IEA-PVPS Task 12 Life Cycle Inventories and Analysis of PV Systems

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June 2026, Session: How Policy Changes Impact ESG Practices in Solar System Design and Component Sourcing

What is the environmental Performance of PV?

"Carbon free" solar energy?

Toxic PV manufacturing?

Depletion of rare minerals?

Energy pay back time?

Environmental hotspots within the PV value chain?

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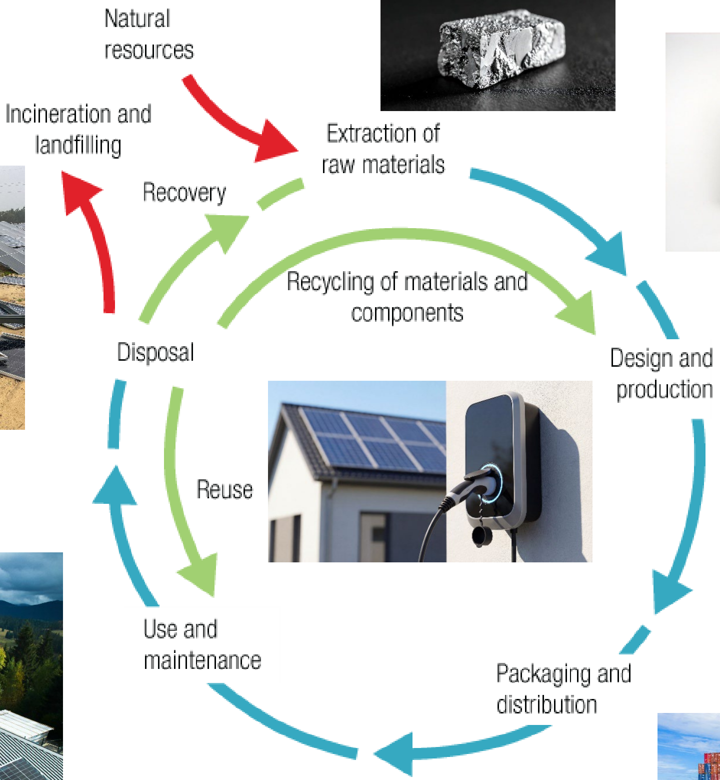
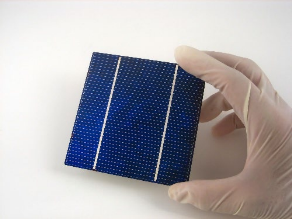
Life Cycle Assessment

A comprehensive method of quantifying material and energy flows, including the associated emissions caused in the life cycle of goods and services.





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IEA PVPS Task 12 – PV Sustainability

The aim of Task 12 is to promote international cooperation and knowledge building in the field of environmental and social sustainability of PV.

Task 12 Subtasks

Subtask 1: Circular Economy (CE)

Subtask 2: Life Cycle Assessment (LCA)

Subtask 3: Ecosystem Integrated PV (ecoPV)

Subtask 4: Broader Sustainability Aspects (BSA)

