Generating simplified but accurate models to assess the environmental impacts of perovskite/silicon tandem modules by parametric approach

Lu WANG[1,2,3], Lars OBERBECK[2,3], Raphaël JOLIVET[1], Mathilde MARCHAND LASSERRE[1], Paula PEREZ-LOPEZ[1]

[1] Mines Paris, PSL University, Centre Observation Impacts Energie (O.I.E.), 06904 Sophia Antipolis, France

[2] Institut Photovoltaïque d'Ile-de-France, 18 Boulevard Thomas Gobert, 91120 Palaiseau, France

[3]TotalEnergies OneTech, 2 Place Jean Millier, 92078 Paris La Défense Cedex, France

E-mail contact: lu.quercin@totalenergies.com

SUMMARY

Perovskite/silicon tandem is a rapidly emerging PV technology that has demonstrated high power conversion efficiency (PCE) and is widely investigated. To ensure its potential on the path towards sustainable development, the environmental impacts of such emerging technology should be evaluated carefully. Life cycle assessment (LCA), a widely used methodology for environmental evaluation, is increasingly required by the authorities to support decision-making in energy transition[1]. However, conducting a standard LCA is usually time-intensive and requires expertise on process and methodological choices. The aim of this research is to generate simplified and accurate models which allow, in particular for non-experts, to assess the environmental impacts of perovskite/Si tandem module easily.

To do so, a parameterized LCA was built to estimate the environmental impacts of 1 kWp power installed of perovskite/Si tandem modules. Different input variable parameters (e.g., PCE of the modules, etc.) were taken into account in the model to ensure its representativeness. With global sensitivity analysis (GSA), key parameters influencing the LCA results were identified. Simplified arithmetic expressions were generated based on these key parameters. The simplified models are a tool for non-expert LCA users to obtain fast estimates of multi-criteria environmental assessment results with low requirements in terms of data collection[2].

The preliminary results have provided us with i) the distributions of the selected impact categories of the target perovskite/Si tandem modules, ii) key parameters influencing each impact category, and iii) the simplified models to calculate the environmental impact of each category. In this paper, for illustration purposes, the results of the impact on climate change will be presented. In such a case, the distribution shows that the impact on climate change would range between 211 and 247 kg CO_2-eq/kWp. The identified key parameters would be the PCE of the modules (in %), the consumption of solar-grade Si (in kg/m^2), and the thickness of solar glass (in mm). Based on these three key parameters, a simplified model has been generated, corresponding to the equation $I_{Climate\ change} = \frac{C\_Si\ (0.384\ Elec\_cons\_SGSi + 35.9) + 5.78\ Glass\_Thickness + 31.8}{PCE}$. At this preliminary stage, the simplified models are applicable to the specific 4T tandem under study, modeled in a French context.

This study provides a set of simplified models that allow non-expert LCA users to assess the environmental performance of different scenarios of perovskite/silicon tandem modules' production and recycling. Such assessments are essential to support efficient decision-making in the industry. Identifying key parameters and their contribution to environmental results' variance may help PV developers to further improve the sustainability of emerging technologies.

References

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