epddanmark

ECO PLATFORM EPD VERIFIED

Owner: SolarLab.dk ApS
No.: MD-23108-EN
Issued: 25-08-2023
Valid to: 25-08-2028

3rd PARTY **VERIFIED**

EPD

VERIFIED ENVIRONMENTAL PRODUCT DECLARATION | **ISO 14025 & EN 15804**



Owner of declaration
SolarLab.dk ApS
Industrivej 8
8260 Viby J, Denmark
CVR: 34720975

Programme
EPD Danmark
www.epddanmark.dk

☐ Industry EPD
☒ Product EPD

Declared Product
Building-integrated photovoltaic (BIPV) façade cladding. Material composition represents an average product for the year 2022.

Number of declared datasets: 2

Production Site
Industrivej 8, 8260 Viby J, Denmark

The product is not manufactured using green certificates (GO) for the energy consumption in A3.

Product Use
The product is a building integrated photovoltaic (BIPV) façade cladding with the function of producing electricity and serving as rain-screen in the building envelope.

Declared Unit
1 Wp of manufactured building-integrated photovoltaic (BIPV) module, with processes at construction and end-of-life stage.

Year of production site data (A3)
2022

EPD version
[1], July 2023

Issued: 25-08-2023
Valid to: 25-08-2028

Basis of calculation
This EPD is developed in accordance with the European standard EN 15804:2012+A2:2019:.

Comparability
EPDs of construction products may not be comparable if they do not comply with the requirements in EN 15804:2012+A2:2019. EPD data may not be comparable if the datasets used are not developed in accordance with EN 15804:2012+A2:2019 and if the background systems are not based on the same database.

Validity
This EPD has been verified in accordance with ISO 14025:2010 and is valid for 5 years from the date of issue.

Use
The intended use of an EPD is to communicate scientifically based environmental information for construction products, for the purpose of assessing the environmental performance of buildings.

EPD type
☐Cradle-to-gate with modules C1-C4 and D
☒Cradle-to-gate with options, modules C1-C4 and D
☐Cradle-to-grave and module D
☐Cradle-to-gate
☐Cradle-to-gate with options

CEN standard EN 15804:2012+A2:2019 serves as the core PCR

Independent verification of the declaration and data, according to EN ISO 14025:2010.

☐ internal ☒ external

Third party verifier:



Linda Høibye, Life Cycle Assessment Consulting



Martha Katrine Sørensen
EPD Danmark

Life cycle stages and modules (MND = module not declared)

Product			Construction process		Use							End of life				Beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport	Installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Re-use, recovery and recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	X

Product Information

Product Description

The product assessed in this study is a building-integrated photovoltaic (BIPV) façade cladding produced by SolarLab ApS. The declared product is designed and built to integrate as bespoke ventilated facades in the outer layer of the building envelope. In comparison to a traditional photovoltaic module, the BIPV façade cladding hence serves as a rain-screen for the building envelope with the added benefit of producing electricity. Moreover, the declared product can be customized to fit the specific design and aesthetic requirements of the building, with options for different colors, shapes and finishes. Additional information regarding the declared product can be obtained on the website of SolarLab.dk ApS:

- **Website:** https://solarlab.global/

The main product components are shown in the table below. Materials account for 100% of the mass of the declared product.

Material	Weight-% of product
Satinated glass (low iron)	64.1%
Aluminum frame	16.0%
EVA encapsulant	5.0%
Aluminum rails	4.4%
PET backsheet	3.3%
Photovoltaic cells	2.5%
Adhesives	1.2%
Wiring	1.0%
Steel backplate	1.0%
Aluminum hangers	0.9%
Rivets and screws	0.6%
Total	**100%**

The product packaging is shown in the table below. Materials account for 99.4% of the mass of the product packaging.

Material	Weight-% of packaging
Wood + pallets	90.5%
Cardboard + paper	8.3%
Screws and fittings	0.6%
Total	**99.4%**

Representativity:

This declaration, including data collection and the modelled foreground system including results, represents the production of the declared product manufactured by SolarLab.dk ApS at the production site located in Viby J, Denmark, which is also the representative geographical area. In order to account for the fact, that the BIPV façade elements are manufactured on a project basis (i.e. customized between projects) the material composition represents an average product for the year 2022.

Background data is based on the LCA database ecoinvent 3.9.1, which was updated in 2022 and complies with EN 15804:2012 +A2:2019, section 6.3.8.2, by being less than 10 years old. Generally, the applied background datasets are of reasonable high quality, and the majority of the datasets are only a couple of years old. All most all datasets are from Denmark, Germany, Croatia, Europe or Asia and energy is country specific. Where data quality has been lacking adjustments of the datasets have been performed to ensure representability.

Hazardous Substances:

The declared product by SolarLab.dk ApS does not contain substances listed in the "Candidate List of Substances of Very High Concern for authorization"

(http://echa.europa.eu/candidate-list-table)

Essential Characteristics:

The main technical specifications of the BIPV façade cladding are listed in the tables below:

Mechanical Properties	Unit	Value
Average weight per 1 m^2	kg	15.61
Panel weight per 1 m^2	kg	13-17
Height (installed)	mm	350-3600
Width (installed)	mm	350-2000
Build height	mm	55-400
Glass thickness	mm	3-8
Fire safety classification*	-	B,s1,d0

*C.f. EN 13501-1:2018

Electrical Properties	Unit	Value
Cell type	-	Mono c-Si
Average nominal power*	Wp/m^2	140.35
Nominal power (Full black)	Wp/m^2	180-220
Nominal power (Color)	Wp/m^2	130-200

*Average product in 2022. The square-meter performance of the module depends on the specific format.

