



Activities in Task 12 and beyond

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Uster, 23 November 2021

Technology Collaboration Programme
by **iea**

Task 12 activities, state October 2021



PVPS

Subtask	Description	
1	Recycling and end-of-life management of PV Systems	
1.1	LCA-TEA of current generation recycling	ongoing
1.2	Lessons from e-waste management	completed
1.3	End-of-life decision support tool	ongoing
2	Life cycle assessment	
2.1	Update of the methodological LCA guidelines on Photovoltaic Electricity (4 th / 5 th edition)	completed
2.2	Net energy analysis methodological guidelines (2 nd edition)	completed
2.3	Primary Mineral Resource intensity of PV	under ExCo review
2.4	Web service on environmental assessment of PV (version 2 / 3)	on hold
2.5	LCA of PV with storage	completed
2.6	LCA of recycling technologies	ongoing
2.7	LCI data and report (2 updates)	completed/ongoing
2.8	Factsheet on Environmental LCA of PV Electricity	completed/ongoing
2.9	LCA of PERC technology	started/ongoing
2.10	Carbon footprint of floating solar systems compared to land-based solar systems	started/ongoing
2.11	Review of metals supply chain criticalities	started/ongoing
3	Broader sustainability topics	
3.1	Quantifying Social and Economic Aspects of PV	completed (interim rep.)
3.2	human health risk assessment methods for PV	completed
3.3	PV sustainability standards	started/ongoing

Life cycle based resource use of PV electricity



FACT SHEET

Environmental life cycle assessment of electricity from PV systems

PV POWER SYSTEMS TASK
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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.

- 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 30 years and maintenance (with wafer)
- 05 End of life - dismantling, recycling, waste management

PV scope



- The scope of this study represents:
- 1 kWh AC energy, produced in Europe
 - Scope includes PV panel, cabling and system installation
 - 975 kWh/kWp annual production
 - Linear degradation 0.7%/p.a.
 - Service life: Panel 30 yrs. Inverter 10 yrs.

This study includes four PV module technologies:

1. Cadmium-Telluride (CdTe) 18%
2. Copper-Indium-Gallium-Selenide (CIS/CIGS) 19%
3. Multi-crystalline Silicon (multi-Si, BSF) 18%
4. Mono-crystalline Silicon (mono-Si, BSF) 19%

Resources

Reports: Life Cycle Inventories and Life Cycle Assessment
Publications: IEA PVPS Task 12 - <https://iea-pvps.org/>

* As per current Task 12 LCA methodology (IEA-PVPS T12-1) linear relationship with the degradation rate dependent yield. If results by a factor of 0.966, while for a degradation rate of 0.9

Environmental Impacts

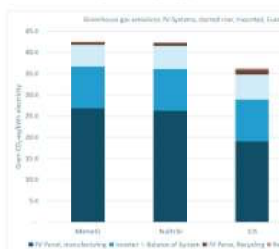
The carbon emissions associated with the generation of PV systems are far lower than emissions from fossil fuels. 1 kg of CO₂ per kWh.

	unit	Mono-Si	Multi-Si
Greenhouse gas emissions	g CO ₂ -eq	425	427
Resource use, fossil fuels	MJ	0.34	0.5
Resource use, minerals and metals	mg Pb _{eq}	0.26	0.3
acid-equivalent	10 ⁻⁶ tonnes H ₂ SO ₄ eq	3.67	3.5
acidification	mg SO ₂ eq	0.28	0.3
water scarcity	l water req.	7.40	6.7
terrestrial ecotoxicity	%	195	181
Date:		2017-2018	

Emissions Contribution

Almost all emissions from the PV life cycle are through production. There is little impact from end-of-life activities and air operation.

This is in direct contrast to fossil and nuclear power plants, which have significant emissions through their ongoing operation and fuel extraction.



Environmental Impact Improvements

The environmental impact of 2016 PV systems relative to 2011 systems:

	Mono-Si	Multi-Si	CIS	CdTe
Greenhouse gas emissions	402%	637%	79.0%	94.8%
Resource use, fossil fuels	445%	66.1%	79.6%	95.9%

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
IREPBT	year	1.2	1.2	1.3	0.9

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

Task 12 was initiated by Brookhaven National Laboratory under the auspices of the U.S. Department of Energy and is now operated jointly by the National Renewable Energy Laboratory (NREL) and the University of New South Wales (UNSW). Support from DOE and UNSW are gratefully acknowledged.