Task 12 Managers

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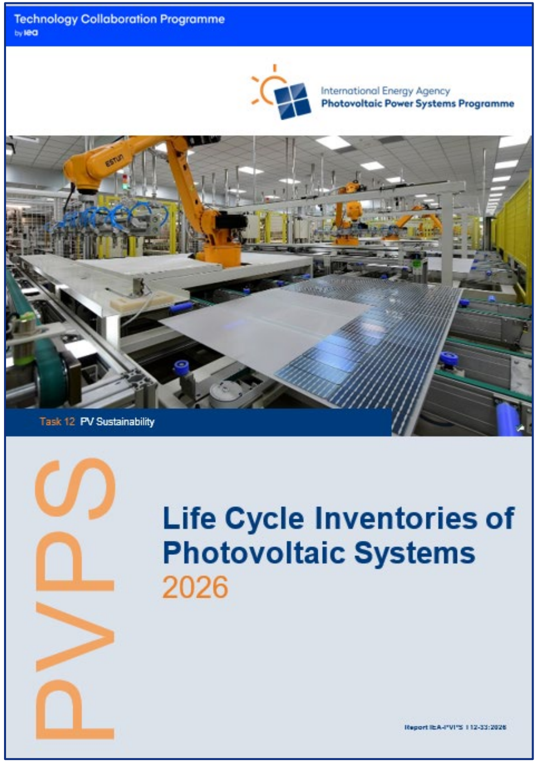
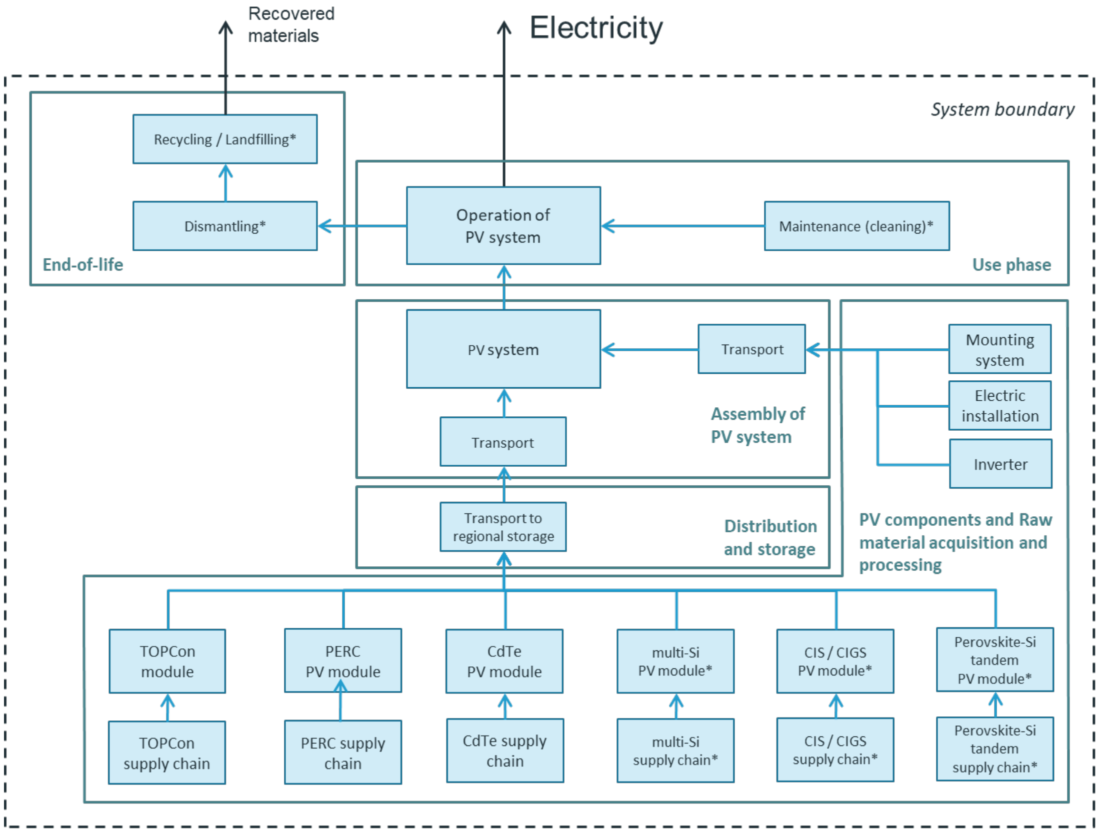
Inventory data and report

- LCI Reports published in 2011, 2015 and 2020
- Latest version is currently under final review and will be released this summer 2026.
- Including spreadsheets with detailed inventories



Götz, M., Deuber, R., Gazbour, N., Brailovsky, P.H., Nold, S., Marchand-Lasserrre, M., Frischknecht, R., Khan, A.A., Bovo, G. Stucki, M. (2026). Life Cycle Inventories of Photovoltaic Systems, Heath, G. (editor), International Energy Agency (IEA) PVPS Task 12, Report T12-33:2026.

PV product system



* Not updated from previous 2020 LCI release

Note: this diagram represents Task 12's entire LCI, not the specific 2026 update.

Life Cycle Inventories of photovoltaic systems

IEA-PVPS inventory report

- In the PVPS report, data on material and energy inputs, as well as emissions and product outputs are collected and modeled separately for the PV modules and the balance of system (BOS).
- The updated datasets have undergone a robust, multi-step quality assurance process.

PV modules

- LCI data were updated for commercial PV modules (TOPCon, PERC and thin-film CdTe). For the TOPCon module supply chain, LCI data are based on a large set of LCAs collected between 2022 and 2025 from Chinese manufacturers in the context of the French PV tender process.
- Data represent different geographic regions of module production and supply chains (China, Europe, North America, and Asia & Pacific).

