



# IEA PVPS Task 12 – PV Sustainability – International collaboration enabling more sustainable photovoltaics

**Quality and Sustainability of PV Systems Conference**  
European Technology & Innovation Platform Photovoltaic  
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# Motivation

- Task 12 provides a common platform to scientifically elaborate sustainability aspects of PV systems and exchange insights amongst a variety of stakeholders.
- The global energy transition towards a decarbonized energy system will see unprecedented growth rates in the deployment of photovoltaic power systems towards double-digit terawatt levels in the next two decades.
- This requires a conscious reflection of the broader impacts of supply chain, manufacturing and deployment on the environment and on societies with various levels and models of PV uptake and penetration.



# Active Contributors

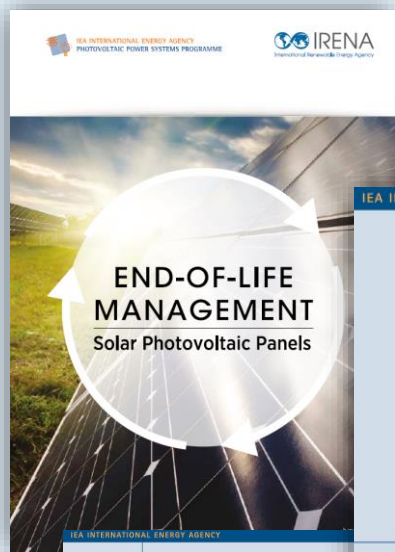
- Susanne Schidler, Fachhochschule Technikum Wien, Austria
- Zhang Jia & Hailing Li, Chinese Academy of Sciences, China
- Isabelle Blanc, MINES Paris Tech, France
- Keiichi Komoto, Mizuho; Japan
- Teiji Minami, NEDO, Japan
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- Jin-Seok Lee, Korea Institute of Energy Research, South Korea
- Linda Kaneryd, Swedish Energy Agency, Sweden
- Marco Raugei, Spain
- Natalia Caldes Gomez, CIEMAT, Spain
- Rolf Frischknecht, treeze, Switzerland
- Carol Olson, ECN, The Netherlands
- Garvin Heath, NREL, USA
- Parikhit Sinha, First Solar, USA
- Jose Bilbao, UNSW, Australia

**12 Countries, 1 Industry Association,  
3 new countries prospected (Chile,  
Denmark, Germany, South Africa)**



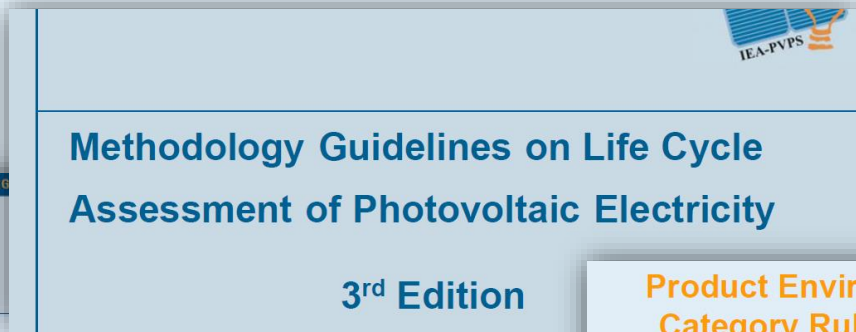


# WORK PERIOD 2013-2017



IEA INTERNATIONAL ENERGY AGENCY

## END-OF-LIFE MANAGEMENT Solar Photovoltaic Panels



## Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity

3<sup>rd</sup> Edition

### Life Cycle Assessment of Future Photovoltaic Electricity Production from Residential-scale Systems Operated in Europe

