SOLMATE

Sustainable reuse and recycling of PV solar panels and EV batteries

GUIDELINES FOR SAFE DISASSEMBLY, PACKAGING & TRANSPORT OF PV MODULES FOR SECOND-LIFE APPLICATIONS

Funded by
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SOLMATE– short for Reuse of SOLar PV Panels and EV Batteries for low-cost decentralised energy solutions and effective Recycling of critical raw MATErials from their end-of-life products, an EU-funded project dedicated to increasing the circularity of photovoltaic (PV) panels and electric vehicle (EV) batteries.

Through innovative diagnostic and repurposing processes, the project aims to extend the lifetime of components and reduce the environmental impact of Europe's renewable energy sector.

A significant part of this effort relies on recovering **intact and functional PV modules** at the end of their first life. When handled carefully, many panels can be reused in second-life applications, supporting:

- Reduced demand for new raw materials
- Lower environmental and carbon footprints
- Affordable access to functional PV systems
- Longer overall lifetime of PV infrastructure

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However, many reuse-eligible PV modules arrive damaged due to improper disassembly, rough handling, or inadequate packaging and transport. Preventing this damage is paramount to enable second-life applications.

> “Every intact PV panel increases Europe’s potential for circular energy systems.”

WHY CAREFUL DISASSEMBLY AND HANDLING MATTER

Once PV modules arrive at SOLMATE testing facilities, they undergo a strict qualification process including:

- Visual inspection
- Electroluminescence (EL) imaging
- IV curve and peak-power measurements
- Electric Insulation test
- System-level qualification for second-life integration

Many defects—especially cracks—occur during disassembly or transport and are not visible to the naked eye and can have big impact on the power or their reuse. Careful disassembly operations are paramount.

Panels that are twisted, dropped, poorly stacked, or exposed to strong vibrations are far more likely to fail testing and enter the recycling stream prematurely.

> “Improper handling reduces the number of modules available for second-life demonstrators and increases waste.

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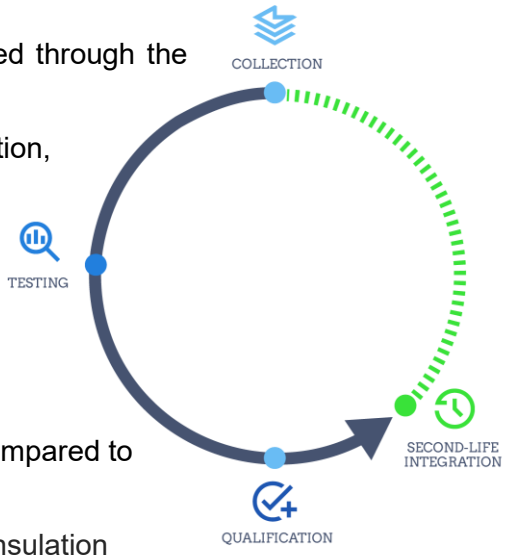
WHAT HAPPENS TO THE PV MODULES AFTER THEY ARE COLLECTED

After transport, PV modules are registered, sorted, and evaluated through the SOLMATE characterisation pipeline:



- **Stage 1 – Visual Inspection:** Checking for cracks, delamination, bent frames, damaged connectors, burn marks, or moisture ingress.
- **Stage 2 – Electroluminescence (EL) imaging**: Identifies microcracks and hidden cell damage that may disqualify a module even if visually intact.
- **Stage 3 – Electrical testing:** Flash testing and IV curve measurements determine the module's real performance compared to its nominal rating.
- **Stage 4** – **Safety test**: HiPot test to reveal potential electric insulation weaknesses
- **Stage 5 - Qualification for Second-Life Systems**: Eligible panels are configured into multi-kWh second-life systems tailored to storage needs and project demonstrators.

GENERAL PRINCIPLES FOR SAFE DISASSEMBLY

1 BEFORE STARTING

- Ensure all operators are trained in handling bulky PV equipment, hold the required electrical qualifications, and follow the site's PPE and safety instructions.
- Wear required Personal Protective Equipment (PPE):
  - Gloves
  - safety shoes
  - protective eyewear
- Prepare a clean, stable, unobstructed working area.
- Assess wind and weather conditions.