Balance of system

- BOS data are presented for inverters as well as electrical and structural components of residential, commercial, and utility-scale PV systems.

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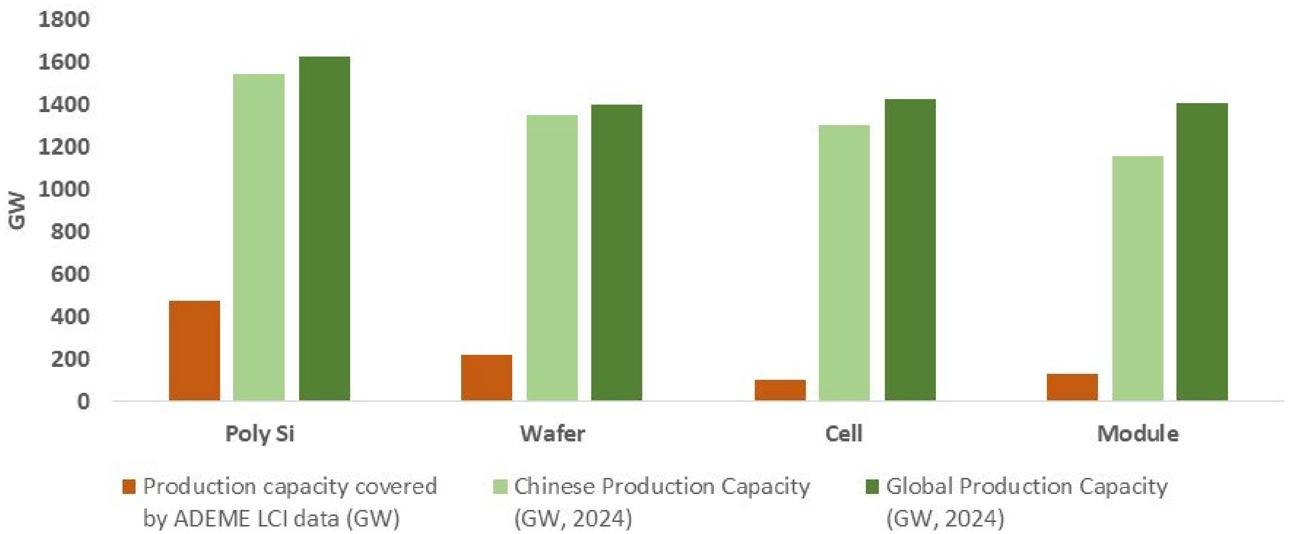
Inventory data from industry and French tender process

- **Public tenders for PV in France** requests manufacturers to provide inventory data.
- Data were reviewed and independently **verified** by control and certification body (CERTISOLIS) as well as **validated** by ADEME.
- LCI data from **83 factories** producing different PV supply chain components were then aggregated, harmonised, anonymised and provided to IEA PVPS for life cycle inventory modelling and publishing.



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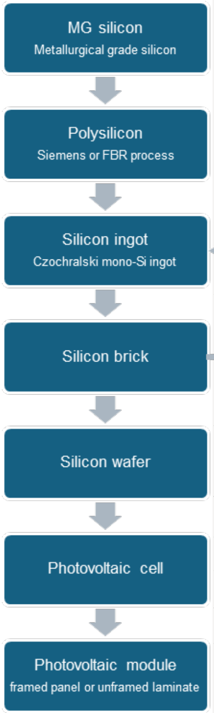
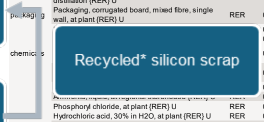
Additional data sources

- **CdTe thin film module** manufacturing from First Solar
- **Inverters** from anonymised global manufacturers
- **Market shares** at different stages in value chain from IEA-PVPS
- **Module efficiencies** for TOPCon and PERC: ITRPV (2025)
- **Background data** from open-source BAFU LCI database (2025)

Results: inventory tables

- Detailed **data tables** with all material and energy inputs and outputs for each process in the PV value chain.
- Data for MG-Si, solar-grade Si, recycled Si, ingot, brick, wafer, TOPCon & PERC cell, module from 83 factories producing different PV supply chain components.
- Data for inverter, electric installations, rooftop, facade and open ground installations etc.
- Data can be imported into LCA software and used to assess various environmental impact categories in different scenarios.





