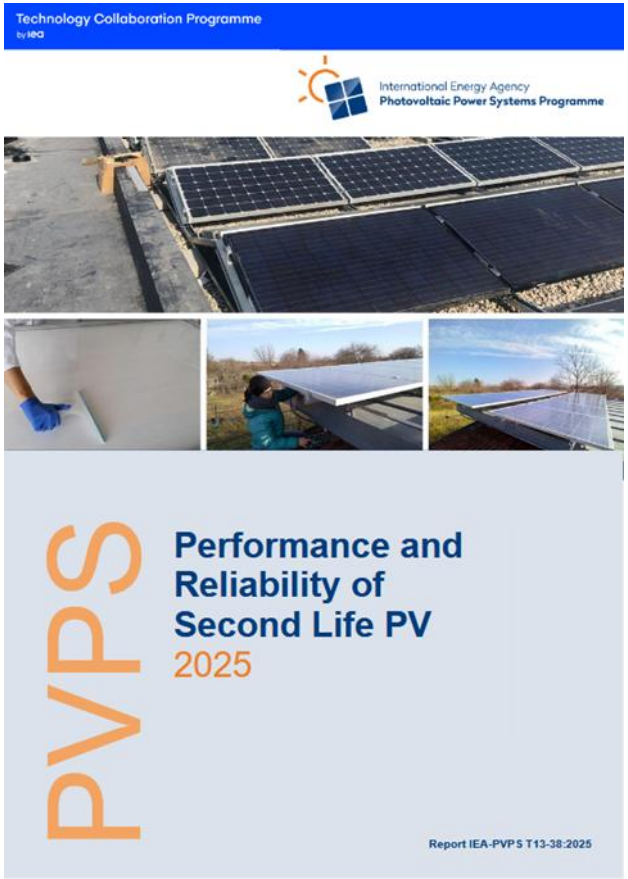
ST1.2 Report

- This work was done as part of the IEA-PVPS Task 13 Subtask 1.2 **“Performance and Reliability of Second Life PV”**
- The final report of this activity will be published until the end of 2025 and can be downloaded for free from this website:
- https://iea-pvps.org/research-tasks/reliability-and-performance-of-pv-systems/



Why? Motivations for repair of PV modules

- Numerous studies regard the repair of PV modules as a promising approach to ensure their continued **functionality** and **safety**, both up to and beyond the expiration of their warranty period
- Another advantage is the **reduction of waste**
- Overall, repair of damaged PV modules should improve of **sustainability** in the solar energy sector

On site!

What to repair?

External damage
Cracks, delamination, or junction box detachment caused by transportation mishandling, improper installation, or localized impact

Intrinsic material or design failures
degradation or failure of poorly selected componets or structural failure resulting from inappropriate module dimensions or improper racking design and installation

Debatable!

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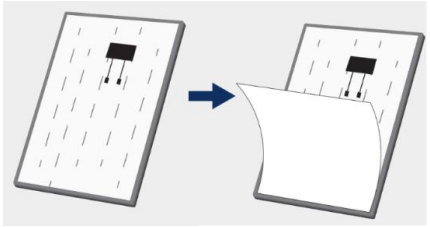
Repair of backsheets (Cracks & isolation issues)

Coating solutions

- Crack filling – restoration of wet leakage insulation
- Stops or slows down further crack growth

✓ Dow Chemical (USA / B)- Silicone based
✓ Kansai Helios (AUT) - Urethane based

Tape solutions



https://solarquarter.com/2021/08/25/moprotm-solution/

https://www.pv-magazine.com/2021/06/07/a-repair-tape-for-cracked-backsheets/

- No scientific literature on the effectiveness and reliability of repair tapes
- Biggest disadvantage: Does not fill the cracks - no restoration of electrical insulation

✓ DuPont (USA)- PVF film with pressure sensitive adhesive
✓ Cybrid (CN) - Repair tape with pressure sensitive adhesive

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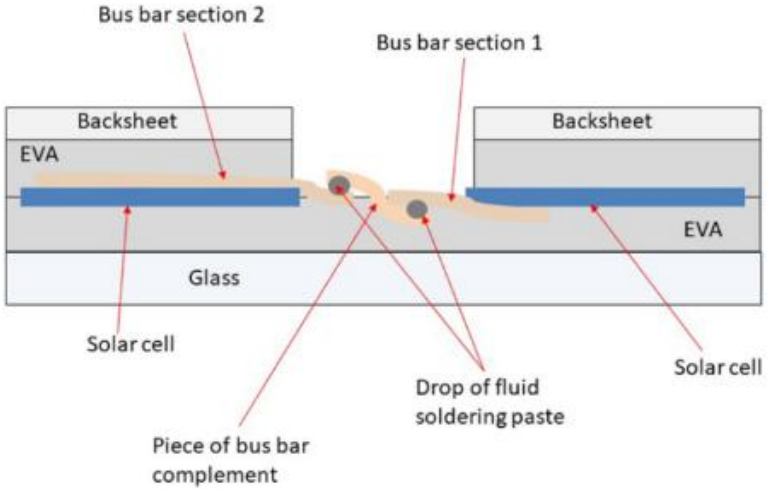
Repair of broken interconnect