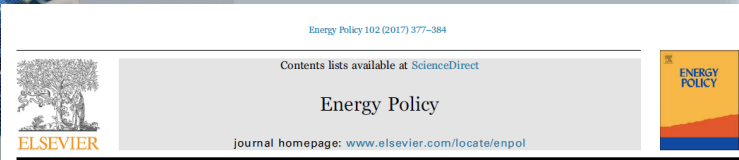


## Product Environmental Footprint Category Rules (PEFCR) for PV



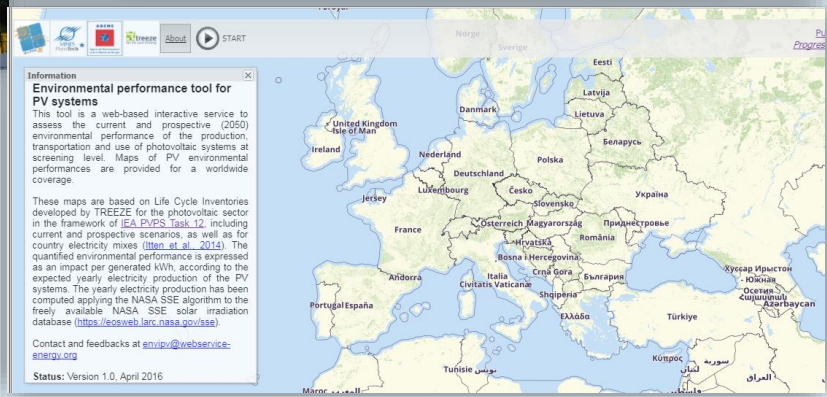
Product Environmental Footprint Category Rules  
PHOTOVOLTAIC MODULES USED IN PHOTOVOLTAIC POWER SYSTEMS FOR ELECTRICITY GENERATION (NACS/CPA class 27.90 "Manufacturing of other electrical equipment")

### Photovoltaics and Firefighters Best Practices in Selected Countries



### Energy Return on Energy Invested (EROEI) for photovoltaic solar systems in regions of moderate insolation: A comprehensive response

Marco Raugel<sup>a,b,\*</sup>, Sgouris Sgouridis<sup>c</sup>, David Murphy<sup>d</sup>, Vasilis Pthenakis<sup>b,e</sup>, Rolf Frischknecht<sup>f</sup>, Christian Breyer<sup>g</sup>, Ugo Bardi<sup>h</sup>, Charles Barnhart<sup>i</sup>, Alastair Buckley<sup>j</sup>, Michael Carbajales-Dale<sup>k</sup>, Denes Csala<sup>l</sup>, Mariska de Wild-Scholten<sup>m</sup>, Garvin Heath<sup>n,o</sup>, Arnulf Jaeger-Waldau<sup>p</sup>, Christopher Jones<sup>q</sup>, Arthur Keller<sup>r</sup>, Enrica Lecisi<sup>s</sup>, Pierluigi Mancarella<sup>t</sup>, Nicola Pearsall<sup>u</sup>, Adam Siegel<sup>v</sup>, Wim Sinke<sup>w</sup>, Philippe Stolz<sup>x</sup>



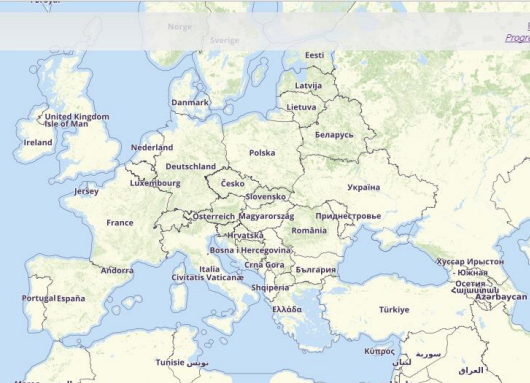
#### Information Environmental performance tool for PV systems

This tool is a web-based interactive service to assess the current and prospective (2050) environmental performance of the production, transportation and use of photovoltaic systems at screening level. Maps of PV environmental performances are provided for a worldwide coverage.

These maps are based on Life Cycle Inventories developed by TREEZE for the photovoltaic sector in the framework of IEA PVPS Task 12, including current and prospective scenarios, as well as for country electricity mixes (Iltis et al., 2014). The quantified environmental performance is expressed as an impact per generated kWh, according to the expected yearly electricity production of the PV systems. The yearly electricity production has been computed applying the NASA SSE algorithm to the freely available NASA SSE solar irradiation database (<https://seweb.larc.nasa.gov/sse/>).

