CIRCULARITY IN THE PV INDUSTRY –
DETAILED ANALYSIS OF ENVIRONMENTAL IMPACTS OF REUSED PV PANELS

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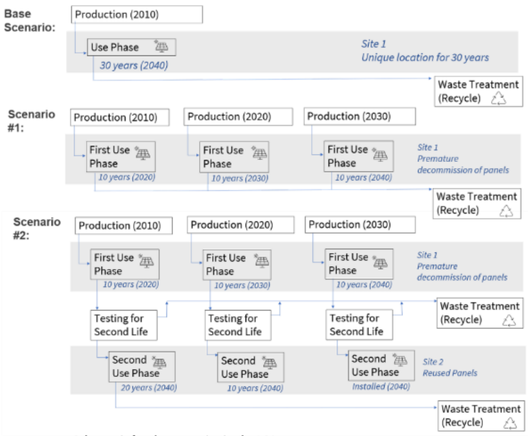
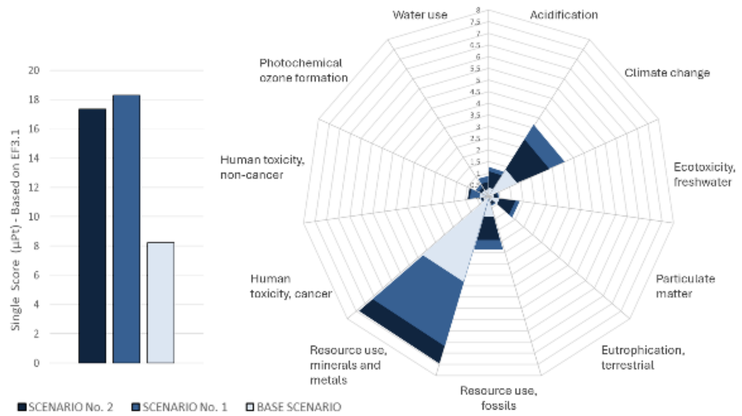
With the rapid global expansion of photovoltaic (PV) installations, the PV industry will face a significant increase in electronic waste as panels reach the end of their lifespan. This challenge is further intensified by premature decommissioning practices aimed at optimizing efficiency. In this context, the reuse of PV panels emerges as a promising solution to enhance circularity within the industry.



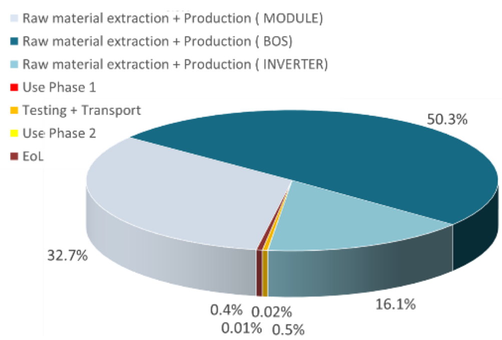
Schematic for the scenarios in the LCA scope.

This study presents a comprehensive cradle-to-grave life-cycle assessment (LCA) to evaluate and compare the environmental impacts of reuse versus recycling in scenarios of premature decommissioning. The analysis covers the entire lifecycle, from raw material extraction and production to both first and second-use phases, transport, testing, and end-of-life management. The functional unit selected is the generation of 1 kWh of direct current (DC) from multicrystalline and monocrystalline silicon panels over a 30-year period. The study compares two key scenarios of premature decommissioning with and without panel reuse.

Results show that keeping PV panels in place for their full 30-year lifespan results in the lowest environmental impact (46.6 gCO2eq/kWh). Premature decommissioning more than doubles the environmental footprint, but reusing panels generates significantly lower emissions (103.3 gCO2eq/kWh) compared to recycling (127.3 gCO2eq/kWh). The study also highlights the substantial impact of Balance of System (BOS) components, particularly mounting systems and inverters, on the overall lifecycle. Additionally, transport and testing associated with preparing panels for reuse contribute minimally to the total environmental footprint (0.02%).



Comparative LCA results. Single score results and contributions per impact category



Distribution of impacts per process in Scenario 2.

The sensitivity analysis showed that while improvements in degradation rates and panel efficiency help reduce environmental impacts, they do not match the benefits of utilizing panels for their entire lifespan. Also, it was identified that two key factors could reduce environmental impacts of the reuse scenario: (1) Reusing BOS components, which could reduce the overall footprint by up to 24%. (2) Ensuring panels remain in good condition during dismantling and transport. If more than 40% of decommissioned panels are unsuitable for reuse, the environmental benefits of reuse could be outweighed by those of direct recycling.

This analysis underscores the potential of PV panel reuse as a sustainable solution, particularly when integrated with robust lifecycle management practices.