EX-ANTE LCA OF PV SYSTEMS BASED ON MASS-PRODUCED PEROVSKITE ON SI TANDEM MODULES

Caterin Salas-Redondo[1*], Carlos Felipe Blanco[2], Willie J.G.M. Peijnenburg[3], Lars Oberbeck[1,4]
[1]Institut Photovoltaïque d'Ile-de-France, 18 Boulevard Thomas Gobert, 91120 Palaiseau, France
[2]Leiden University, 2300 RA Leiden, The Netherlands
[3]Center for Safety of Substances and Products, National Institute of Public Health and the Environment, 3720 BA Bilthoven, The Netherlands
[4]Total Gas, Renewables & Power, 2 Place Jean Millier, 92078 Paris La Défense Cedex, France
*caterin.salas-redondo@ipvf.fr

A comprehensive life cycle assessment (LCA) is reported of a perovskite/Si tandem module of about 2 m² area, with 30% power conversion efficiency (PCE), 30 years lifetime and an annual degradation of 0.5% [i], manufactured in a 1 GW production plant. By means of the LCA method, we calculate the contribution to the International Reference Life Cycle Data System (ILCD) impact categories [ii] associated with a perovskite/Si tandem module based PV system compared with a system based on passivated emitter and rear cell (PERC) modules used as reference. We consider a functional unit of 1 kWh of generated direct current electrical energy from the tandem module over its lifetime.
It was found that the most significant hotspots are the silicon wafer production and the balance of system (BOS) components, i.e. mounting system, inverter and electric installation (cf. Figure 1). Overall, the impact contributions to the environment caused by the perovskite sub-module are below 1% throughout all the ILCD categories in focus: climate change, freshwater ecotoxicity, water resource depletion and human toxicity. Even the contribution of lead to human toxicity is just about 0.01%. Among the hotspots of the perovskite/Si tandem module, the key processes influencing the potential environmental impact from the perovskite sub-module are (cf. Figure 2a): ITO sputtering, coating of the perovskite layer as well as annealing. The environmental impact of the Si sub-module is by far dominated by the Si wafer (cf. Figure 2b).
The key result found in this work is the relevance of the performance and reliability of the PV system to achieve lower environmental impacts. A comparison between optimistic, realistic, and pessimistic scenarios was performed to investigate this matter: in the worst-case scenario, the environmental impact of the PV tandem system would have a general 50% increase throughout all ILCD impact categories, whereas in the optimistic one, the results suggest a reduction of 46% to the global impact contributions.

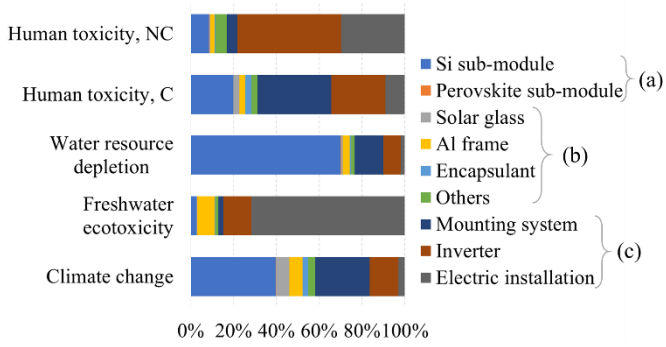

Figure 1. Contribution of each component of the perovskite/Si PV system to the ILCD categories in focus, i.e. climate change, freshwater ecotoxicity, water resource depletion and human toxicity, for 1 kWh of electricity produced by a perovskite/Si tandem module based slanted-roof installation. (a) Perovskite/Si tandem module, (b) PV panel (encapsulation, frame, module elements), where solar glass is also used as substrate of the perovskite sub-module, (c) BOS components.

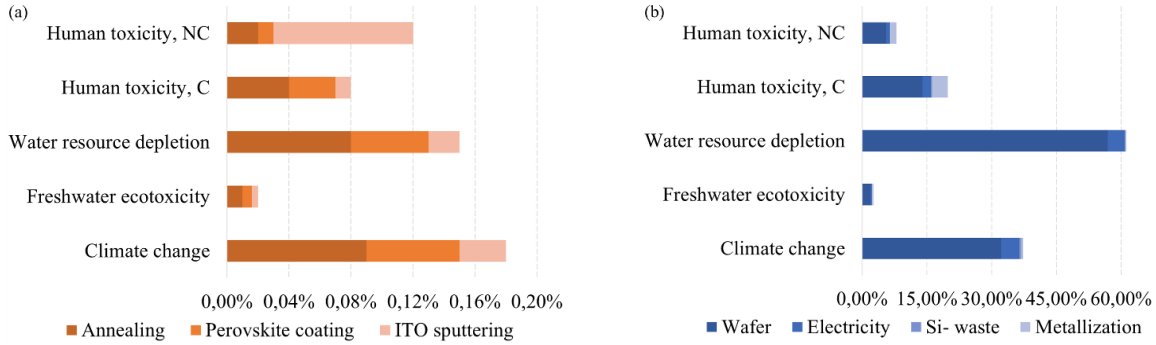

Figure 2. Detailed share of environmental impacts from the hotspots of (a) perovskite and (b) silicon sub-modules.

[i] L. Oberbeck et al., IPVF's PV technology vision for 2030. Prog. Photovolt. Res. Appl. 2020; 1–8.
[ii] European Commission-Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook- Recommendations for Life Cycle Impact Assessment in the European context. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011.