Electricity production is regarded as one of the most essential properties of photovoltaics. Here,

it should be noted, that the square-meter performance depends on the specific format of BIPV façade cladding. Moreover, as detailed in NPCR 029:2022 v.1.2, Section 6.2.5, the energy produced by a PV module depends on the installed power peak [Wp], degradation factor, geographic location and direction as well as placement of the installation. Produced electricity over the lifetime of the declared product should therefore be calculated at an individual building level assessment. Please refer to the *Additional Information* for information on electricity production. Technical information can also be obtained by contacting SolarLab.dk ApS or on their website.

Reference Service Life (RSL):

The reference service life (RSL) is declared to be a default period of 25 years as detailed in NPCR 029:2022 v1.2, Section 6.3.3, since no third-party validated report concerning the lifespan of the declared product is provided. It should, however, be noted that the product has multiple functions to fulfill, for which reason two RSL values are applicable:

Energy Producing Unit: Reference service life of 25 years for ≥80% of the labelled power output based on NPCR 029:2022 v1.2, Section 6.3.3.

Façade Cladding: Reference service life of 50 years based on BUILD Report 2021:32, SfB 48(1), by The Department of Built Environment (BUILD) at Aalborg University (AAU).

The RSL values presumes a correct installation (A5) and maintenance (B2) in accordance with the instructions provided by SolarLab.dk ApS.

Pictures of Product:

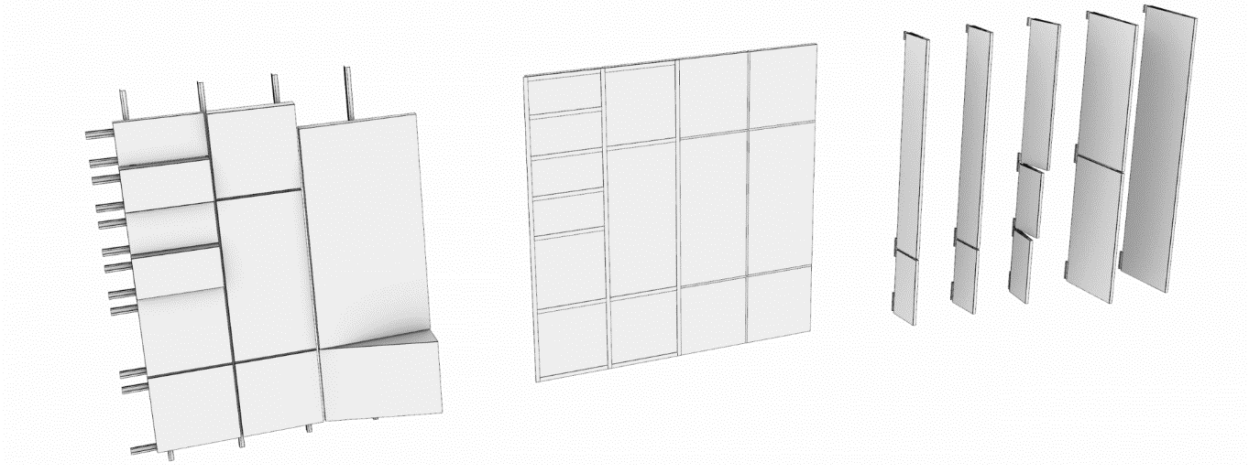


Figure 1: *Example of product variations (rain-screen, louvre, and curtain-wall) available for the customized BIPV façade cladding by SolarLab.dk ApS*



Figure 2: Example of BIPV façade. Copenhagen International School at Nordhavn, Copenhagen, Denmark.

LCA Background

Declared Unit (DU):

As prescribed by NPCR 029:2022 v1.2, Section 6.3.2, the declared unit (DU) is defined as:

1 Wp of manufactured building-integrated photovoltaic (BIPV) module, with processes at construction and end-of-life stage.

Results of this study will be displayed for both the declared unit of 1 Wp and for 1 m² of façade. The following table displays the relevant factors to convert the results from 1 Wp to 1 m² of BIPV module.

Name	Unit	Value
Declared unit	Wp	1
Conversion factor to 1 kg	Wp/kg	8.93
Conversion factor to 1 m²	Wp/m²	140.35

Product Category Rules (PCR):

This EPD is developed according to the core product category rules (PCR) for construction products detailed in EN 15804:2012+A2:2019, and the following two complementary standards:

- NPCR 029:2022 v1.2 – Part B for photovoltaic modules
- NPCR 010:2022 v2.0 – Part B for building boards

Guarantee of Origin – certificates

The declared product is not produced using guarantees of origin (GOs) for the energy consumption during the manufacturing stage (A3) at SolarLab.dk ApS in 8260 Viby J, Denmark.

Foreground System:

The production at SolarLab.dk ApS (A3) and their suppliers of photovoltaic laminate is modelled based on site-specific data. The electricity consumption is modelled as a residual supply mix in Denmark. The remaining activities are modelled with average supply mixes representing the individual countries (e.g. HR, CN & DE) or regions (e.g. EU & rest of world) pertaining to the specific processes in the value chain. Additional LCI data from Latunussa et al. (2016) and the Danish Environment Agency (2019) is used in modelling end-of-life scenario (C1-C4).

