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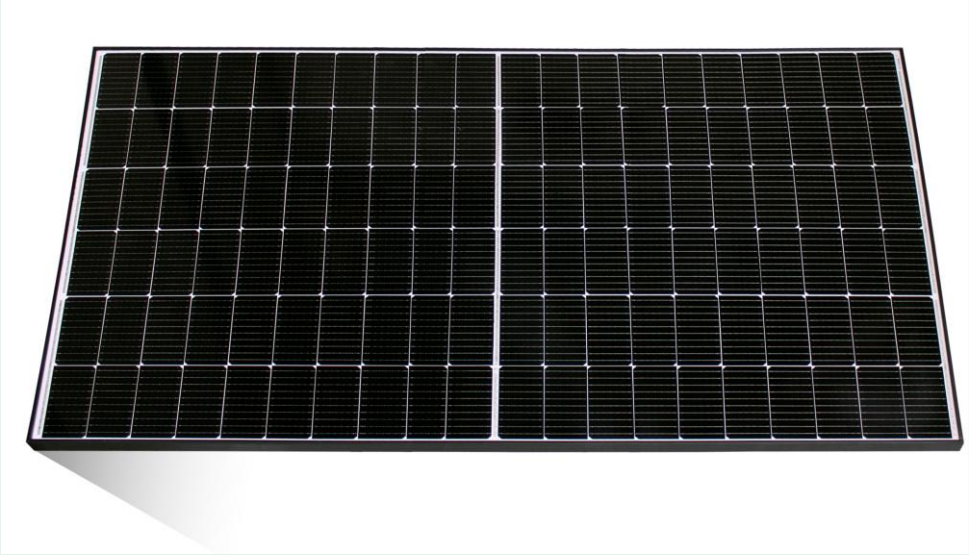
# Environmental Product Declaration

## In accordance with ISO14025:2006 and EN15804:2012+A2:2019

## Mono-crystalline TOPCon, bifacial solar photovoltaïc modules



**Owner of the declaration:**
SOLVIS d.o.o. Ulica Vesne Parun 15 Varaždin Varaždinska županija Croatia

**Product name:**
Mono-crystalline TOPCon, bifacial solar photovoltaïc modules

**Declared unit:**
1m$^2$ of manufactured photovoltaic module

**Product category /PCR:**
NPCR 029:2022 Part B for photovoltaic modules 1.2

**Program holder and publisher:**
The Norwegian EPD foundation

**Declaration number:**
NEPD-15286-18657

**Registration number:**
NEPD-15286-18657

**Issue date:**
26.03.2026

**Valid to:**
26.03.2031

The Norwegian
EPD Foundation

# General information

## Product:
Mono-crystalline Double glass, N-Type, solar photovoltaic modules

## Program operator:
The Norwegian EPD Foundation
Post Box 5250 Majorstuen, 0303 Oslo, Norway
Phone: +47 23 08 80 00
e-mail: post@epd-norge.no

## Declaration number:
NEPD-15286-18657

## This declaration is based on Product Category Rules:
NPCR 029:2022 Part B for photovoltaic modules 1.2

## Statement of liability:
The owner of the declaration shall be liable for the underlying information and evidence. EPD Norway shall not be liable with respect to the manufacturer, life cycle assessment data, and evidences.

## Declared unit:
1m$^2$ of manufactured photovoltaic module

## Declared unit with option:

## Functional unit:
1 Wp of manufactured photovoltaic module, from cradle-to-grave and module D, with activities needed for a study period for a defined reference service life (≥80% of the labelled power output)

## Verification:
Independent verification of the declaration and data, according to ISO14025:2010

internal ☐ external ☒

Sign

Julie Skullestad
Independent verifier approved by EPD Norway

## Owner of the declaration:
SOLVIS d.o.o.
Contact person: Goran Nađ
Phone: -
e-mail: goran.nad@solvis.hr

## Manufacturer:
SOLVIS d.o.o.
Ulica Vesne Parun 15 Varaždin Varaždinska županija Croatia
Phone: -
e-mail: goran.nad@solvis.hr