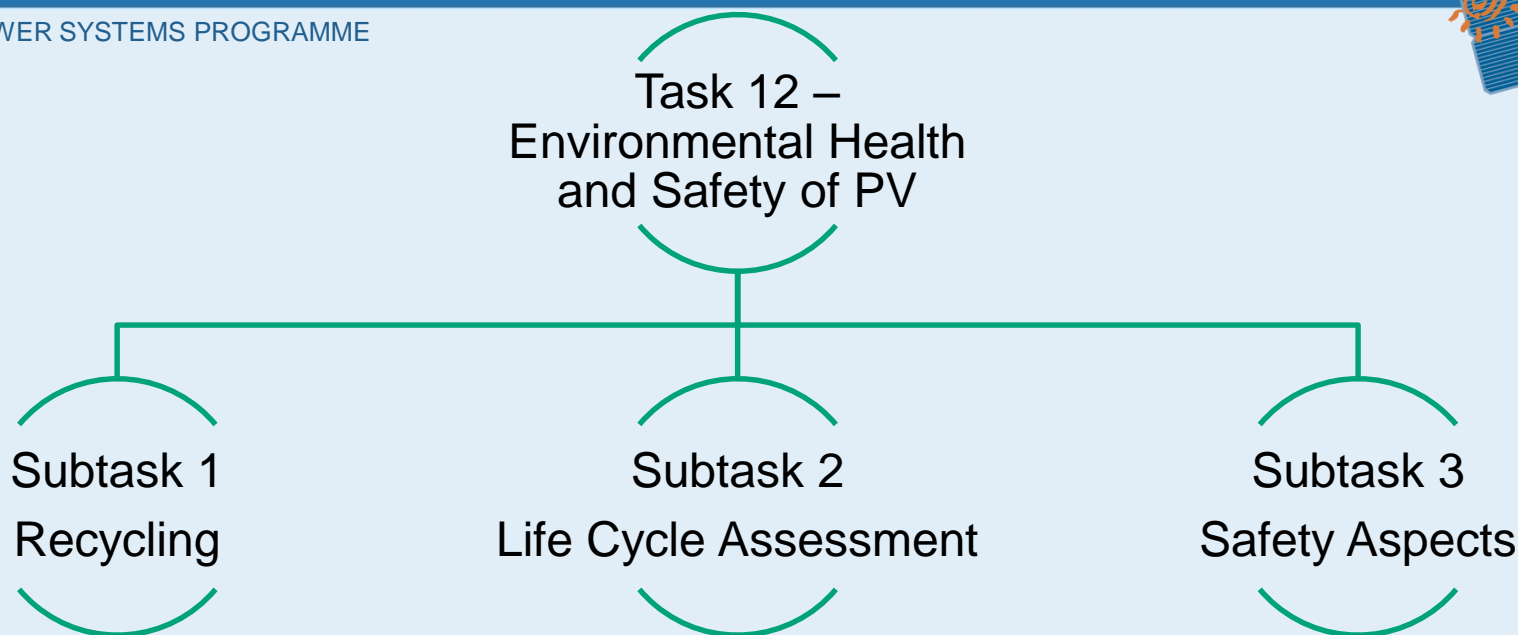
Contact and feedbacks at [enpv@webseience-energy.org](mailto:enpv@webseience-energy.org)

Status: Version 1.0, April 2016



PVPS  
PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME  
Report IEA-PVPS



IEA PVPS T12 / IRENA Report	3rd Edition of LCA Methodology Guidelines	Firefighters Safety Report
Recycling Life Cycle Inventories	Successful completion of EU PEF Pilot Phase with PEFCR & Screening Study	IEC PV Sustainability and EHS risk assessment – Technical Report
Recycling Life Cycle Assessments	Life Cycle Inventory updates (Global Supply Chain, Balance of System, PV panels)	
Recycling Technology Developments & Patent Analysis	Net Energy methodological guidelines	
2 Side Events on Life Cycle Management	Prospective LCA for 2050	
Support of development of NSF 457 Sustainability Leadership Standard	Water use and Water Footprint of PV	
Support of development of EN50625-2-4 & -3-5	ENVI PV Webservice	
Numerous publications	Screening of social and socio-economic impact indicators	



# WORK PERIOD 2017-2022

## Task 12 PV Sustainability

Recycling and End-of-life management

Life Cycle Assessment

Other Sustainability Topics





# Subtask 1 - Recycling

Activity	Deliverable(s)	Target Date(s)
<b>Activity 1.1 – LCA-TEA of current generation recycling</b>	Integrated LCA-TEA (techno-economic analysis) of current generation module recycling technologies (CdTe and C-Si); build from prior workplan's LCI	CdTe: 2018 C-Si: 2019 (depending on funding)
<b>Activity 1.2 – lessons from e-waste</b>	Technology and regulatory/management lessons from e-waste that are transferable to module recycling	2018
<b>Activity 1.3 - end of life decision support tool</b>	A tool (spreadsheet or web-based) for operators of large-scale PV power plants to consider economic and environmental trade-offs of different end of life options (retain, repair, sell to secondary market, recycle) applicable in world regions; with case studies	1. Tool: 2019 2. Case studies: 2021
<b>Activity 1.4: BOS end of life management</b>	Review of regulatory requirements and options, including projection of waste volume, for balance of system components including electronics and to the point of interconnection (using Task 12/IRENA report as a model)	2020
<b>Activity 1.5: module design for recycling</b>	[Scope under discussion after changing activity leader]	TBD