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Life cycle based Resource Use of PV electricity



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- Goal and Scope
 - Assess life cycle based resource use impacts of PV electricity
 - 1 kWh PV electricity, produced with residential scale PV system installed on a pitched roof in Europe
 - Panel technologies: crystalline Silicon (mono, multi), CdTe
 - Cradle to grave (resource extraction, panel manufacture, operation, end of life)
- Indicators:
 - *Abiotic Resource Depletion Potential, ultimate reserves* (recommended): relative contribution to the depletion of resources.
 - *Abiotic Resource Depletion Potential, economic reserves* (suggested): potential resource availability issues related to resource scarcity.
 - *Surplus Ore Potential* (interim recommended): relative consequences of the contribution to changing resource quality.
 - *ESSENZ* (integrated method to assess resource efficiency; interim recommended): potential resource accessibility issues related to short-term geopolitical and socio-economic aspects.

Resource use of PV electricity: main contributing metals and minerals



Relative contribution of different metals and minerals to the resource use impacts of 1kWh PV electricity, quantified with the Abiotic Depletion Potential (ADP), ultimate reserves, the Abiotic Depletion Potential (ADP), economic reserves, the Surplus Ore Potential (SOP) and the resource criticality indicator ESSENZ, per kWh AC electricity produced with residential scale PV systems operated in central Europe;

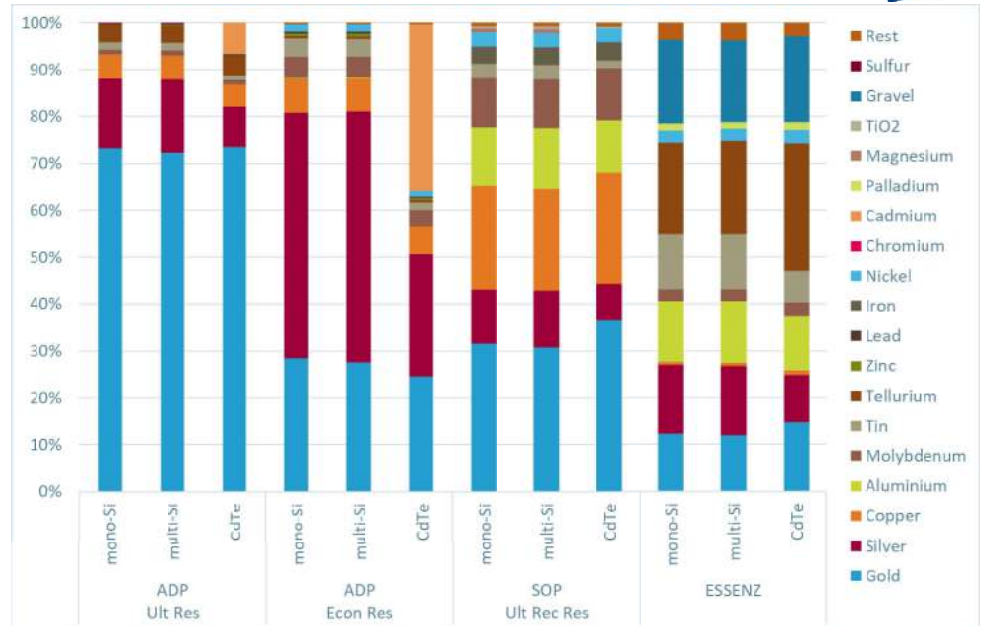
Characteristics of the PV system:

residential scale, pitched roof; average annual yield over lifetime: 975 kWh/kWp (incl. degradation);

Lifetime:

panel: 30 years;

inverter: 15 years.



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Swiss research project: Active glass façades



Grosspeter Tower, Basel



Flumroc, Flums



Viridén+Partner, Zurich



Rudolf, Thun



Solaris 416, Zurich



Setz, Möriken

Stolz P., Krebs L., Frischknecht R., Urena Hunziker D. and Muntwyler U. (2021) Life Cycle Assessment of Active Glass Façades. Commissioned by the Federal Office for the Environment (FOEN), the Federal Office of Energy (SFOE) and the City of Zurich, Office of Building Construction (AHB), Uster and Burgdorf, Switzerland.