	Name	Location	InfrastructureProcess	Unit	Photovoltaic cell, single-Si, TOPCon, LPCVD, at plant {CN} U	Photovoltaic cell, single-Si, TOPCon, PECVD, at plant {CN} U	Photovoltaic cell, single-Si, TOPCon, LPCVD, at plant {US} U	Photovoltaic cell, single-Si, TOPCon, PECVD, at plant {US} U	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN	US	US			
	InfrastructureProcess				0	0	0	0			
	Unit				m2	m2	m2	m2			
	Photovoltaic cell, single-Si, TOPCon, LPCVD, at plant {CN} U	CN	0	m2	1	0	0	0			
	Photovoltaic cell, single-Si, TOPCon, PECVD, at plant {CN} U	CN	0	m2	0	1	0	0			
	Photovoltaic cell, single-Si, TOPCon, LPCVD, at plant {US} U	US	0	m2	0	0	1	0			
	Photovoltaic cell, single-Si, TOPCon, PECVD, at plant {US} U	US	0	m2	0	0	0	1			
	Single-Si wafer, photovoltaics, TOPCon, at plant {CN} U	CN	0	m2	1.08E+0	1.10E+0	0	0	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Single-Si wafer, photovoltaics, TOPCon, at regional storage {US} U	US	0	m2	0	0	1.08E+0	1.10E+0	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
materials	Metallization paste, front side, at plant {RER} U	RER	0	kg	1.50E-3	1.87E-3	1.50E-3	1.87E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Metallization paste, back side, at plant {RER} U	RER	0	kg	1.43E-3	1.47E-3	1.43E-3	1.47E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Steel, low-alloyed, at plant {RER} U	RER	0	kg	4.98E-4	4.98E-4	4.98E-4	4.98E-4	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Ethanol, 99.7% in H2O, from biomass, at distillation {RER} U	RER	0	kg	3.79E-5	1.18E-3	3.79E-5	1.18E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
packaging	Packaging, corrugated board, mixed fibre, single wall, at plant {RER} U	RER	0	kg	2.78E-2	1.96E-2	2.78E-2	1.96E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	[illegible]	[illegible]	0	kg	4.85E-2	1.73E-2	4.85E-2	1.73E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender) plastic pallet + plastic total
	[illegible]	[illegible]	0	p	4.19E-4	4.08E-4	4.19E-4	4.08E-4	1	1.07	(2,1,1,2,1,1); Industry data (French tender) 1p pallet = 25kg
chemicals	[illegible]	[illegible]	0	kg	1.22E-4	2.64E-4	1.22E-4	2.64E-4	1	1.07	(2,1,1,2,1,1); Industry data (French tender) TMA
	[illegible]	[illegible]	0	kg	3.01E-2	8.09E-2	3.01E-2	8.09E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender) Additive
	[illegible]	[illegible]	0	kg	7.86E-5	6.37E-3	7.86E-5	6.37E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Ammonia, liquid, at regional storehouse {RER} U	RER	0	kg	1.31E-2	1.29E-2	1.31E-2	1.29E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Phosphoryl chloride, at plant {RER} U	RER	0	kg	6.24E-4	0	6.24E-4	0	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Hydrochloric acid, 30% in H2O, at plant {RER} U	RER	0	kg	3.09E-2	5.61E-2	3.09E-2	5.61E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender) in H2O iso without water
	Nitric acid, 50% in H2O, at plant {RER} U	RER	0	kg	0	1.12E-2	0	1.12E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Hydrogen fluoride, at plant {GLO} U	GLO	0	kg	2.43E-1	2.33E-1	2.43E-1	2.33E-1	1	1.07	(2,1,1,2,1,1); Industry data (French tender) in H2O iso without water
	Sodium hydroxide, 50% in H2O, mercury cell, at plant {RER} U	RER	0	kg	9.47E-2	1.86E-1	9.47E-2	1.86E-1	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Hydrogen peroxide, 50% in H2O, at plant {RER} U	RER	0	kg	3.73E-1	2.98E-1	3.73E-1	2.98E-1	1	1.07	(2,1,1,2,1,1); Industry data (French tender) in H2O iso without water
	Phosphane, at plant {GLO} U	GLO	0	kg	0	2.24E-4	0	2.24E-4	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