# Subtask 2 – LCA

Activity	Deliverable(s)	Target Date(s)
<b>Activity 2.1: LCA methodological guidelines</b>	Timing to be based on availability of material for updating – we envision 2 within this work period: 4 <sup>th</sup> edition (potential additional topics: recycling, BiPV electricity; plus other updates); 5 <sup>th</sup> edition (potential new topics?)	4 <sup>th</sup> : TBD 5 <sup>th</sup> : TBD
<b>Activity 2.2: Net energy analysis methodological guidelines</b>	2 <sup>nd</sup> edition: Method guidelines report update	TBD (timing dependent on policy and research community need)
<b>Activity 2.3: Primary Mineral Resource intensity of PV</b>	apply UNEP/LCI Harmonization project method development to PV case study (perhaps ending with ENVI-PV visualization)	2020
<b>Activity 2.5: LCA of PV with storage</b>	LCA of PV with different storage devices and scales 1. Residential scale with Li-ion batteries 2. Utility scale	1. 2019 2. 2019
<b>Activity 2.6: LCA of recycling technologies</b>	Focus on dedicated PV recycling technologies 1. LCI 2. LCA	1. 2021 2. 2022





# Subtask 3 – Other Sustainability Topics

Activity	Deliverable(s)	Target Date(s)
Activity 3.1: Case Studies for Quantifying Social and Economic Aspects of PV	case studies applying indicators identified in 2017	2019
Activity 3.2: Human health risk assessment methods for PV	Exposure assessment framework for a few key scenarios (e.g., fire, broken module, disposal)	2020
Activity 3.3: PV sustainability standards	Review of PV sustainability standards, tender requirements, investor grading and how they can enable market expansion and maturation and considering experience with other relevant products	2020
Activity 3.4: PV as contributor to Intended Nationally Determined Contributions (INDC) from COP21 agreement	case study for specific country(ies) - PV's role towards meeting the INDC targets	2021



# Recent Task 12 Deliverables

## ➤ Subtask 1: Recycling

1. *Technology trends in private and public sectors as observed through analysis of patents and public-sector R&D plans*
2. *LCA of recycling technologies*

## ➤ Subtask 2: LCA

2. *LCI report updates*
  - Water use in PV life cycle
  - PV module recycling
  - Global supply chain updates
  - Inverters
  - Emerging PV technologies (e.g., perovskite)
3. *LCI of current generation c-Si and CdTe recycling*
4. *Water footprint of PV*
5. *EC PEFCR – accepted to EUPVSEC and PIP*
6. *Methods for Quantifying Social and Economic Aspects of PV*



# Task 12 Support of PV Sustainability Leadership Standard Development

- NSF 457 – Sustainability Leadership Standard for PV Module Manufacturing (ANSI)
  - Comprehensive framework for the establishment of product sustainability performance criteria and corporate performance metrics that exemplify sustainability leadership in the market with third party verification
  - Aims to enable easier specification of high sustainability performance in large purchase contracts of PV modules
    - Potentially adopted by Green Electronics Council for EPEAT registry
  - Involvement of T12 experts in the working groups
  - Published December, 2017



# Task 15 Cooperation

- Continued dialogue with Task 15 subtask D – environmental assessment methods for of BiPV
- Proposal that BiPV generation of electricity be added as a topic within Task 12's LCA guidelines and Task 15 to develop BiPV in the context of a building's LCA as their independent advancement.

# Task 13 Cooperation

- Involve Task 13 experts as sounding board for new Life Cycle Inventory data for reality checks
- Cooperation on supply chain transparency and interrelated topics on lifetime, quality and reliability – as those aspects are very important for meaningful life cycle assessment parametrization



# Future Collaboration with IEA TCP SHC

- Planning to launch a new Task on “LCA of solar heating and cooling technologies”.
- French T12 expert attended a preparatory workshop held in France in April 2018.