## Place of production:
Ulica Vesne Parun 15 Varaždin Varaždinska županija Croatia

## Management system:
ISO 14001, ISO 9001, IEC 62941, OHSAS 18001:2007, ISO 45001

## Organisation no:
EUID : HRSR.090021197
VAT ID: HR80258164780

## Issue date:
26.03.2026

## Valid to:
26.03.2031

## Year of study:
01/11/2024 to 31/10/2025

## Comparability:
EPD of construction products may not be able to compare if they do not comply with EN 15804 and are seen in a building context.

## The EPD has been worked out by:
Nelly Riffard - Kapstan

Approved

Manager of EPD Norway

# Product

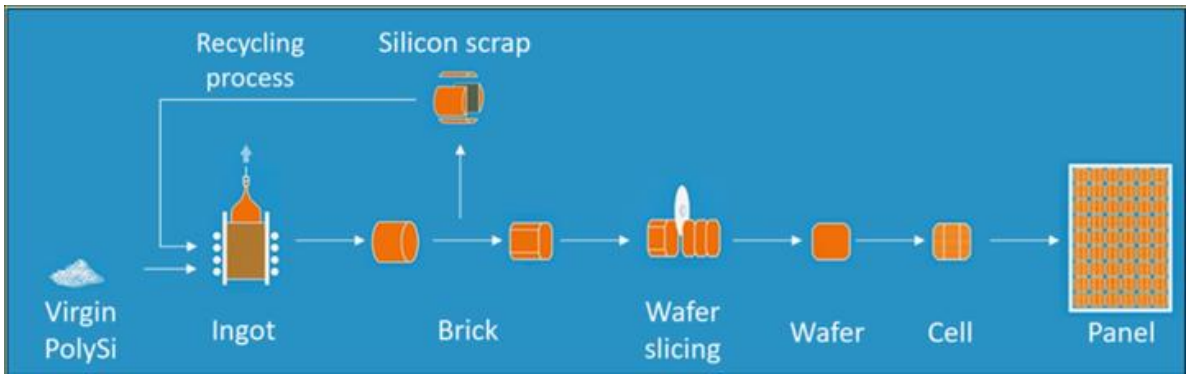
## Product description:

430 – 635 Wp mono-crystalline solar photovoltaic module, designed to be installed on roofs or as stand-alone systems for local power production. Solar cells are assembled together with the backsheet, EVA, glass, frame and electrical connections to produce the finished solar module in the production factory in Croatia.

This EPD represents multiple modules with small variations in size, number of cells, power… (see table of module characteristics in "Technical details"). The results are calculated based on the maximum inventory amongst the modules. The variation between each module results is lower than 10 %.

## Product specification:

The solar module production from silicon is explained in the figure below:




Step 1 - **PolySi**: The raw material used to produce the cells is a high purity silicon called "Solar grade silicon" or "PolySi".

Step 2 - **Ingot**: The PolySi is transformed into a monocrystalline ingot by heating up the silicon with a process called "Czochralski process".

Step 3 - **Wafer**: the ingot is then cut into bricks and sliced into wafers by diamond wire slicing.

Step 4 - **Solar cell**: the wafer is transformed into a cell through chemical treatments and screen-printing wiring.

