Fact sheet

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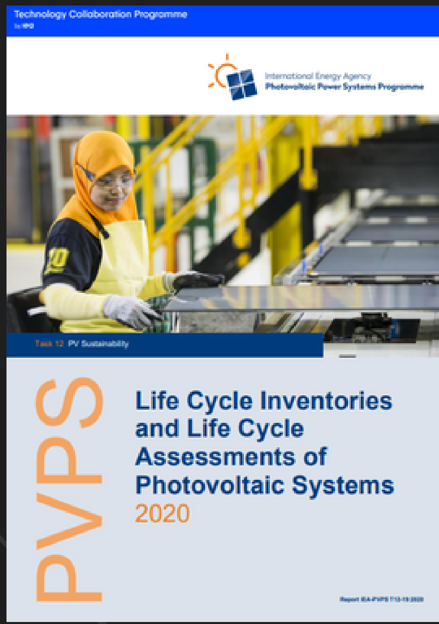

Environmental life cycle assessment of electricity from PV systems

2021 DATA UPDATE

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PV POWER SYSTEMS TASK 12

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IEA PVPS

Life Cycle Assessment

PV Life Cycle Assessment (LCA) is a structured, comprehensive method of quantifying and assessing material and energy flows and their associated emissions from:

01 **Manufacturing** - resource extraction, raw material production, wafer, cell and panel production

02 **Transport** - distribution and storage

03 **Installation** - roof mounting and cabling

04 **Use** - over a 30 year period and maintenance (with water)

05 **End of Life** - dismantling, recycling, waste management

PV Scope

The scope of this study represents an **average residential PV system**:

- 1 kW AC power, produced with a 3 kWp roof-mounted PV system in Europe
- Scope includes PV panel, cabling, mounting structure, inverter and system installation
- 975 kWh/kWp annual production
- Linear degradation 0.7%pa[1]
- Service life: Panel 30 yrs, Inverter 15 yrs

This study includes four PV module technologies with the following efficiencies:

1. Cadmium-Telluride (CdTe) 18.2%
2. Copper-Indium-Gallium-Selenide (CIS/CIGS) 17.0%
3. Multi crystalline Silicon (multi-Si, BSF[2]) 18.0%
4. Mono crystalline Silicon (mono-Si, BSF[2]) 20.0%

1. As per current Task 12 LCA methodology (IEA-PVPS T12-18:2020). Results can be adjusted by assuming a linear relationship with the degradation rate dependent yield. For a degradation rate of 0.5% pa simply multiply results by a factor of 0.968; while for a degradation rate of 0.9% pa multiply results by a factor of 1.053.
2. LCI data on more recent technologies such as PERC are not yet available.

Payback Time

Non renewable energy payback time is defined as the period required for a renewable energy system to generate the same amount of energy (in terms of non renewable primary energy equivalent) that was used to produce the system itself:

	UNIT	Mono-Si	Multi-Si	CIS	CdTe
NREPBT	Year	1.2	1.2	1.3	0.9

Environmental Impacts

The **carbon emissions** associated with the generation of 1 kWh of solar electricity from PV systems are far lower than emissions from fossil fuel generators, which can emit up to 1 kg of CO2 per kWh.

	UNIT	Mono-Si	Multi-Si	CIS	CdTe
Greenhouse gas emissions	g CO2 eq	42.9	44.0	35.4	25.5
Resource use, fossil fuels	MJ	0.51	0.52	0.51	0.35
Resource use, minerals and metals	mg Sb eq	5.21	5.30	4.64	5.23
Particulate matter	10^{-9} disease incidences	3.85	3.88	1.19	0.94
Acidification	mmol H+ eq	0.36	0.37	0.21	0.18
Water scarcity	l water eq	4.49	3.90	3.13	2.09
Module efficiency	%	20.0	18.0	17.0	18.2
DATA		2019-2021		2010/2020	2019-2020

Environmental Impact Changes

Changes in the environmental impact of 2021 PV systems relative to 2018 data are included in the table below. Percentages above 100% are results of an increase in environmental impacts, while percentages below 100% are results of a decrease in environmental impacts compared to the previous data.

	Mono-Si	Multi-Si	CIS	CdTe
Greenhouse gas emissions	101%	104%	97%	96%
Resource use, fossil fuels	95%	97%	94%	92%
Resource use, minerals and metals	99%	99%	100%	99%
Particulate matter	106%	110%	86%	87%
Acidification	101%	103%	93%	93%
Water scarcity	100%	103%	97%	95%

Key changes compared to 2018 data

Crystalline silicon PV panels

- Increased panel efficiency (leading to a decrease in life cycle environmental impacts)
- Higher thermal energy demand in polysilicon production (increase in impacts)
- Increased share of Chinese and Asian producers of cells and wafers (increase in impacts)

CIS PV panels

- increased panel efficiency (decrease in impacts)

CdTe PV panels

- Increased panel efficiency (decrease in impacts)
- Increased manufacturing efficiency - material and energy (decrease in impacts)

Evolution of greenhouse gas emissions over time

This table shows the **changes of greenhouse gas emissions** from the electricity produced by a rooftop residential PV system in Switzerland, using mono-crystalline technology. The reduction in emissions is due to increases in efficiency and improvements in the manufacturing process.

	UNIT	1996	2003	2007	2014	2016	2020	2021
Greenhouse gas emissions	g CO_2 eq/kWh	121	72	76	80	107	43	43
Module efficiency	%	13.6	14,8	14.0	14.0	15.1	19.5	20.0
Yield	kWh/a	862	882	922	922	882	976	976

Task 12 Objectives

- Quantify the **environmental profile of PV** in comparison to other energy technologies;
- Define and address **environmental health & safety and sustainability issues** that are important for market growth.

Sub tasks:

1. End of Life of PV Systems
2. Environmental Life Cycle Assessment (LCA)
3. Other PV sustainability topics

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International Energy Agency
Photovoltaic Power Systems Programme

Download the Report **here**.

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