2 ELECTRICAL SAFETY

- Switch off the inverter.
- Avoid pulling on electrical cables.
- Disconnect MC4 / other connectors gently.
- Use insulated tools when required (Cutting cables of a module in a PV string from tree modules without caution, even after inverter disconnection, poses a real risk of accident due to live bare conductor on the string side).
- Shade or face modules downward temporarily to reduce voltage generation.

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3 SAFE REMOVAL FROM MOUNTING STRUCTURES

To prevent breakage, deformation or cracks:

- Do not walk on modules
- Remove all fasteners completely to avoid twisting or bending the module frame.
- Support the module with two hands or two operators.
- Do not remove, twist or bend the frame.
- Never drop or slide modules on abrasive surfaces.
- Do not place heavy objects on top of modules.
- Prevent wind from catching or toppling panels.

4 DO NOT DISASSEMBLE PANEL COMPONENTS

Modules must remain intact and complete, including frames, junction boxes, and cables.

Removing components reduces reuse value and violates required take-back conditions.

! Do not cut cables, remove junction boxes, or separate layers. The module must stay complete.

5 VISUAL INSPECTION BEFORE PACKAGING

Check for the following:

- Broken, shattered, or cracked front glass
- Melted or damaged junction boxes
- Delamination, bubble formation, or moisture intrusion
- Bent frames or panel deformation
- Severe scratches that may compromise safety

+ Panels with **minor surface wear** may still be suitable for reuse. Panels with **structural damage** are typically unsuitable.

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6 SORTING AND TECHNOLOGY IDENTIFICATION

Modules must be separated by PV technology type:

- Crystalline silicon (mono- and poly-crystalline)
- Amorphous silicon (a-Si)
- Micromorph thin-film
- CIGS
- CdTe

Do not mix different technologies on a single pallet.

This separation:

- Aids safe treatment
- Improves efficiency of testing
- Ensures correct routing for reuse or recycling
- Follows take-back conditions

7 PACKAGING GUIDELINES

7.1 PALLETS

- Use intact, undamaged pallets larger than module dimensions.
- Ensure pallets can be accessed by forklift from at least two sides.

Examples of high-quality packaging

Examples of low-quality packaging

7.2 MODULE ORIENTATION

- Place modules glass side facing upwards (important for stability and safety at treatment centres).

7.3 STACKING

- Keep module stacks square, aligned, and stable.
- Maximum height including pallet: 1.70 m,

only if the packaging is rightfully secured.

- Reuse plastic/cardboard corners when possible.

Improper stacking and cut connectors

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7.4 WRAPPING AND STRAPPING

- Use 2 straps per side.
- Wrap from the base of the pallet upward.
- Prefer transparent film so visual inspection is possible.

7.5 CONDITIONS

- Store modules in a dry and protected environment.
- Do not mix PV panels with:
  - solar thermal panels
  - small solar gadgets
  - unrelated waste streams

! Panels must be clean, complete, and uncontaminated for collection.

8 SITE LOGISTICS AND TRANSPORT REQUIREMENTS

- Ensure access for a semi-trailer via paved or stable roads.
- Place pallets in an area suitable for forklift handling.
- A certified forklift operator must be present if lifting is required.
- Avoid stacking pallets during transport.
- Secure loads fully to avoid shifting or vibration damage.
- Protect pallets from rain, snow, or debris during loading and transport.

9 COMMON MISTAKES TO AVOID

9.1 DISASSEMBLY MISTAKES

- Twisting or bending frames
- Dropping modules
- Pulling connectors instead of unlocking them
- Allowing panels to fall

9.2 PACKAGING MISTAKES

- Mixing different PV technologies and/or dimensions
- Placing modules face down
- Uneven stacking or pressure points
- Using damaged pallets
- Insufficient strapping or wrapping

9.3 TRANSPORT MISTAKES

- No load securing
- Over stacking pallets
- Rough, fast or imprecise forklift operation

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LinkedIn → SOLMATE Horizon Europe

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Official website → https://www.solmate-project.eu/

For take-back requirements in France:
SOREN – www.soren.eco

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