Step 5 - **Solar module**: the cells are combined, between 48 and 66 cells per module. The different components of the panel are given below.

| Materials | Value for EPD2 | % |
|---|---|---|
| Cells | 9,902E-01 | 7% |
| Glass | 1,038E+01 | 70% |
| EVA | 8,858E-01 | 6% |
| Aluminium frame | 1,266E+00 | 9% |
| Junction box | 1,086E-01 | 1% |
| String connector | 2,713E-02 | 0% |
| Cell connector | 8,735E-02 | 1% |
| Silicone | 1,441E-01 | 1% |
| Soldering flux | 6,743E-03 | 0% |
| Wooden pallet | 7,762E-01 | 5% |
| Cardboard | 1,356E-01 | 1% |
| Low density PE | 5,971E-03 | 0% |
| PP | 2,682E-03 | 0% |
| Plastics | - | - |
| Plastic film | - | - |
| Paper | 2,980E-04 | 0% |
| Polyester film | - | - |

## Technical data:

The modules are produced according to IEC 61215 / 61730, IEC 61701, IEC 61215, IEC 62782, IEC 62716, ISO 11925-2, IEC 62938, IEC 62804, AS 40404.2

This EPD is valid for the following module types:

- SV144-xxx E (YYY) GG22 HCM10
- SV120-xxx E (YYY) GG22 HCM10
- SV108-xxx E (YYY) GG22 HCM10
- SV132-xxx E (YYY) GG22 HCG12R
- SV108-xxx E (YYY) GG22 HCG12R
- SV96-xxx E (YYY) GG22 HCG12R

| | SV144-xxx E (YYY) GG22 HCM10 | SV120-xxx E (YYY) GG22 HCM10 | SV108-xxx E (YYY) GG22 HCM10 | SV132-xxx E (YYY) GG22 HCG12R | SV108-xxx E (YYY) GG22 HCG12R | SV96-xxx E (YYY) GG22 HCG12R |
|---|---|---|---|---|---|---|
| Area ($m^2$) | 2,58 | 2,16 | 1,95 | 2,70 | 2,22 | 2,00 |
| Weight (kg) | 30,00 | 26,80 | 24,30 | 33,00 | 27,90 | 24,90 |
| Number of cells | 72 cells | 60 cells | 54 cells | 66 cells | 54 cells | 48 cells |
| Size of cells | 182x182 | 182x182 | 182x182 | 182x210 | 182x210 | 182x210 |
| Power min | 575 W | 430 W | 430 W | 625 W | 510 W | 450 W |
| Power max | 585 W | 440 W | 440 W | 635 W | 520 W | 460 W |
| Liftime [year] | 30 | 30 | 30 | 30 | 30 | 30 |
| Wp/area | 226 | 203 | 225 | 235 | 234 | 230 |

*Table 1: Module characteristics*

This study has been conducted according to the requirements of:

- ISO 14044;
- ISO 14025;
- EN15804+A2:2019;
- NPCR part A “Construction products and services” version 2.0;
- NPCR 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” version 1.2.

