



Testing & Requalification of PV Modules for Reuse

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The urgency and the opportunity

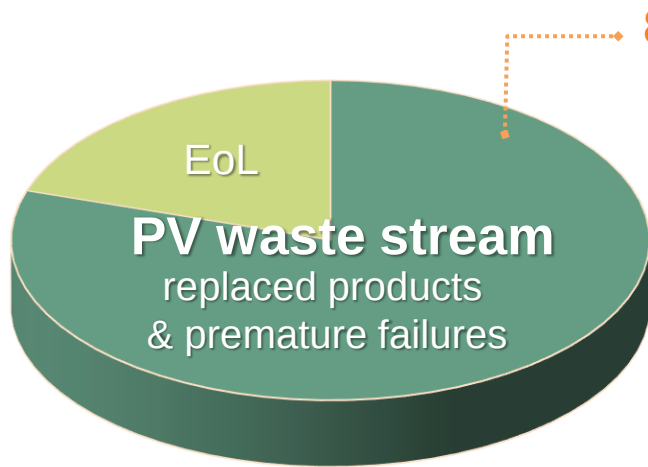


The wave is coming here: from 4 Mt in 5 years, to 50 Mt of PV waste in 15 years from now.

Premature Decommissioning:

- Revamping/repowering creates a stream of used modules that are only 10-15 years old.
- (early and mid-life) PV faults

PVPS



2/3 can be **repaired-refurbished and reused**.

⇒ 50% of the PV waste can be diverted from the recycling/disposal paths*, into a second-life cycle.

Waste management priority order (Directive 2008/98/EU)



1. Re-use is better than recycling in terms of **environmental impacts**
2. The EU normative allows the trade of secondhand modules (**WEEE Directive Annex VI**)
3. Decommissioned PV modules may still have **residual commercial value**

* today's default strategy for decommissioned PV modules in Europe

The challenge(s)



- **Lack of trust in *safety* and (residual) *value***
- **Lack of standardization**

Building trust: regulatory framework



IEC TC82 Project Team (since 2022)

Developing **IEC TR 63525** ⇒ foundation for future Technical Specifications/Standards

Aim: harmonize methods ensuring **safety, performance, lifetime** at feasible costs

Why is it challenging?



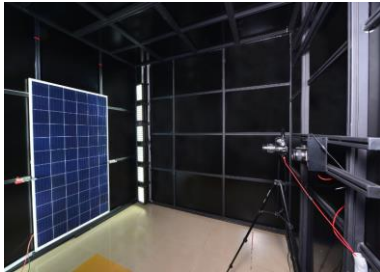
- Diverse “1st life” conditions: Creating tests that represent all used modules is complex.
- Cost Pressure: Reuse processes must be extremely efficient to compete with cheap new modules.
- Testing Strategy dilemma

Two Practical Requalification Pathways



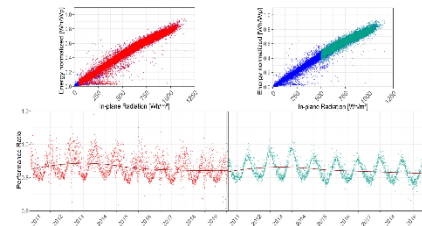
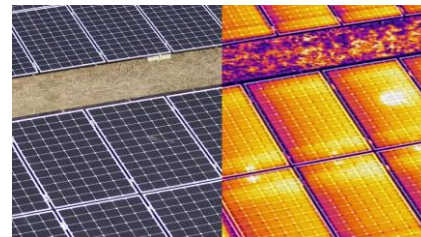
Individual Testing (The “Pile in a Warehouse”)

- For plants with non-uniform degradation and distinct faults or for modules already in a warehouse.
- Every single module is tested visual, I-V, dry insulation, bypass diode, EL.
- Factory lines: ~60 modules/h i.e. (~200 MW/year) (on-site with mobile units = ~200 modules/day → too slow).
- Resource-intensive, expensive → but maximum assurance, easier to standardize.