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Goal and scope

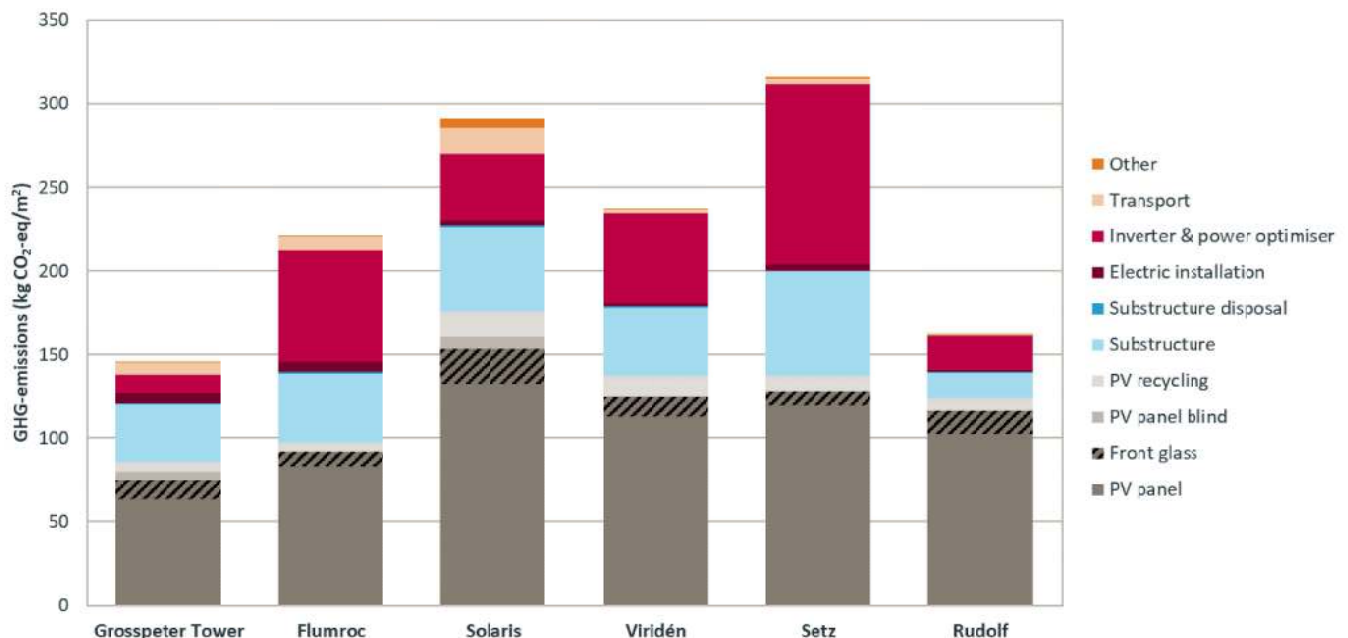


- Quantify the environmental impacts of active glass façades and roofs of 6 buildings and of 8 façade systems
- Reference unit: m² façade and kWh AC electricity (building case studies only)
- System boundary includes (*: considered in building case studies only)
 - Panel
 - Supporting structure
 - Cabling*
 - Inverter*
 - Power optimisers*
- Allocation
 - Building: panel front glass, supporting structure
 - PV electricity: panel (except front glass), cabling, inverters, power optimisers

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Buildings: Greenhouse gas emissions per m² glass façade