### Market:
World

### Reference service life, product:
30 years

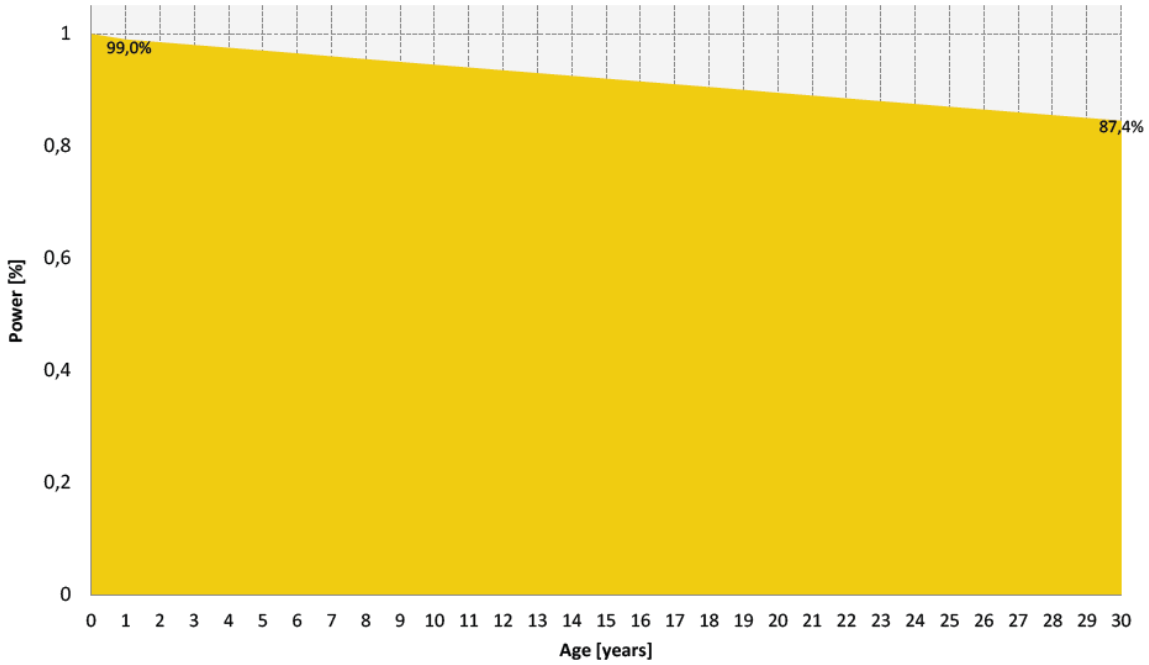



*Figure 1: Yearly degradation (30 years)*

### Reference service life, building:
25 years

### Additional technical information

## LCA: Calculation rules

### Declared unit:

1m$^2$ of manufactured photovoltaic module

## Cut-off criteria:

No known significant flows have been excluded from the study.

## Allocation:

The allocation is made in accordance with the provisions of ISO 14025. Incoming energy and water and waste production in-house is allocated equally among all products through surface allocation. Effects of primary production of recycled materials allocated to the main product in which the material was used. The recycling process and transportation of the material is allocated to this analysis.

## Data quality:

Specific data comes from actual consumption of the module assembly factory (November 2024 – October 2025). This data has been collected by the manufacturer and checked by the LCA practitioner.

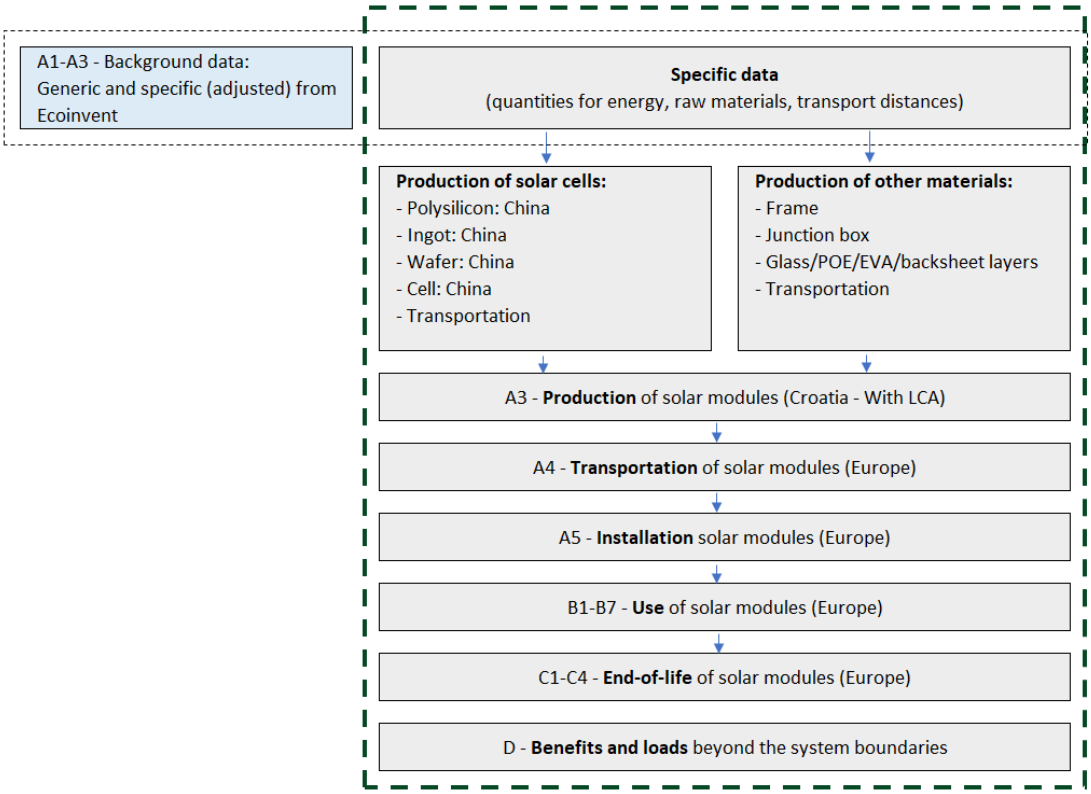
Generic data is from Ecoinvent v3.11 and Simapro v10.2.0.2. Characterization factors from EN15804:2012 + A2: 2019. Generic data <10 years old. Ecoinvent system model used: cut-off.