gases	Oxygen, liquid, at plant {RER} U	RER	0	kg	3.08E-2	3.73E-2	3.08E-2	3.73E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Argon, liquid, at plant {RER} U	RER	0	kg	1.20E-4	1.67E-3	1.20E-4	1.67E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Helium, at plant {GLO} U	GLO	0	kg	0	1.61E-6	0	1.61E-6	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Nitrogen, liquid, at plant {RER} U	RER	0	kg	7.11E-1	7.77E-1	7.11E-1	7.77E-1	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	silane, at plant {RER} U	RER	0	kg	4.89E-3	7.11E-3	4.89E-3	7.11E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Ammonia, liquid, at regional storehouse {RER} U	RER	0	kg	6.56E-3	9.03E-3	6.56E-3	9.03E-3	1	1.07	(2,1,1,2,1,1); Industry data (French tender) proxy for nitrous oxide
water	Tap water, water balance according to MoeK 2013, at user {CN} U	CN	0	kg	1.21E+2	1.19E+2	0	0	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Tap water, water balance according to MoeK 2013, at user {US} U	US	0	kg	0	0	1.21E+2	1.19E+2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
energy	Electricity, medium voltage, at grid {CN} U	CN	0	kWh	1.66E+1	1.99E+1	0	0	1	1.07	(2,2,1,1,1,3); Woodhouse et al. (2019): c-Si PV Manufacturing Costs 2018
	Electricity, medium voltage, at grid {US} U	US	0	kWh	0	0	1.66E+1	1.99E+1	1	1.07	(2,2,1,1,1,3); Woodhouse et al. (2019): c-Si PV Manufacturing Costs 2018
infrastructure	Ancillary building, wafer factory, steel, simulated data {DE} U	DE	1	p	1.57E-9	7.08E-10	1.57E-9	7.08E-10	1	3.00	(2,1,1,2,1,1); Industry data (French tender) converted to ancillary building modelled by Brailovsky (2026); contains metal working machine
	Cell factory, steel construction, simulated data {DE} U	DE	1	p	6.30E-9	2.84E-9	6.30E-9	2.84E-9	1	3.00	(2,1,1,2,1,1); Industry data (French tender) converted to cell factory modelled by Brailovsky (2026); contains metal working machine
transport	Transport, freight, lorry, fleet average {RER} U	RER	0	tkm	4.37E-1	4.11E-1	4.37E-1	4.11E-1	1	2.09	(4,5,na,na,na,na); Transport distance: 100km; wafer: 200km; disposal: 500km, weight EUR-flat pallet 25kg
	Transport, freight, rail {RER} U	RER	0	tkm	4.34E-1	4.79E-1	4.34E-1	4.79E-1	1	2.09	(4,5,na,na,na,na); Transport distance: 200km
disposal	Treatment, PV cell production effluent, to wastewater treatment, class 3 {CH} U	CH	0	m3	1.09E-1	1.07E-1	1.09E-1	1.07E-1	1	1.34	(3,4,4,3,1,5); Calculation: 90% of tap water
	Disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U	CH	0	kg	2.17E-1	1.71E-1	2.17E-1	1.71E-1	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Disposal, municipal solid waste, 22.9% water, to sanitary landfill {CH} U	CH	0	kg	4.16E-3	4.24E-4	4.16E-3	4.24E-4	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
	Disposal, hazardous waste, 25% water, to hazardous waste incineration {CH} U	CH	0	kg	7.59E-2	2.60E-2	7.59E-2	2.60E-2	1	1.07	(2,1,1,2,1,1); Industry data (French tender)
emission air, high population	Heat, waste	-	-	MJ	5.97E+1	7.16E+1	5.97E+1	7.16E+1	1	1.40	(4,4,4,3,1,5); Calculation based on electricity use
	Water, CN	-	-	kg	1.21E+1	1.19E+1	0	0	1	1.69	(4,4,4,3,1,5); Assumption: 10% evaporation of process water; Frischknecht & Büsser Knöpfel (2013)
	Water, US	-	-	kg	0	0	1.21E+1	1.19E+1	1	1.69	(4,4,4,3,1,5); Assumption: 10% evaporation of process water; Frischknecht & Büsser Knöpfel (2013)
	Aluminium	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.11	(2,3,4,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen fluoride	-	-	kg	1.38E-4	1.38E-4	1.38E-4	1.38E-4	1	1.63	(2,3,4,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Lead	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.11	(2,3,4,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	3.17E-8	3.17E-8	3.17E-8	3.17E-8	1	5.11	(2,3,4,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of