Background System:

The database, ecoinvent 3.9.1, (published in 12-2022) is utilized for the background system. As a result, both upstream- and downstream activities are based on average supply mixes for the specific country or region depending on the given dataset. Upstream datasets for photovoltaics have been further adjusted to accurately represent the geography of the value chain and energy consumption has been modified to represent present production practices based on Frischknecht et al. (2020).

System Boundary:

This EPD is based on a cradle-to-gate with options scope and covers the life cycle modules A1-A3, A4-A5, C1-C4, and D, in which 100 weight-% of the product has been accounted for.

The general rules for the exclusion of inputs and outputs follows the requirements specified in EN 15804:2012+A2:2019, Section 6.3.6, where the total of neglected input flows per module shall be a maximum of 5 % of energy usage and mass and 1 % of renewable and non-renewable primary energy usage and mass for unit processes. In addition, particular care has been taken to include materials and flows known to have the potential to cause significant emissions into air, water and soil related to the environmental indicators assessed in this study. In this respect, conservative assumptions in combination with plausibility considerations and expert judgement has been used to demonstrate compliance with this criterion.

Product stage (A1-A3):

The product stage comprises the acquisition of all raw materials, products and energy, transport to the production site, packaging and waste processing up to the ”end-of-waste” state or final disposal. The LCA results are declared in aggregated form for the product stage, which means, that the sub-modules A1, A2 and A3 are declared as one module A1-A3.

The declared product consists of a photovoltaic laminate with satinated glass, mono c-SI cells and an ethylene-vinyl acetate (EVA) encapsulant. Overall, the BIPV façade system consists of three core elements: (i) an outer façade panel, (ii) an aluminum mounting solution, and (iii) an electrical system that connects the BIPV system to the buildings electrical system.

The production facilities of SolarLab.dk ApS are utilized for assembly. In this respect, the

activities of SolarLab.dk ApS primarily consist of assembling a series of components into the final product ready for transportation to the building site. Because of this, no specific process heat or water is utilized at the facility and internal transport exclusively consists of electric forklifts. Energy consumption is evenly allocated between the surface area (m²) of products by SolarLab.dk ApS during the year 2022, since no single product can be attributed more energy than another.

Construction Stage (A4-A5):
The transportation between SolarLab.dk ApS at Industrivej 8, 8260 Viby J, Denmark, and the building site can generally be classified as batches through direct sales with an assumed distance of 300 km. It should be recognized that the installation process will vary depending on the specific building. While assumptions for lift operation, based on average site data, are included in this EPD (See *Additional Information*), the following ancillary components are not and should instead be considered at the building level assessment as prescribed by the standard NPC 029:2022. V1.2 for photovoltaic modules, Section 6.2.3:

- Wiring
- Switches
- Solar inverters
- Battery banks
- Battery charger
- Screws, fasteners and other additional materials
- Materials for the mounting system of the module
- Other electrical components and systems necessary to connect the photovoltaic module to the electrical grid
- Personnel activities and transport of personnel

Additionally, NPCR 010:2022 V2.0 for building boards, Section 6.2.3, specifies that fasteners and other additional ancillary materials shall not be included in the EPD.

Use Stage (B1-B7):
The use stage (B1-B7) is not included within the scope of this EPD. Furthermore, it should be noted, that the electricity produced by photovoltaics depends on the installed power peak [Wp], degradation factor, geographic location and cardinal direction of the installation. The electricity production of the BIPV façade cladding by SolarLab.dk ApS should therefore be calculated at a building level assessment. Please refer to the *Additional Technical Information* in this EPD or Section 6.2.5 in NPCR 029:2022 v1.2 for an overview of how the electricity production of the declared product can be calculated.

End of Life (C1-C4):
The deconstruction of the products covered by this study is assumed to be done manually with exception of lift operation. The lift operation will vary depending on the building but is assumed to be the same as the installation process in this EPD. The collection and waste treatment of photovoltaics is regulated by EU's Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE). This entails a structured system of waste collection due to the extended producer responsibility, which means that the developers and importers of photovoltaics are responsible for the product throughout the whole lifetime. For the waste treatment of the photovoltaic modules, Denmark has no end-processing facilities and only a few pre-processing facilities for electronic waste. As a result, the photovoltaics are exported to Germany for waste treatment. The mechanical treatment in laminated glass recycling plants represents a state-of-the-art process for recycling c-Si modules and the waste processing of the PV modules are therefore assumed to be performed based on these processes. NPCR 029:2022 v.1.2 includes a default conservative scenario for life cycle modules C3 for waste processing and disposal (C4), which is used for the waste treatment of the photovoltaic modules.

Re-use, recovery, & recycling potential (D):
Several of the materials used in the production have potential benefits and load beyond the system boundary. These include the following:

- Silicon – 86% metallurgical grade silicon, 14% loss
- Glass – 100% of the recycled glass is used for insulation
- Aluminum – 95% aluminum (made from virgin ores), 5% loss
- Steel – 95% steel (made from virgin ores), 5% loss
- Copper – 95% copper (made from virgin ores), 5% loss
- Municipal Incineration: 30% electricity (Average), 56% heat (Average), 14% loss.

Electricity generated through the waste incineration at the CHP plant is assumed to replace the average German electricity mix, while thermal energy is utilized as district heating in Germany.