Re-soldering of broken interconnects

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https://doi.org/10.1016/j.renene.2024.120012

Repair services

Several companies offer PV module repair services

In most cases, no specific information on repair approaches & quality assessment is given

Manufacturer-independent photovoltaic module repairs

Solar panels are all constructed in a similar way. This is a big advantage, as it makes repairs relatively easy. Without much trouble, broken bypass diodes, charred junction boxes, bent or cracked module frames or scratched backsheets from all types of solar panels and manufacturers can be repaired.

Repairs possible after:	Repairs possible for:	Module replication necessary:
Storm damages	Broken bypass diodes	• Broken glass
Lightning and overvoltage	Junction boxes	• Broken solar cells
Snow pressure	Module frames	• Delamination
Frost damage	Backsheets	• Other damages
Damages from animals	Module cables	
Material damage	Solar connectors	

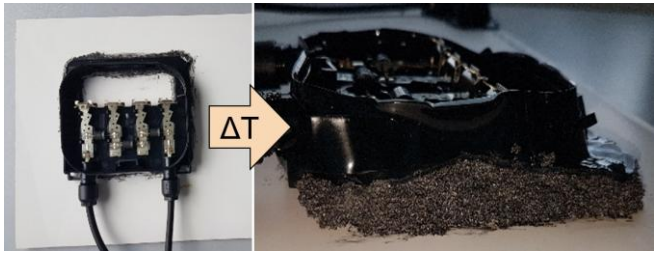
TO SOLAR PANEL REPLICATION

Repair services offered by Second Sol

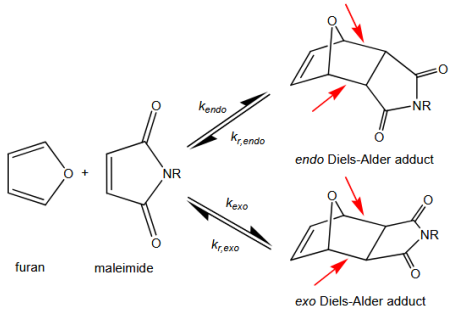
Mobile repair workshop. © Suncycle Iberica

Design for repair

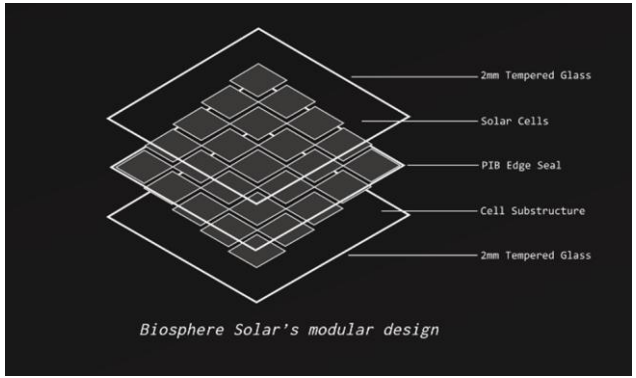
- **No comprehensive strategies** addressing “Design for Repair” or the “Right for Repair” have been published for PV modules
- **Emerging “Design for Repair” concepts:** Current research explores **reversible adhesives**, **self-healing materials**, and encapsulant-free designs to enable easier repair and cell replacement in PV modules



https://doi.org/10.1016/j.ijadhadh.2023.103454



http://dx.doi.org/10.3390/polym12112543



https://www.biosphere.solar

Low TRL Challenges: Most proposed approaches remain at low technology readiness levels and lack validation for long-term durability and reliability.

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See Poster 5DV.2.8 for more details!