Sampling (The “Intact Plant”)

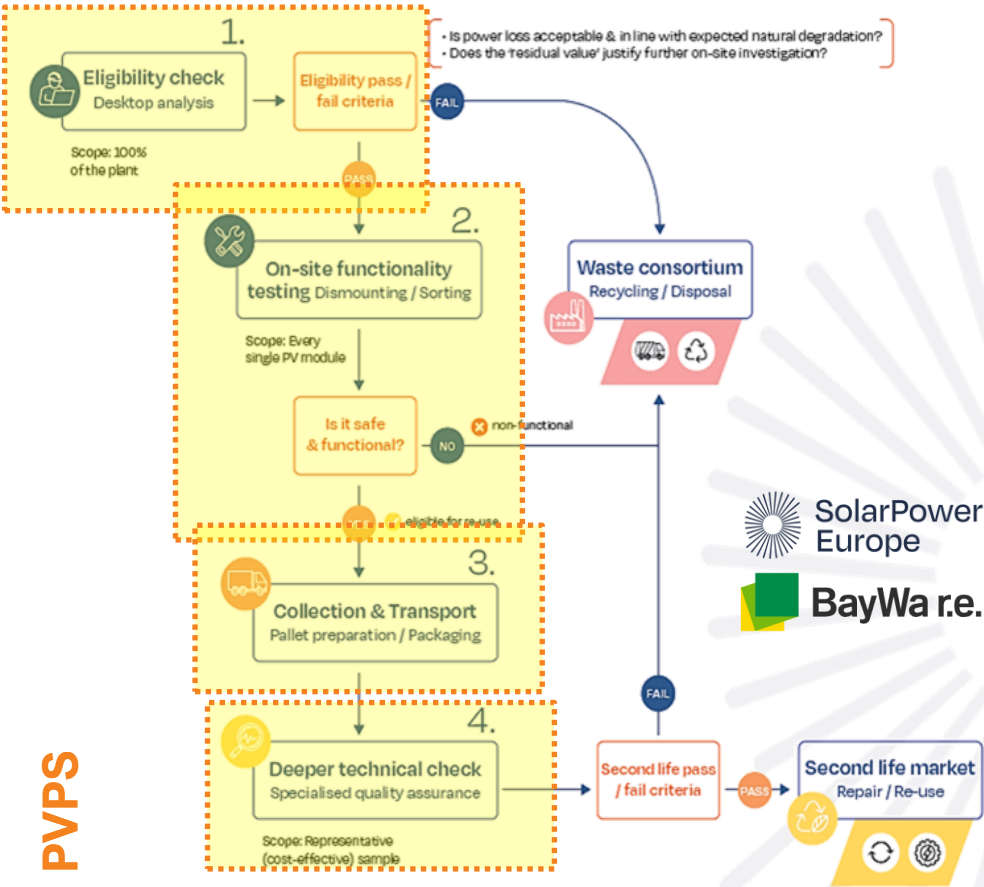
- For large, operational plants with similar degradation.
- Relies on historical data (monitoring, drone IR, PLR..)
- Statistical testing: visual, EL, insulation under wetting, power at STC.
- Basis: Adapting sampling plans from new plant inspection (ISO 2859-1*, SolarPower Europe guidelines).
- Much faster, lower cost → but justification & acceptance criteria still unclear.