Flowchart:

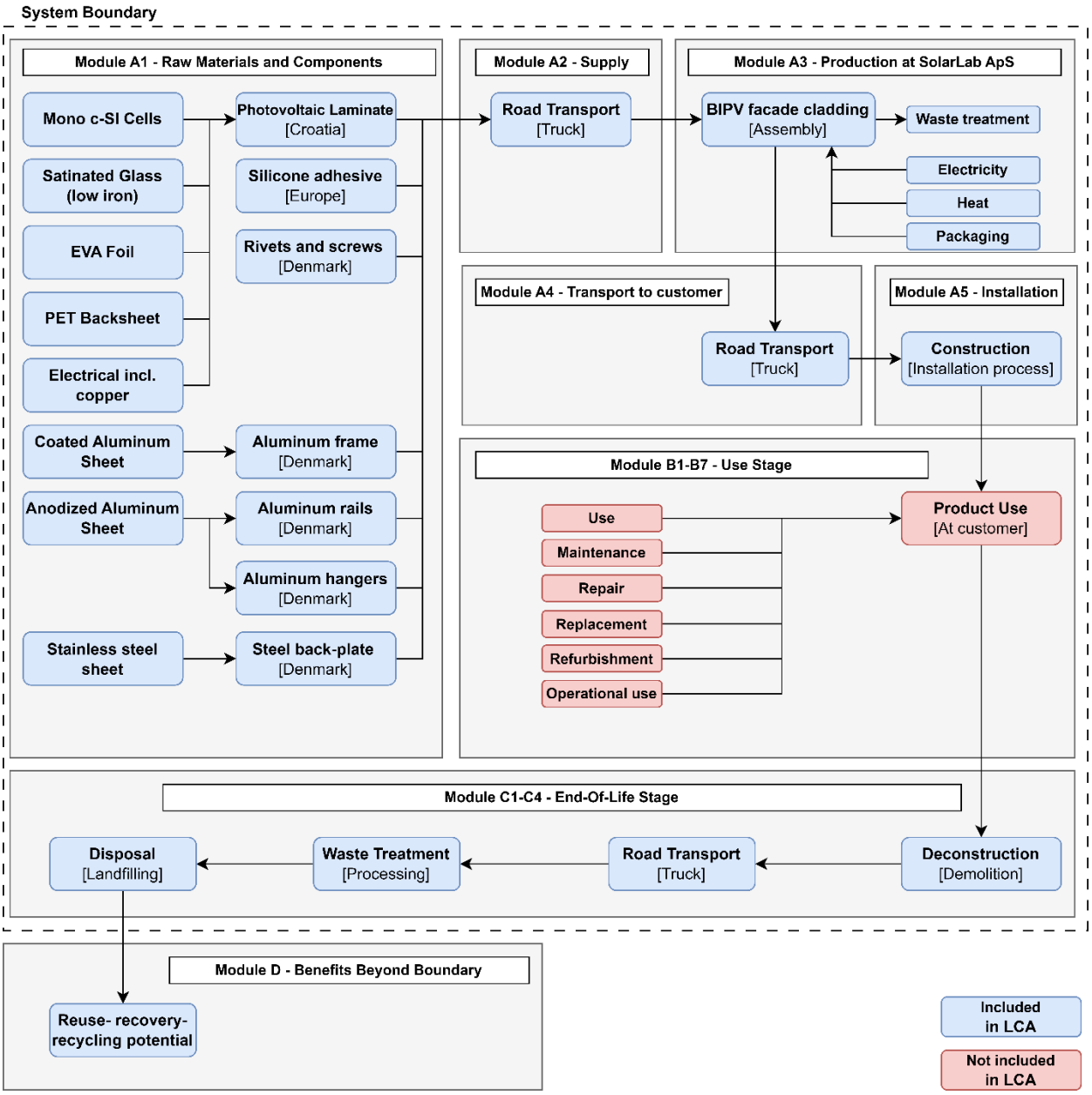


Figure 3: *Product value chain and life cycle diagram for the BIPV façade cladding by SolarLab.dk ApS*

LCA Results

Due to the multiple functions of the BIPV façade cladding, two datasets are presented for the declared product i.e. 1 Wp and 1 m² equivalent to 140.35 Wp. Note that the nominal power output (140 Wp) of the LCIA results per 1 m² should not be exceeded when assessing electricity production at a building level as this may result in over- or underestimation of the environmental impact. See *Additional Information* or contact SolarLab.dk ApS for further guidance on calculating electricity production. The datasets can be found on the following pages:

- **Page 8-9:** 1 Wp of BIPV facade cladding
- **Page 10-11:** 1 m² of BIPV facade cladding (140 Wp)

