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SOLAR PV. PERFORMANCE & RELIABILITY



PHOTORAMA



ReSi'lex



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Advancing Photovoltaic Sustainability and Circularity in Europe



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ADVANCING **PHOTOVOLTAIC** **CIRCULARITY** IN EUROPE FOR **SUSTAINABLE FUTURE**

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Executive Summary

Europe is a leader in the fight against climate change and in the clean energy transition. Solar energy is the key renewable energy source to achieve this green transition in the EU. The European Green Deal and the Critical Raw Materials Act are a package of European policies aimed at making the EU climate-neutral by 2050, promoting sustainable economic growth and addressing the EU's dependency on critical raw materials.

TRUST-PV, PHOTORAMA, RESiLEX, ICARUS, and CIRCUSOL are European-funded projects that work together to implement innovative solutions through the photovoltaic (PV) value chain. The main targets focus on developing eco-design innovations, ensuring sustainable operation and maintenance, experimenting and assessing reuse practices, and providing technological solutions for waste manufacturing and End-of-Life (EoL) waste management.






The Context

The photovoltaic industry in the transition to clean and sustainable energy

Solar energy has been clearly identified as the best candidate to lead the energy transition and to move towards a carbon-neutral paradigm. The role of the photovoltaic industry is decisive in this mission, since a massive deployment of photovoltaic energy is expected in the next few decades. Europe, as a leader in the fight against climate change and in the clean energy transition, has launched several initiatives to coordinate the macroeconomic strategy, with a particular focus on solar energy (Fit for 55, REPowerEU, EU Solar Energy Strategy). More globally, the Circular Economy Action Plan (CEAP) provides guidelines to support European industries in developing sustainable and circular business perspectives, while the Critical Raw Materials Act (CRMA) sets up measures to secure the supply in Europe of critical raw materials needed for the energy transition. Conservative estimates indicate that the European solar industry could create over 100,000 jobs in the upstream PV sector, including both low- and high-end educational jobs. The EU solar energy strategy of 2022 aims to bring online over 320 gigawatts of solar photovoltaic by 2025 (more than double compared to 2020) and almost 600 gigawatts by 2030. The EU must prepare to handle huge volumes of PV waste in the coming decades, and to recover the valuable materials from this waste.

Challenges and opportunities in the PV industry

In order to move towards a sustainable industry and promote circularity, the photovoltaic industry needs to address several challenges in particular:

-  **Develop a robust secondhand market for reuse.** At its early stage, the development of the reuse market in Europe depends on several factors to become viable. In order to be able to reuse PV modules and prevent them from entering the waste stream prematurely, they need to be submitted to functionality testing procedures that are technically feasible, cost-effective and contextualised to the secondhand market, giving priority to safety over performance.
-  **Evolving and improving practices in waste management.** PV waste is a current challenge, and will become a much larger challenge as the volume of decommissioned PV modules in European countries increases. Europe has implemented a pioneering legislative framework for mandatory EoL management, which constitutes huge progress. Nevertheless, the requirements are too often insufficient or not suitable and must be revised to incentivize good practices.
-  **Recovery and reuse of Critical Raw Materials.** Landfilling or down-cycling practices for either recycling manufacturing waste or end-of-life devices will lead to massive and irreversible loss of critical and valuable materials. Indeed, they are mostly not recycled today. The recovery and reuse of secondary raw materials is an opportunity to increase strategic resources and supply and develop new markets for Europe.



By adopting circular economy business models for the photovoltaic industry, the EU will contribute to the goals of the Green Deal and Critical Raw Materials Act by reducing resource consumption, minimising waste generation, and fostering a sustainable, low-carbon economy, as well as diversifying and securing a sustainable domestic supply of critical raw materials. In this context, the PV industry must become exemplary in terms of sustainability, fostering economic, environmental and social benefits, while carefully considering the whole value chain. From supply chain to manufacturing, use, decommissioning, and waste management, all stakeholders should work together to develop an inclusive and systemic industry. Innovation, investments, collective rethinking and a sound legislative framework are required to make progress. The EU-funded projects TRUST-PV, PHOTORAMA, RESiLEX, ICARUS, and CIRCUSOL provide five recommendations in this policy brief for this purpose.



Recommendations

Recommendation 1 (by TRUST-PV): Support development of an international standard to foster reuse of PV modules and grow a PV reuse market

Business case studies have shown that there is huge potential for a PV reuse market, especially connected to revamping and repowering activities. However, the lack of an international standard on preparing PV modules for reuse is a major barrier. A standard providing a cost effective, clear and easy-to-perform set of recommendations focused on testing the functionality and safety of decommissioned PV modules eligible for reuse is required. This would facilitate investment in partnerships to help develop this promising secondhand market in a safer way, avoiding the risk of liabilities connected to incorrect disposal and management of PV waste. It would also address the problem of lack of warranty and increase the reliability of this new product in Europe, while at the same time reducing the risk of exporting e-waste to developing countries.