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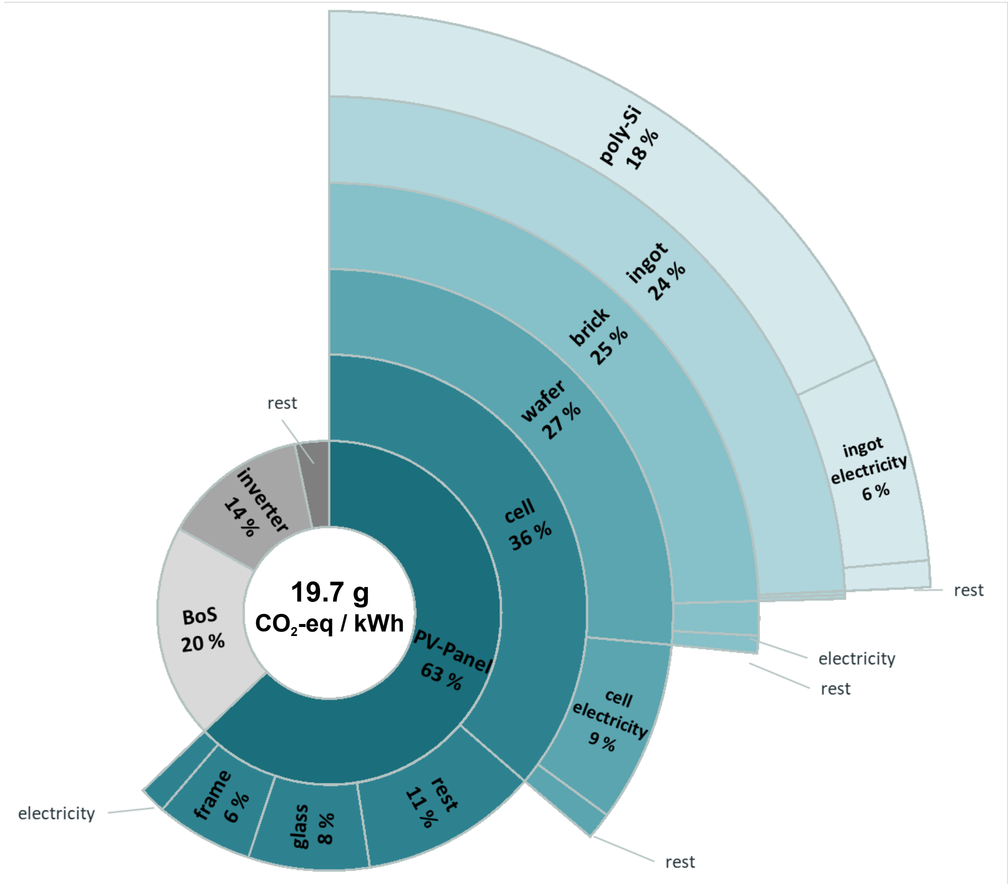
Supply chain contributions to climate impact of electricity from mono-Si residential PV in Central Europe