Qualification for PV re-use: exemplary scheme



PVPS



Step 1: Eligibility checks



Step 2: Functionality Testing



Step 3: Collection & Transport

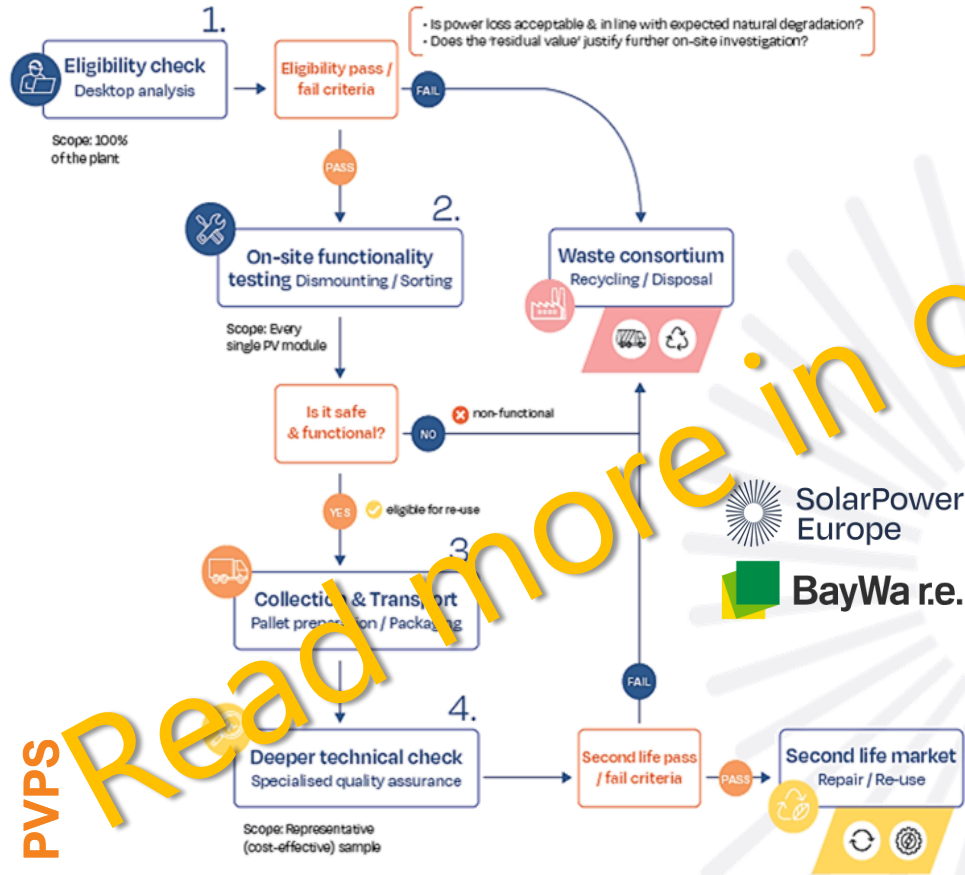


Step 4: Deeper Technical Check



This is the high-level playbook.

Qualification for PV re-use: exemplary scheme



Safety testing criteria¹

- IEC 61730-2 MST 13: ground continuity
all frame parts are electrically connected?
- IEC 61730-2 MST 16: isolation resistance
- In case of failing these tests?
 - ⇒ divert to recycling stream or
 - ⇒ consider for low system voltages (<60 V)

¹ van der Heide A, Tous L, Wambach K, et al. (2021). Progress in Photovoltaics 30(8): 910-920.

Reality Check: Lessons from a 5 MW Case Study



The subject: 5 MW Plant, Italy (12-year-old mc-Si modules) undergoing **revamping**.

Key findings:

- High Variance: Power losses from 12.5% to 35%.
- Safety Risk: Dry insulation test passed; Wet test failed on damaged module.
Wet testing = non-negotiable for safety.
- Material Lottery: Different backsheets found in same module type.



Sampling is risky here.
100% testing + wet leakage advised.

The bottom line – Burning questions



Developing a cost-effective, high-throughput PV “reuse-ready” testing process, with universally accepted criteria, is the critical next step.

- Reuse preferable to recycling — but how **to scale**?
- **Who** guarantees performance and (re)liability? **How**?
- Can reuse **compete** with new modules at 0.11 €/W?
- Should reused modules have their own (sort of...) certification label?

The Path to Scale Requires Diverse Solutions



	High-volume refurbishing specialist	Precision diagnosis/repair specialist
Core question	How to process volume efficiently?	How to salvage value from faults in PV plants?
Approach	Automated sorting, testing, and triage in a central factory.	Advanced diagnostics and efficient repair, even on-site
Analogies	A high-tech recycling & sorting plant.	A specialized “diagnosis & surgery” unit for PV modules
Who?		

The path forward isn't a single solution, but a portfolio.

Thank you

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