Results: BIPV façade cladding – 1 Wp

ENVIRONMENTAL IMPACTS PER 1 Wp – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	[kg CO_2 eq.]	1.00E+00	8.04E-03	7.94E-02	3.98E-02	2.17E-02	4.82E-02	4.75E-04	-2.16E-01
GWP-fossil	[kg CO_2 eq.]	1.01E+00	8.03E-03	4.12E-02	3.98E-02	2.16E-02	4.71E-02	4.70E-04	-2.10E-01
GWP-biogenic	[kg CO_2 eq.]	-1.46E-02	6.78E-06	3.82E-02	1.03E-05	2.12E-05	1.12E-03	4.27E-06	-5.05E-03
GWP-luluc	[kg CO_2 eq.]	1.32E-03	3.61E-06	5.33E-06	4.36E-06	1.03E-05	2.01E-05	7.91E-08	-4.61E-04
ODP	[kg CFC 11 eq.]	1.54E-07	1.70E-10	6.43E-10	6.12E-10	4.58E-10	4.18E-10	1.33E-11	-2.57E-09
AP	[mol H^+ eq.]	5.63E-03	2.44E-05	1.45E-04	1.39E-04	6.87E-05	1.03E-03	2.51E-06	-1.69E-03
EP-freshwater	[kg PO_4 eq.]	5.16E-04	5.39E-07	1.52E-06	1.18E-06	1.47E-06	1.47E-05	1.97E-08	-1.43E-04
EP-marine	[kg N eq.]	1.09E-03	8.34E-06	5.94E-05	5.69E-05	2.36E-05	4.44E-04	2.28E-06	-2.29E-04
EP-terrestrial	[mol N eq.]	1.10E-02	8.81E-05	6.35E-04	6.10E-04	2.50E-04	5.15E-03	1.17E-05	-2.43E-03
POCP	[kg NMVOC eq.]	4.76E-03	3.65E-05	2.29E-04	2.21E-04	1.03E-04	1.15E-03	4.62E-06	-7.61E-04
ADPm[1]	[kg Sb eq.]	6.33E-05	2.49E-08	1.72E-08	1.35E-08	6.77E-08	1.40E-06	4.77E-10	-9.48E-06
ADPf[1]	[MJ]	1.29E+01	1.10E-01	5.24E-01	5.04E-01	2.99E-01	2.59E-01	9.76E-03	-2.26E+00
WDP[1]	[m^3 world eq. deprived]	5.56E-01	4.23E-04	1.25E-03	1.11E-03	1.23E-03	4.68E-03	3.73E-05	-4.52E-02
Caption	GWP-total = Global Warming Potential - total; GWP-fossil = Global Warming Potential - fossil fuels; GWP-biogenic = Global Warming Potential - biogenic; GWP-luluc = Global Warming Potential - land use and land use change; ODP = Ozone Depletion; AP = Acidification; EP-freshwater = Eutrophication – aquatic freshwater; EP-marine = Eutrophication – aquatic marine; EP-terrestrial = Eutrophication – terrestrial; POCP = Photochemical zone formation; ADPm = Abiotic Depletion Potential – minerals and metals; ADPf = Abiotic Depletion Potential – fossil fuels; WDP = water use								
Disclaimer	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.								

ADDITIONAL ENVIRONMENTAL IMPACTS PER 1 Wp – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
PM	[Disease incidence]	7.07E-08	5.34E-10	3.66E-09	3.56E-09	1.67E-09	3.00E-09	6.28E-11	-1.35E-08
IRP[2]	[kBq U235 eq.]	1.03E-01	1.78E-04	3.74E-04	2.39E-04	4.00E-04	2.12E-03	1.25E-05	-1.33E-02
ETP-fw[1]	[CTUe]	1.04E+01	4.83E-02	2.23E-01	2.12E-01	1.27E-01	1.98E-01	5.47E-03	-1.16E+00
HTP-c[1]	[CTUh]	5.33E-10	1.67E-12	2.84E-11	2.80E-11	5.07E-12	1.22E-11	9.19E-14	-1.43E-10
HTP-nc[1]	[CTUh]	5.62E-08	3.04E-11	2.52E-10	2.45E-10	8.69E-11	5.79E-09	2.16E-12	-3.06E-09
SQP[1]	-	7.49E+00	5.64E-02	4.27E-02	3.37E-02	1.78E-01	9.21E-02	2.02E-02	-8.53E-01
Caption	PM = Particulate Matter emissions; IRP = Ionizing radiation – human health; ETP-fw = Eco toxicity – freshwater; HTP-c = Human toxicity – cancer effects; HTP-nc = Human toxicity – non-cancer effects; SQP = Soil Quality (dimensionless)								
Disclaimers	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.								
	[2] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.								

RESOURCE USE PER 1 Wp – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	3.45E+00	1.92E-03	3.52E-01	2.87E-03	4.63E-03	2.87E-02	2.60E-04	-3.62E-01
PERM	[MJ]	3.48E-01	0.00E+00	-3.48E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	[MJ]	3.95E+00	1.92E-03	3.96E-03	2.87E-03	4.63E-03	2.87E-02	2.60E-04	-3.62E-01
PENRE	[MJ]	1.23E+01	1.10E-01	5.24E-01	5.04E-01	2.99E-01	5.65E-01	9.76E-03	-2.26E+00
PENRM	[MJ]	3.06E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-3.06E-01	0.00E+00	0.00E+00
PENRT	[MJ]	1.26E+01	1.10E-01	5.24E-01	5.04E-01	2.99E-01	2.59E-01	9.76E-03	-2.26E+00
SM	[kg]	3.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	[m^3]	2.30E-02	1.59E-05	4.96E-05	3.96E-05	4.26E-05	1.87E-04	1.15E-05	-1.86E-03
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Net use of fresh water								

WASTE CATEGORIES AND OUTPUT FLOWS PER 1 Wp – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	9.78E-04	7.00E-07	3.52E-06	3.39E-06	1.90E-06	8.19E-07	4.74E-08	-6.15E-05
NHWD	[kg]	1.84E-01	4.54E-03	2.62E-02	7.22E-04	1.46E-02	8.10E-02	6.60E-02	-3.25E-02
RWD	[kg]	2.67E-05	4.36E-08	8.98E-08	5.53E-08	9.69E-08	5.81E-07	2.83E-09	-3.63E-06
CRU	[kg]	3.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	[kg]	2.71E-03	0.00E+00	1.05E-02	0.00E+00	0.00E+00	3.47E-02	0.00E+00	0.00E+00
MER	[kg]	4.13E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	[MJ]	0.00E+00	0.00E+00	4.06E-02	0.00E+00	0.00E+00	8.71E-02	0.00E+00	0.00E+00
EET	[MJ]	0.00E+00	0.00E+00	1.52E-01	0.00E+00	0.00E+00	1.63E-01	0.00E+00	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy								