Recommendation 2 (by PHOTORAMA): Create a dedicated category for PV waste in the WEEE directive 2012/19/EU to adapt the collection/recovery/recycling targets and incentivize recovery of valuable and critical materials

PV panels are different from consumer equipment in terms of composition, lifetime and market evolution. PV equipment should be moved out of category 4 of the EU's WEEE (Waste from Electrical and Electronic Equipment) directive into a specific category, in which the collection target is adapted to the availability of the waste stream and market volatility. A common standardised methodology to assess recovery and recycling ratios is required to harmonise practices between EU member states and provide reliable data. PV panels are complex devices containing valuable and critical materials in low percentage by weight, but significant at large waste volume and in value. They are usually not recovered, while the legislative targets can still be reached by recyclers. Including a criterion (possibly informative at an early stage) on critical and valuable materials to be recovered would incentivize innovation and progress in the field, and support the global target for recycling of the CRMA (15 % of the EU's annual consumption by 2030).



Recommendation 3 (by RESiLEX): Support new and existing industries to ensure a fully European silicon value chain for the PV sector

The enhancement of the silicon value chain is of utmost importance for the EU's resilience. Silicon is a crucial component in most of the EU's strategic sectors, such as batteries, PV and ICT. The European PV sector is anticipated to grow at an annual rate of 15-25% in the coming decades. Ensuring the viability of a sustainable and cost-competitive mining extraction, processing, and refining industry in Europe is critical for increasing EU resilience, not just for silicon but for other critical minerals as well. Innovative solutions for a new circular model along the silicon value chain (e.g. through recycling solutions) can reduce the criticality of this element and increase EU resilience by minimising physical supply risk and the dependence on market price fluctuations caused by exports.

Recommendation 4 (by ICARUS): Support implementation of a full Circular Economy Framework for processing and refining PV manufacturing waste

Whereas new technical processes and procedures are emerging for facilitating reuse of PV modules, a circular economy framework complete with regulatory and legislative support and incentives is necessary to bring these efforts to fruition. Closing the loop by integrating secondary raw material will enable large PV industries to adopt the circular economy approach - and at the same time inspire further ones (metallurgical, chemical, building industries). Increased use of recycled raw materials supplies will yield an economic advantage while maintaining existing industrial processes and limiting costs. Working from secondary raw materials also brings more acceptance from customers and increased sustainability. This is of high interest in many markets, where sustainability is a deal maker for customers.

Recommendation 5 (by CIRCUSOL): Promote regulatory requirements incentivizing circularity and recovery of critical raw materials

PV modules have not been designed for repair, recycling and recovery of various components and materials, including critical raw materials. This in turn poses challenges to various operations to enhance circularity - repair and repurposing of these products, as well as recycling and recovery of components and raw materials. Design for circularity and recovery of critical raw materials could be enhanced through a variety of regulatory requirements, such as design specifications, stipulating specific recovery targets for critical raw materials or the use of recycled content, mandatory information provision, and the use of a digital product passport, amongst others.

Project Group

Project Acronym: TRUST-PV

TRUST-PV: Increase Friendly Integration of Reliable PV plants considering different market segments

Short description: TRUSTPV will improve the performance reliability of solar power plants, supporting the development of O&M-friendly and grid-friendly solar PV components and solutions in large portfolios of distributed and utility-scale PV.

Grant Agreement No. 952957

Project website: www.trust-pv.eu



Project Acronym: PHOTORAMA

PHOTORAMA: PHOtovoltaic waste management - advanced Technologies for recOvery and recycling of secondary RAW Materials from end-of-life modules

Short description: PHOTORAMA is an EU-funded innovation action striving to improve recycling of Photovoltaic (PV) panels and recovery of Raw Materials (RM).

Grant Agreement No. 958223

Project website: <https://www.photorama-project.eu/>



Project Acronym: RESiLEX

RESiLEX: Resilience Enhancement for the Silicon Industry Leveraging the European matrix

Short description: The general objective of Project RESiLEX is to demonstrate 7 industry-driven technological and business innovative solutions covering the full Silicon value chain in order to contribute to improving the resilience and sustainability of this critical raw material value chain in Europe.

Grant Agreement No. 101058583

Project website: www.resilex-project.eu



Project Acronym: ICARUS

ICARUS: Innovative eco-efficient processing and refining routes for secondary raw materials

Short description: The EU-funded ICARUS project will demonstrate at an industrial level eco-efficient modular processing solutions to recover 95% of high-value raw materials from silicon ingot and wafer manufacturing.

Grant Agreement No. 958365

Project website: <https://www.icarus.eu.com/>



Project Acronym: CIRCUSOL

CIRCUSOL: Circular business models for the solar power industry

Short description: CIRCUSOL aims to establish solar power as a spearhead sector to demonstrate a path driven by Product-Service System (PSS) business models towards a circular economy in Europe.

Grant Agreement No. 776680

Project website: <https://www.circusol.eu/>





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