

Table S1. The amount of lead (Pb) installed in a PST module and assumptions about its emission into the air, fresh water and soil at the end of its service life as part of a worst-case scenario.

Input (I)/output (O)	mass	rel.	DS ¹
Substance	[g]	[%]	
I lead iodide (PbI ₂)	6.2	100%	PD
I lead (Pb)	2.8	45%	CA
I iodide (I)	3.4	55%	CA
O lead (Pb), emitted	2.8	100%	AS
O to air	0.1	5%	SD[1]
O to fresh water	2.4	86%	SD[1]
O to soil ²	0.3	10%	SD[1]

¹ data source: PD - primary data (data obtained from surveys carried out between July 2018 and February 2021 as part of the ProTandem project); CA - calculated; AS - assumption; SD - secondary data: [1] Hauck et al., (2017).² It was assumed that emissions into the soil affect industrial and agricultural soils in equal parts.

Table S2. Comparison of the impact per kWh of the PST and SHJ module with that of the German grid mix (GDM).

Impact category	CFM ¹ abbr.	unit per module	SHJ [amount]	PST [amount]	GDM ² [amount]
climate change, default	GWP	g CO ₂ eq.	40.6	37.7	573.0
particulate matter form. ³	PMFP	mg PM _{2.5} eq.	63.6	59.5	166.0
fossil depletion	FDP	g oil eq.	15.5	14.3	166.0
freshwater consumption	FWC	L	1.4	1.2	2.2
freshwater ecotoxicity	FETP	mg 1,4-DB eq.	348.6	307.0	35.8
freshwater eutrophication	FEP	mg P eq.	20.6	18.3	2.4
human toxicity, non-cancer	HTP (NC)	g 1,4-DB eq.	43.5	36.6	13.4
ionizing radiation	IRP	Bq Co-60 eq. ⁴	6.9	6.2	9.2
marine ecotoxicity	METP	g 1,4-DB eq.	0.6	0.5	0.1
marine eutrophication	MEP	mg N eq.	2.9	2.7	17.7
metal depletion	MDP	mg Cu eq.	187.7	176.5	1060.0
terrestrial acidification	TAP	mg SO ₂ eq.	149.1	137.4	532.0
terrestrial ecotoxicity	TETP	g 1,4-DB eq.	57.1	52.0	187.0

¹ characterisation factor at midpoint; ² Impact of the German grid mix according to the GaBi DB process "DE: Electricity grid mix ts" with the reference year 2016 (valid until 2022); ³ Fine Particulate Matter Formation; ⁴ Bq Co-60 eq. to air.

References

Hauck, M., Ligthart, T., Schaap, M., Boukris, E., Brouwer, D., 2017. Environmental benefits of reduced electricity use exceed impacts from lead use for perovskite based tandem solar cell. *Renew. Energy* 111, 906-913. <https://doi.org/10.1016/j.renene.2017.04.044>