BIOGENIC CARBON CONTENT PER 1 Wp – BIPV facade cladding		
Parameter	**Unit**	**At the factory gate**
Biogenic carbon content in product	[kg C]	0.00E+00
Biogenic carbon content in accompanying packaging	[kg C]	1.21E-02
Note	1 kg biogenic carbon is equivalent to 44/12 kg of CO_2	

Results: BIPV façade cladding – 1 m² (140 Wp)

ENVIRONMENTAL IMPACTS PER 1 m² (140 Wp) – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	[kg CO_2 eq.]	1.41E+02	1.13E+00	1.11E+01	5.59E+00	3.04E+00	6.76E+00	6.66E-02	-3.03E+01
GWP-fossil	[kg CO_2 eq.]	1.42E+02	1.13E+00	5.78E+00	5.59E+00	3.04E+00	6.60E+00	6.60E-02	-2.95E+01
GWP-biogenic	[kg CO_2 eq.]	-2.06E+00	9.51E-04	5.36E+00	1.44E-03	2.97E-03	1.57E-01	5.99E-04	-7.09E-01
GWP-luluc	[kg CO_2 eq.]	1.85E-01	5.07E-04	7.48E-04	6.12E-04	1.45E-03	2.82E-03	1.11E-05	-6.47E-02
ODP	[kg CFC 11 eq.]	2.16E-05	2.39E-08	9.02E-08	8.59E-08	6.43E-08	5.87E-08	1.86E-09	-3.60E-07
AP	[mol H^+ eq.]	7.91E-01	3.42E-03	2.04E-02	1.95E-02	9.64E-03	1.45E-01	3.52E-04	-2.38E-01
EP-freshwater	[kg PO_4 eq.]	7.25E-02	7.57E-05	2.13E-04	1.66E-04	2.07E-04	2.06E-03	2.76E-06	-2.01E-02
EP-marine	[kg N eq.]	1.53E-01	1.17E-03	8.34E-03	7.99E-03	3.32E-03	6.23E-02	3.20E-04	-3.21E-02
EP-terrestrial	[mol N eq.]	1.54E+00	1.24E-02	8.92E-02	8.57E-02	3.50E-02	7.22E-01	1.64E-03	-3.41E-01
POCP	[kg NMVOC eq.]	6.68E-01	5.13E-03	3.21E-02	3.10E-02	1.44E-02	1.62E-01	6.48E-04	-1.07E-01
ADPm[1]	[kg Sb eq.]	8.88E-03	3.50E-06	2.42E-06	1.89E-06	9.50E-06	1.97E-04	6.70E-08	-1.33E-03
ADPf[1]	[MJ]	1.81E+03	1.54E+01	7.35E+01	7.08E+01	4.19E+01	3.64E+01	1.37E+00	-3.17E+02
WDP[1]	[m^3 world eq. deprived]	7.80E+01	5.93E-02	1.75E-01	1.56E-01	1.73E-01	6.57E-01	5.23E-03	-6.35E+00
Caption	GWP-total = Global Warming Potential - total; GWP-fossil = Global Warming Potential - fossil fuels; GWP-biogenic = Global Warming Potential - biogenic; GWP-luluc = Global Warming Potential - land use and land use change; ODP = Ozone Depletion; AP = Acidification; EP-freshwater = Eutrophication – aquatic freshwater; EP-marine = Eutrophication – aquatic marine; EP-terrestrial = Eutrophication – terrestrial; POCP = Photochemical zone formation; ADPm = Abiotic Depletion Potential – minerals and metals; ADPf = Abiotic Depletion Potential – fossil fuels; WDP = water use								
Disclaimer	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.								

ADDITIONAL ENVIRONMENTAL IMPACTS PER 1 m² (140 Wp) – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
PM	[Disease incidence]	9.92E-06	7.50E-08	5.14E-07	5.00E-07	2.35E-07	4.21E-07	8.81E-09	-1.90E-06
IRP[2]	[kBq U235 eq.]	1.45E+01	2.50E-02	5.24E-02	3.36E-02	5.61E-02	2.97E-01	1.76E-03	-1.86E+00
ETP-fw[1]	[CTUe]	1.46E+03	6.78E+00	3.13E+01	2.98E+01	1.79E+01	2.78E+01	7.67E-01	-1.63E+02
HTP-c[1]	[CTUh]	7.48E-08	2.34E-10	3.99E-09	3.93E-09	7.11E-10	1.71E-09	1.29E-11	-2.00E-08
HTP-nc[1]	[CTUh]	7.89E-06	4.26E-09	3.53E-08	3.44E-08	1.22E-08	8.13E-07	3.03E-10	-4.30E-07
SQP[1]	-	1.05E+03	7.92E+00	5.99E+00	4.73E+00	2.49E+01	1.29E+01	2.83E+00	-1.20E+02
Caption	PM = Particulate Matter emissions; IRP = Ionizing radiation – human health; ETP-fw = Eco toxicity – freshwater; HTP-c = Human toxicity – cancer effects; HTP-nc = Human toxicity – non-cancer effects; SQP = Soil Quality (dimensionless)								
Disclaimers	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.								
	[2] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.								

