Solar panels - A global e-waste and a secondary source of critical raw materials

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INTRODUCTION

The current global growth of photovoltaics is very dynamic, driven primarily by rising global energy demand. The crystalline silicon (c-Si) solar panels (SPs) dominate, with ~90% of the total market share. With the average lifetime of SPs (<25 years), society is beginning to be faced with a large amount of solar electronic waste (e-waste).
Most importantly, the degradation of SPs can lead to the release of toxic trace elements, making them emerging contaminants. In addition to major constituents such as glass (~70%), plastic polymer (~10%), Al (~8%), Si (~5%) and hundreds to thousands ppm of Ag, Cu, Sb, Sn and Pb are typically found in e-waste from c-Si SPs (IRENA, 2022).

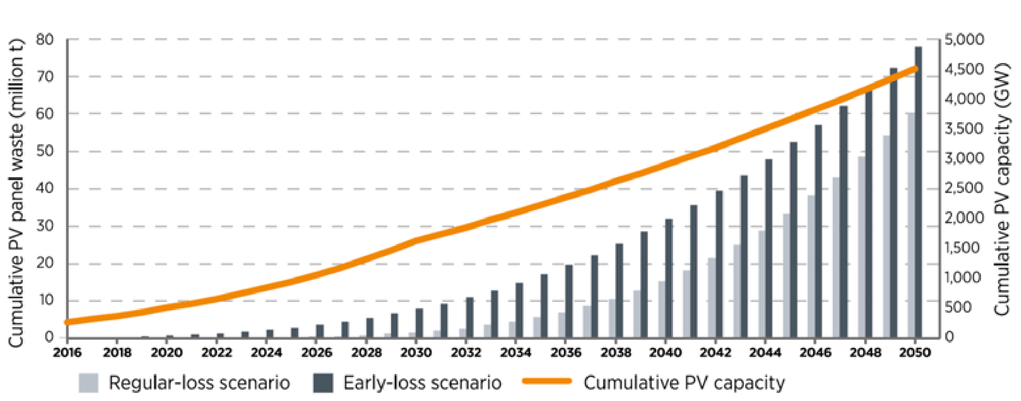

Fig. 1. Estimated cumulative global e-waste volumes (million t) of SPs (IRENA, 2022).

Table 1. List of elements emphasized in this research.

Element	Symbol	Priority pollutant[a]	Critical/strategic raw material[b]
Silver	Ag	+++	+++ (U.S.)
Antimony	Sb	+++	+++ (EU)
Copper	Cu	+++	+++ (EU)

[a] Priority pollutant list (USEPA, 2014).
[b] Report on Critical Raw Materials (CRM) and the Circular Economy (EU, 2018, 2023), EC's Raw Material Information System http://rmis.jrc.ec.europa.eu

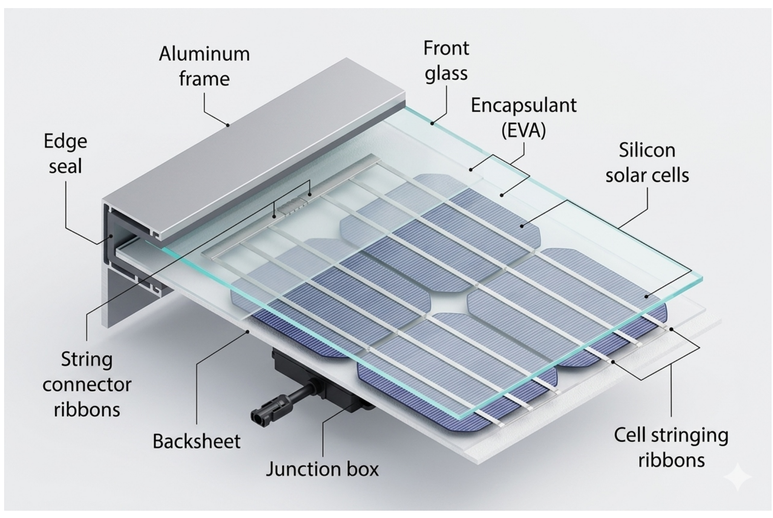

Fig. 2. Major c-Si SP components (redrawn from IRENA, 2022).

PRELIMINARY DATA

The highest Ag, Sb, Cu concentrations were found in the final product of SPs recycling - metal(loid)-rich SPs fraction, and the mixture of c-Si cells (without protective glass) (Fig. 3).

Clearly, both Ag and Cu are used in SPs for their conductivity, i.e., their ability to collect and transmit electrical energy through contacts, coatings and wires. As for Sb, there is an apparent enrichment in/on the glass matrix of SPs, in contrast to Ag and Cu. It should be highlighted that Sb-based compounds (Sb_2Se_3, Sb_2O_3 etc.) are commonly added here as antireflective coatings to enhance light absorption and solar performance.

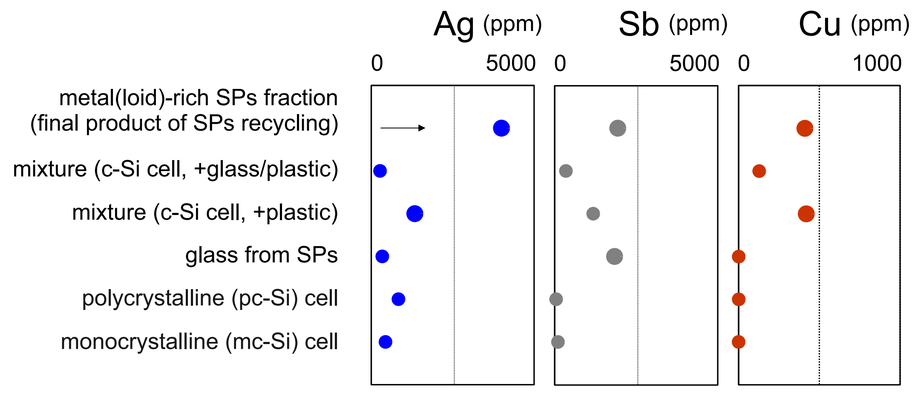

Fig. 3. Distribution of metal(loid)s in different (operationally defined) samples of SPs and pc/mc-Si cells.
The individual materials were obtained from the Solar Panel Recycling Division of DEKONTA Inc. (CZ); https://www.dekonta.cz/en/.

FUTURE WORK

Based on the preliminary data, further leaching (long-term) experiments are planned to simulate acid rain leaching conditions and to assess how the metal(loid)s may migrate into soils.
Synthetic rainwater (SRW; EPA Method 1312, USEPA, 1994) and acetic acid (CH_3COOH) will be used.
Old (<2016) and new SPs, regarding their different material composition, are planned to be involved within the project.

References:
IRENA, 2022. Renewable Capacity Statistics 2022. The International Renewable Energy Agency, Abu Dhabi.
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