Repair vs. Replacement

Factor	Consideration for Repair	Consideration for Replacement
Damage severity	Minor issues (small cracks, chips, surface damage)	Severe damage (glass breakage, delamination, twisted frames, water ingress, deep backsheet cracks)
Module age	Relatively new panels (within warranty period or early in lifespan)	Nearing or exceeding 20–25-year lifespan
Warranty coverage	Damage covered by manufacturer or installer warranty	Damage not covered by warranty (e.g., weather, pests)
Cost effectiveness	Repair cost significantly less than new module + labour	Repair cost comparable to or exceeding new module + labour
Performance impact	Minor dip in output, expected significant recovery post-repair	Significant, persistent dip in output; no substantial improvement expected from repair
Widespread damage	Only a few panels affected; rest of system healthy	Multiple panels extensively damaged, delaminated, or failing
System needs	Current system meets energy needs; no desire for upgrade	Energy needs have changed; desire for more efficient, modern technology
Component failure	Problem isolated to external components (e.g., inverter, wiring)	Both inverter and panels are aging/failing concurrently

Summary literature and market survey

Component	Failure modes	Mode	Field repair possible without dismantling	Automatable	TRL
Backsheet	Chalking; Cracks; Microcracks; Insulation issues	Coating	Yes*	Yes	7
		Tapes	Yes	No	9
		New Backsheet	No	Yes	9
Glass	Cracks	Coating/ Adhesive	Yes	Yes	3-4
Interconnect	Broken soldering; Broken ribbons	Invasive Repair	No	No	3-4
Junction box	Delamination; Water ingress; Failed bypass diodes	Exchange	Yes	No	9
Frame	Delamination	Exchange	No	No	9
Cables & Connectors	Torn cables and connectors	Exchange	Yes	No	9

**** Sometimes, but in many cases, the module must be removed from the holder***

Summary literature and market survey

- Many papers on **circular economy** of PV mention reuse and repair of PV as one potential way to increase sustainability
- Nearly no discussion on **Design for Repair** approaches
- Scientific literature on technical repair procedures have been found for
  - ✓ PV Backsheet & Glass
  - ✓ Cell Interconnects
  - ✓ Inverter electronics
- **Market ready repair solutions** only available for PV backsheets
- Companies for **2nd life photovoltaics** list repair services on their website – in most cases no description of repair approach / procedure available
- **Current repair approaches are labor-intensive** - often exchange with new module is more feasible from an economic point of view

Commercial services

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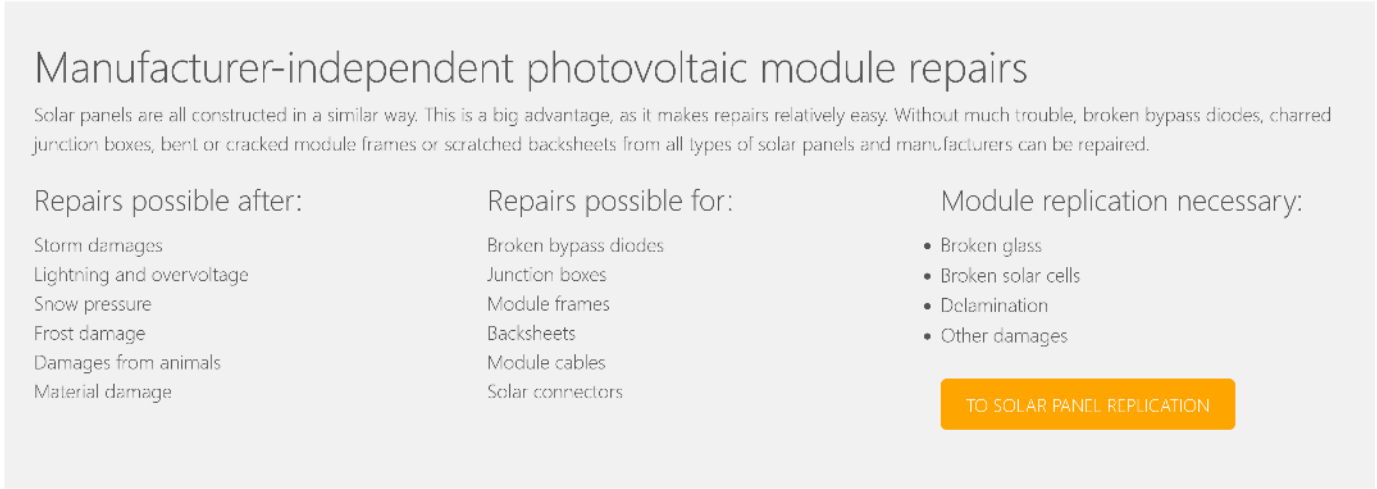

No specific information on repair approaches & quality assessment

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Vorsprung in der Modulsanierung

- Fehleranalytik von Solarparks
- Veredelung von Solar Modulen
- Stärkung der lokalen Strukturen

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