total mono-Si system GHG emissions
19.7 g CO_2-eq / kWh

mono-Si module GHG emissions
12.4 g CO_2-eq / kWh



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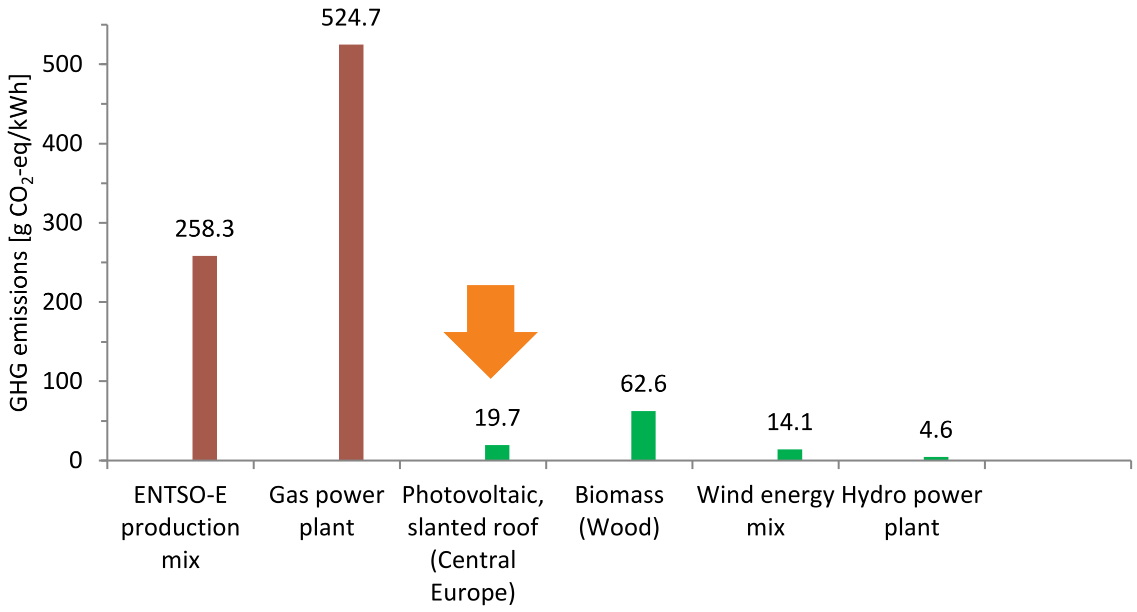
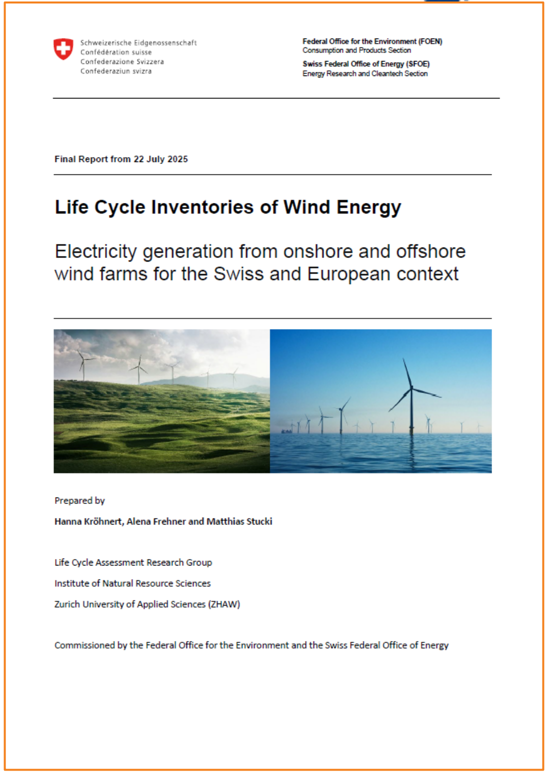
10 kW_p Rooftop systems in Central Europe: 1000 kWh/kW_p. Including degradation (linear, 0.7%/a). 60 % TOPCon and 40 % PERC modules reflecting 2024 market shares. To adjust results for a degradation rate of 0.5 %/a multiply results by 0.968; while for a degradation rate of 0.9 %/a, multiply results by a factor of 1.053. Service life: 30 years (panel), 15 years (inverter)

Wind and PV as Low Carbon Technologies

Updated and published LCI of wind energy.

→ PV and Wind are corner stones of the energy turnaround and decarbonization of the electricity mix.

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Federal Office for the Environment (FOEN)
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Energy Research and Cleantech Section

Final Report from 22 July 2025

Life Cycle Inventories of Wind Energy

Electricity generation from onshore and offshore wind farms for the Swiss and European context

Prepared by

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Commissioned by the Federal Office for the Environment and the Swiss Federal Office of Energy

https://doi.org/10.21256/zhaw-33947

Conclusion

IEA PVPS Task 12 publishes comprehensive life cycle **inventory data for analysing the environmental performance** of solar energy

The updated datasets have undergone a robust, multi-step **quality assurance process**. Representativeness is strong but not uniform.

Data and report will be published **open-source** this summer 2026.

Tender policies like in France support **transparency in sustainability** of the PV sector.

With LCA **environmental hotspots** in PV value chains can be identified and addressed with **Eco-Design** iea-pvps.org

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IEA PVPS

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Task 12 PV Sustainability
IEA PVPS

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