RESOURCE USE PER 1 m² (140 Wp) – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	4.85E+02	2.69E-01	4.94E+01	4.03E-01	6.50E-01	4.02E+00	3.65E-02	-5.08E+01
PERM	[MJ]	4.88E+01	0.00E+00	-4.88E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	[MJ]	5.55E+02	2.69E-01	5.56E-01	4.03E-01	6.50E-01	4.02E+00	3.65E-02	-5.08E+01
PENRE	[MJ]	1.72E+03	1.54E+01	7.35E+01	7.08E+01	4.19E+01	7.93E+01	1.37E+00	-3.17E+02
PENRM	[MJ]	4.29E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-4.29E+01	0.00E+00	0.00E+00
PENRT	[MJ]	1.77E+03	1.54E+01	7.35E+01	7.08E+01	4.19E+01	3.64E+01	1.37E+00	-3.17E+02
SM	[kg]	4.30E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	[MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	[m^3]	3.22E+00	2.23E-03	6.96E-03	5.56E-03	5.97E-03	2.62E-02	1.62E-03	-2.61E-01
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Net use of fresh water								

WASTE CATEGORIES AND OUTPUT FLOWS PER 1 m² (140 Wp) – BIPV facade cladding									
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	1.37E-01	9.82E-05	4.94E-04	4.76E-04	2.67E-04	1.15E-04	6.65E-06	-8.63E-03
NHWD	[kg]	2.59E+01	6.37E-01	3.68E+00	1.01E-01	2.05E+00	1.14E+01	9.26E+00	-4.56E+00
RWD	[kg]	3.75E-03	6.12E-06	1.26E-05	7.76E-06	1.36E-05	8.15E-05	3.97E-07	-5.10E-04
CRU	[kg]	4.30E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	[kg]	3.80E-01	0.00E+00	1.47E+00	0.00E+00	0.00E+00	4.87E+00	0.00E+00	0.00E+00
MER	[kg]	5.80E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	[MJ]	0.00E+00	0.00E+00	5.70E+00	0.00E+00	0.00E+00	1.22E+01	0.00E+00	0.00E+00
EET	[MJ]	0.00E+00	0.00E+00	2.14E+01	0.00E+00	0.00E+00	2.28E+01	0.00E+00	0.00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy								

BIOGENIC CARBON CONTENT PER 1 m² (140 Wp) – BIPV facade cladding		
Parameter	**Unit**	**At the factory gate**
Biogenic carbon content in product	[kg C]	0.00E+00
Biogenic carbon content in accompanying packaging	[kg C]	1.70E+00
Note	1 kg biogenic carbon is equivalent to 44/12 kg of CO_2	

Additional Information

Technical Information on Electricity Production:

The electricity production of the photovoltaic modules depends on several variables e.g. installed power peak (Wp), degradation factor, geographic location, and cardinal orientation of the installation. For this reason, the produced electricity over the lifetime of the declared product will vary depending on the specific building project.

As a result, the produced electricity of the BIPV façade cladding is not declared in this environmental product declaration (EPD). Instead, the necessary information is included to calculate the total produced electricity for the given building based on site specific data. For calculating the energy production, the following formulas are applied as specified in NPCR 029:2022, Section 6.2.5:

Energy production for the first year:

$$E_1 = S_{rad} \times A \times y \times PR \times (1 - deg)$$

Energy production for the second year:

$$E_2 = E_1 \times (1 - deg)$$

Energy production for any given year:

$$E_n = E_1 \times (1 - deg)^n$$

Energy production for the full reference service life (RSL):

$$E_{RSL} = E_1 \times \left(1 + \sum_{n=1}^{RSL-1} (1 - deg)^n\right)$$

The following table lists the applied parameters:

Parameter	Description	Unit	Value
S_{rad}	Site specific annual average solar radiation on module (shading not included). The annual radiation must take into consideration the specific inclination (i.e. scope and tilt) and orientation.	kWh/kWp/year	Site specific
A	Total surface area of the active BIPV installation (7.125E-03 m²/Wp)	m²	Site specific
y	Module yield i.e. electrical power of the module under standard test conditions[1] (STC) divided by the area of the module (A) as declared in the EPD.	kWp/m²	0.14535
PR	Performance ratio as a coefficient for losses. Site specific performance ratio can be modelled with PV simulation software tools, e.g. PVSyst or similar, and accounts for losses from inverters, temperatures, DC cables, AC cables, shading, weak radiation, dust, and snow etc. [2]	-	Site specific
deg	Yearly degradation rate. If no data is available, a default linear degradation rate of 0.007 (0.7%) per year is assumed.	%	0.7
n	Year of operation	-	-
RSL	Reference service life of the energy producing unit	years	25

Note that the nominal power output (140 Wp) of the LCIA results per 1 m² should not be exceeded when assessing electricity production at a building level as this may result in over- or underestimation of the environmental impact. Please refer to the Danish Building Code, Technical Provision 11, §297 - §298 and supplementary guidance on the climate impact of buildings provided in Section 1.8 - Emissionsfaktorer for additional information concerning photovoltaic modules in a building level assessment.

