Mineral Resource Use Footprints of Residential PV Systems

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Executive Summary

Resource use intensity is often mentioned as one of the main characteristics of PV systems and PV electricity. Recently, the International Energy Agency published a report on the role of critical minerals in clean energy transitions. The Product Environmental Footprint pilot study on PV electricity quantified (among other environmental impacts) its abiotic depletion potential. So far, a comprehensive assessment of resource use impacts highlighting the different facets of its impacts is however lacking.

For the first time, the resource use impacts of PV electricity are quantified simultaneously with four impact category indicators recommended or suggested by the Life Cycle Initiative hosted at UN Environment. The indicators cover distinctly different aspects of resource use, namely resource depletion with the Abiotic Depletion Potential, ultimate reserves (ADPUR), economic resource scarcity with the Abiotic Depletion Potential, economic reserves (ADPER), resource quality with the Surplus Ore Potential, Ultimate Recoverable Resources (SOPURR) and re-source criticality with the ESSENZ method.

The resource use impacts caused from the generation of 1 kWh electricity with a residential scale photovoltaic (PV) system installed in Central Europe using mono- and multi-crystalline silicon panels and CdTe panels, respectively are quantified. The product system includes ma-nufacture, use and end of life treatment (take back and recycling) of the PV panels, cabling, inverter and supporting structure, the supply chains of the raw materials and energy used in PV panel and inverter manufacture as well as transport logistics.

The production of 1 kWh AC electricity produced with residential scale PV systems requires between 16 and 20 grams of primary mineral resources with up to 90% of them used in infra-structures such as factories and roads and in (solar) glass production and a few percent each being iron (supporting structure), aluminium (frame) and copper (cabling and inverter).

Resource use impacts on resource depletion and on resource quality are similar for all three PV technologies. Less than ten minerals and metals contribute to at least 95 % of the overall score of all four resource use impact indicators. Gold, silver and copper are always in the top ten minerals and metals (see Fig. 1.1). While Gold is mainly used in the inverter electronics and copper in the cabling and in the inverter, silver is mainly used in crystalline silicon panels and in the inverter electronics.

Tellurium (CdTe panel and inverter electronics), tin (inverter electronics) as well as gravel and sand (infrastructures and panel glass) are important substances regarding resource criticality (ESSENZ).

The inverter often contributes most to the resource use impacts followed by the PV panel. The alloying elements used in the supporting structure contribute significantly to the surplus ore potential (SOP).

The study contributes to better understand the various and multi-facetted resource use impacts of different PV systems. The study helps readers to choose the resource use indicator approp¬riate for their question or concern. The results help to identify which metals and/or minerals could be targets for reduction in use (increase material efficiency) and for increase in resource recovery during end-of-life treatment. Depending on the indicator (and on the resource use related question at stake) this may be different metals and/or minerals.

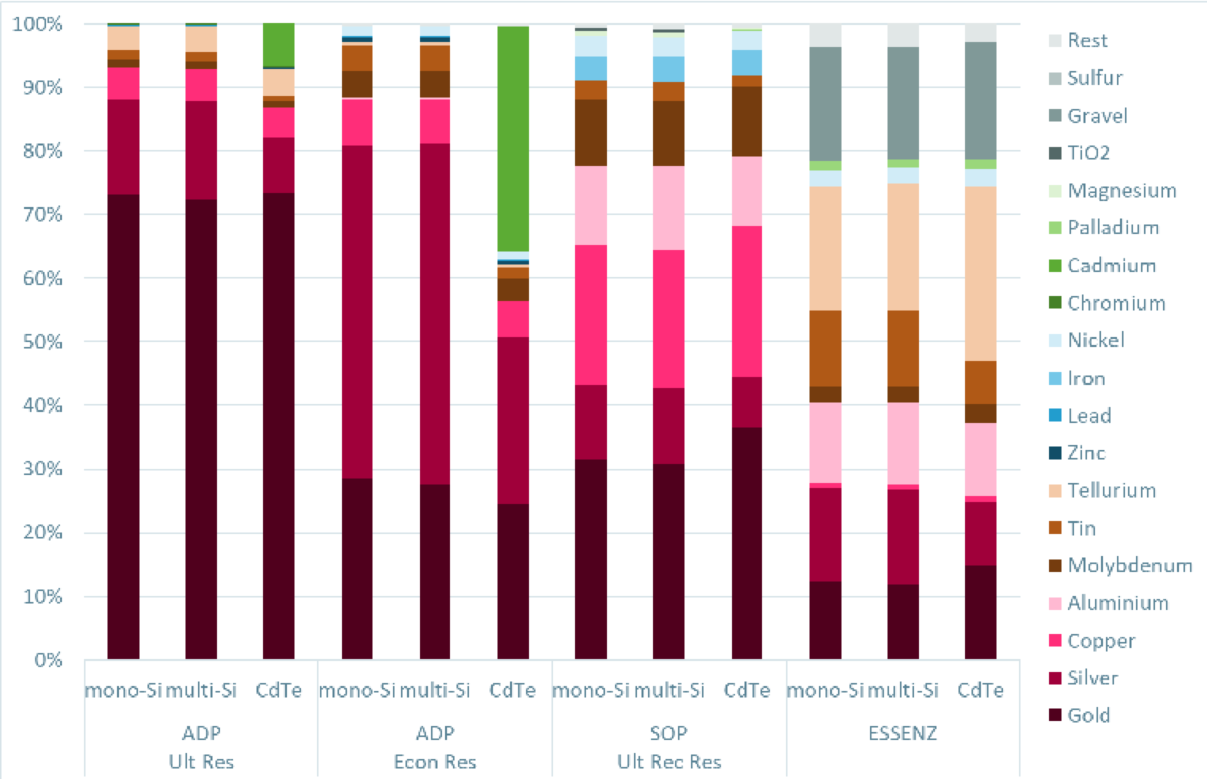

Fig. 1.1 Relative contribution of different metals and minerals to the resource use impacts, quantified with the Abiotic Depletion Potential (ADP), ultimate reserves, the Abiotic Depletion Potential (ADP), economic reserves, the Surplus Ore Potential (SOP) and the resource criticality indicator ESSENZ, per kWh AC electricity produced with residential scale PV systems operated in central Europe; average annual yield over lifetime: 975 kWh/kWp (incl. linear degradation of 0.7 % per year); panel lifetime: 30 years; inverter lifetime: 15 years.

Information and data on the share of minerals and metals recovered during collection, treat-ment and recycling of panels, inverters, cabling and supporting structures would allow to quan¬tify the impacts on depletion, scarcity, quality, and criticality of consumptive resource use. This information and data should be collected for metals and minerals contributing significantly to resource use impacts including Gold, silver, copper, tellurium and tin, and the respective life cycle inventory datasets should be complemented accordingly.

Future research should establish recovery rates of the most important minerals and metals achieved and achievable in commercially operated recycling facilities of crystalline silicon, CIS and CdTe panels as well as inverters and electric installations. Such information should then be embedded in the life cycle inventories of PV systems and their supply chains.