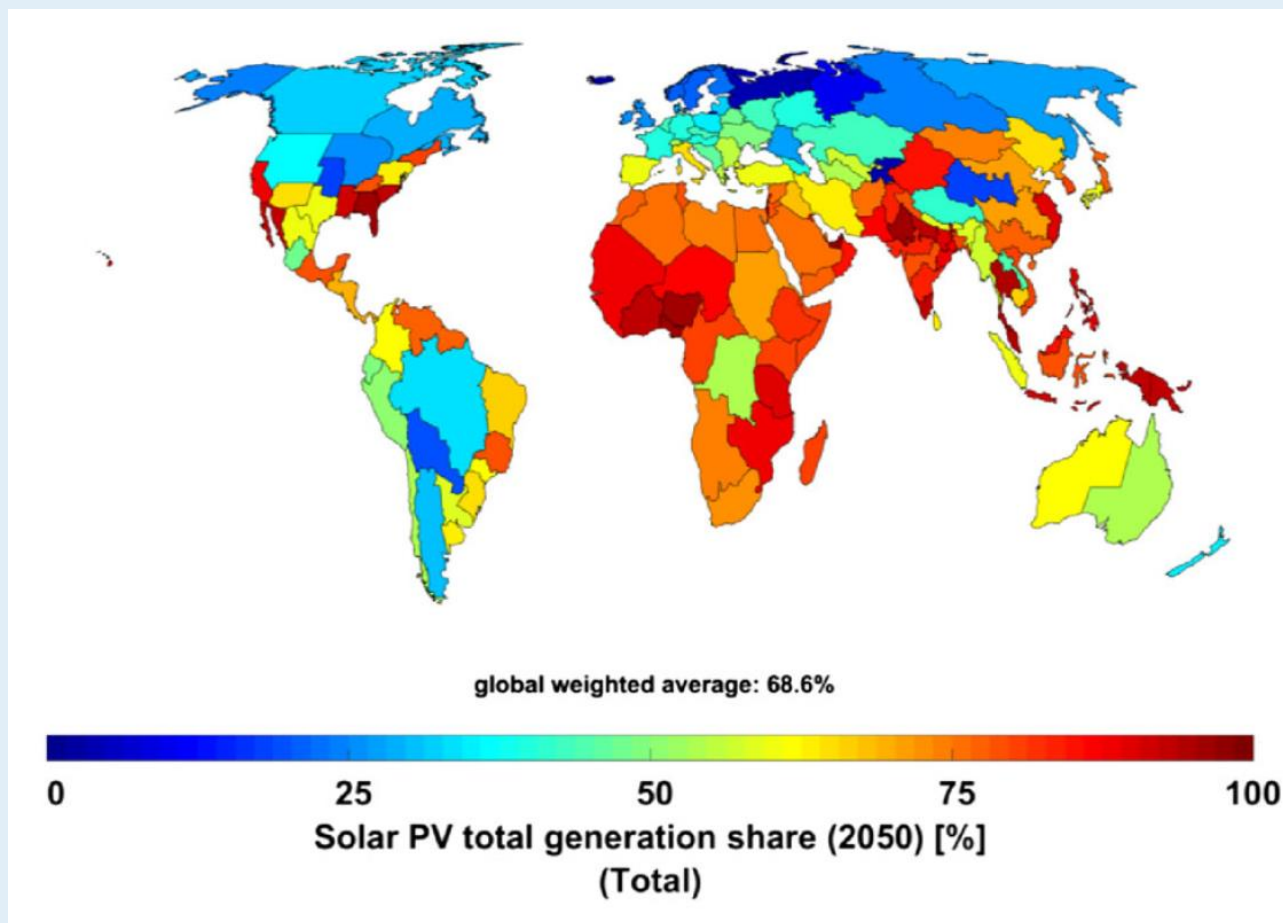
# Future Task 12 Meetings/Workshops

- WCPEC workshop – R&D Roadmap for c-Si module recycling
  - 8:30-10 am, Thursday
- Task 12 expert meeting: Sydney, Australia
  - Week of November 26, 2018





# Thank You!



## A Picture of the Future ...

Source: Breyer et.al. (2017)., „ Solar photovoltaics demand for the global energy transition in the power sector “, 10.1002/pip.2950