LCA Interpretation:

Examining the impact contributions of production activities (A1-A3) for the BIPV façade cladding by SolarLab.dk ApS, it is clear that the manufacturing of both the photovoltaic laminate and aluminum components contributes to a significant part of the overall environmental impact across the majority of indicators. The electricity consumption for the raw material supply and production of components (A1)

[1] The ratio is given for standard test conditions: irradiance 1000 W/m2, cell temperature 25 °C, wind speed 1 m/s, AM1.5.
[2] For guidance on the calculation of site specific performance ratio (PR) please contact SolarLab.dk ApS.

appears as the most dominant contributor within the product system – in particular the production of photovoltaic cells for the PV laminate. Impacts concerning global warming from fossil sources (GWP-fossil), eutrophication (EP), and abiotic depletion of fossil fuels (ADPf) can largely be prescribed to the notable share of fossil energy sources in electricity supplies (e.g. China). Here emissions can be attributed to the Chinese electricity supply with a particular emphasis on the mining and combustion of hard coal. In addition, a notable portion of emissions are associated with the manufacturing of components consisting of aluminum (i.e. frame, rails, and hangers) with a particular emphasis on acidification (AP) and global warming from land use and land-use change (GWP-luluc). It should, however, be recognized that the manufacturing of aluminum components also has a notable impact on the aforementioned indicators such as GWP-fossil.

Limited impact is seen from the production stage (A4-A5), which is considered relative arbitrary, as it will largely depend on the specific construction project. Concerning the waste treatment (C1-C4), a limited impact is seen in comparison to the production stage (A1-A3). Lastly, benefits and loads beyond the system boundary (D) is counteracting ≈10-20% of the impact for most impact categories throughout the entire life cycle. These avoided impacts are caused by the recycling of silicon, aluminum, and steel as well as energy generated through municipal incineration of waste materials (e.g. plastics). While glass makes up the majority of the product mass, it is attributed a limited share of avoided impacts since the majority (90%) is assumed to end of in landfills due to impurities from recycling activities.

Technical Information on Scenarios:

A4 - Transport to the building site	Unit	Value
Fuel type	-	Diesel
Vehicle type	-	Truck (7.5-16 ton)
Classification	EURO5	-
Transport distance	km	300
Capacity utilization (including empty runs)	%	32.9

A5 - Installation	Unit	Value
Description of installation	-	Description
Operating hours of lift	h/m²	0.4
Waste materials (packaging)	kg/m²	3.5

C1-C4 - End of life	Unit	Value
For reuse	kg/m²	0.0
For recycling	kg/m²	4.9
For energy recovery	kg/m²	1.4
For final disposal	kg/m²	9.3

D - Re-use, recovery and recycling potential	Unit	Value
Municipal incineration at CHP facility (DE)		
Electricity	%	30%
Heat	%	56%
Loss	%	14%
Recycling – Photovoltaic cells (DE)		
Metallurgical grade silicon	%	86%
Loss	%	14%

Indoor Air:

The EPD does not give information on release of dangerous substances to indoor air because the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonized test methods according to the provisions of the respective technical committees for European product standards are not available.

Soil and Water:

The EPD does not give information on release of dangerous substances to soil and water, because the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonized test methods according to the provisions of the respective technical committees for European product standards are not available.

References

Publisher	epddanmark www.epddanmark.dk Template version 2023.1
Programme operator	Danish Technological Institute Buildings & Environment Gregersensvej DK-2630 Taastrup www.teknologisk.dk
LCA-practitioner	NIRAS NIRAS A/S Østre Havnegade 12 DK-9000, Aalborg www.niras.dk Project manager: Yana Ramsheva LCA practitioners: Asbjørn Uldbjerg Bundgaard QA/internal review: Jesper Jakobsen
LCA software /background data	SimaPro 9.5.0.0 ecoinvent 3.9.1 (Published d. 12-2022)
3rd party verifier	Linda Høibye Life Cycle Assessment Consulting DK-7120 Vejle Øst

ecoinvent 3.9.1
https://ecoinvent.org/

General Program Instructions
General Program Instructions, version 2.0, spring 2020
www.epddanmark.dk

EN 15804:2012+A2:2019
DS/EN 15804 + A2:2019 - "Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products"

EN 50583-1:2016
EN 50583-1:2016 – Photovoltaics in buildings – Part 1: BIPV Modules

EN 50583-2:2016
EN 50583-2:2016 – Photovoltaics in buildings – Part 2: BIPV Systems

EN 13501-1:2018
Fire classification of construction products and building elements - Classification using data from reaction to fire tests

NPCR 010:2022 v2.0
NPCR 010:2022 v2.0 – Part B for Building Boards

NPCR 029:2022 v1.2
NPCR 029:2022 v1.2 – Part B for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials

EN 15942:2011
DS/EN 15942:2011 – ” Sustainability of construction works – Environmental product declarations – Communication format business-to-business”

ISO 14025:2010
DS/EN ISO 14025:2010 – ” Environmental labels and declarations – Type III environmental declarations – Principles and procedures”

ISO 14040:2008
DS/EN ISO 14040:2008 – ” Environmental management – Life cycle assessment – Principles and framework”

ISO 14044:2008
DS/EN ISO 14044:2008 – ” Environmental management – Life cycle assessment – Requirements and guidelines”

Danish Environment Agency, 2019
Miljøprojekt nr. 2059 - På vej – Mod øget genanvendelse af husholdningsaffald (livscyklusvurdering og samfundsøkonomisk konsekvensvurdering)

C. Latunussa, F. Ardente, G. A. Blengini, L. Mancini, 2016
Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels. Solar Energy Materials and Solar Cells 156

R. Frischknecht, P. Stolz, L. Krebs, M. de Wild-Scholten, P. Sinha, V. Fthenakis, H. C. Kim, M. Raugei, M. Stucki, 2020
Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, International Energy Agency (IEA) PVPS Task 12, Report T12-19:2020.