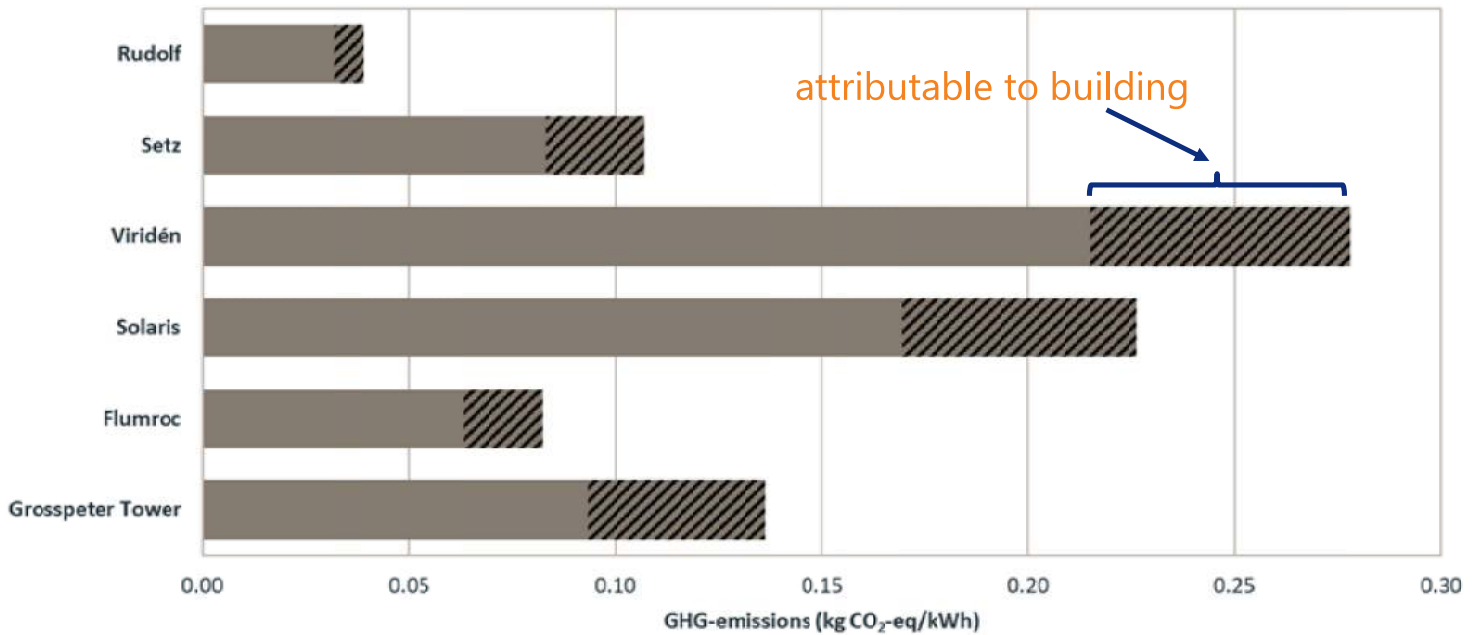


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Stolz et al. (2021)

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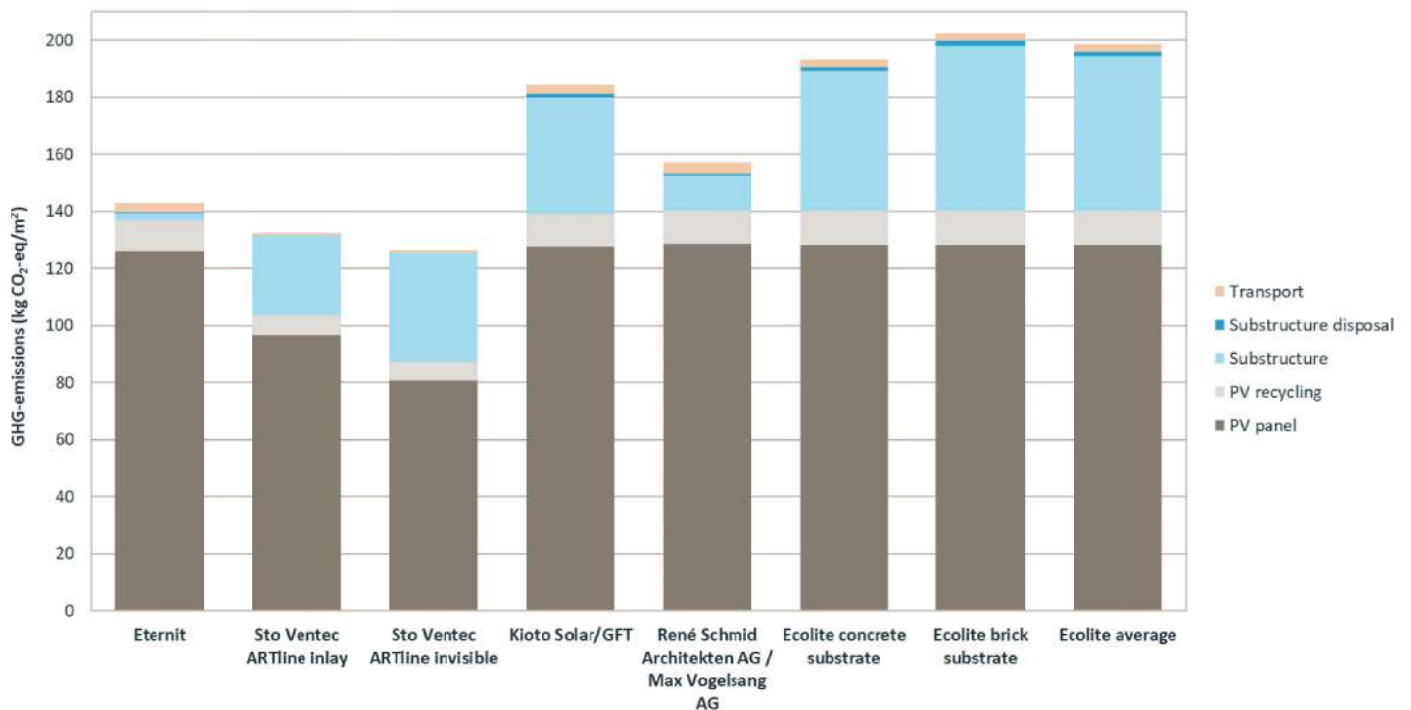
Buildings: Greenhouse gas emissions per kWh electricity



PV

Stolz et al. (2021) 9

Façade systems: Greenhouse gas emissions per m² glass façade



DVDC