System boundaries (X=included, MND=module not declared, MNR=module not relevant)

| Product stage | | | Assembly stage | | Use stage | | | | | | | End of life stage | | | | Benefits & loads beyond system boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw materials | Transport | Manufacturing | Transport | Assembly | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | De-construction demolition | Transport | Waste processing | Disposal | Reuse-Recovery-Recycling-potential |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| X | X | X | X | MND | MND | MND | MND | MND | MND | MND | MND | X | X | X | X | X |

## System boundary:

The study is based on a cradle to grave analysis i.e., from raw material extraction to the disposal of waste. A summary of what is included and excluded is shown below:




The PolySi, ingots, wafers, cells and modules are manufactured in China. The supply chain is shown below:

| Production | Site |
|---|---|
| Virgin Polysi | China |
| Ingot/brick | China |
| Wafer | China |
| Recycled Polysi | China |
| Cells (TOPCon) | China |
| Modules | Croatia |

# LCA: Scenarios and additional technical information

The following information describes the scenarios in the different modules of the EPD.

All data is provided per declared unit.

## Transport from production place to assembly/user (A4)

The transport step A4 covers the transport from the factory in Croatia to the installation sites in Europe by sea and road.

| Transport from production place to assembly/user (A4) | Capacity utilisation (incl. return) [%] | Distance [km] | Fuel/Energy consumption | Unit | Value |
|---|---|---|---|---|---|
| Truck | 50 | 1000 | Diesel (4.44E-2 L/tkm) | tkm | 2,11E-02 |

The calculation of fuel consumption is based on the weight of the product and packaging. It includes return freight.

## Assembly (A5)

| | Unit | Value |
|---|---|---|
| Wooden pallet | kg | 7,762E-01 |
| Cardboard | kg | 1,356E-01 |
| Low density PE | kg | 5,971E-03 |
| PP | kg | 2,682E-03 |
| Paper | kg | 2,980E-04 |

The modules are installed by hand. The screwdriver electricity consumption is neglected. As in PCR part B, the fasteners (screws) are not included in the LCA. The only impact is the packaging waste given in the table above.

## Use (B1)

Photovoltaic modules harness solar energy throughout their entire lifecycle via the photovoltaic effect. The amount of electricity they produce is directly influenced by solar irradiance. The electricity production is calculated as below:

$$E_{year\ i} = I_{sun} \times S_{1kWp} \times Eff_{panel} \times PR \times D_{panel} \times (1 + b)$$

Where:

- $I_{sun}$ is the sun irradiation received by the module in kWh. $m^{-2}$.$year^{-1}$, which depends on the site location.
- PR, or Performance Ratio, is the ratio between the energy produced by the panel and the final energy at the output of the photovoltaic system in order to take into account the various losses (cables, inverter, etc.).
- $Eff_{panel}$, or panel efficiency, is the ratio between the energy produced and the solar radiation received.
- b is the bifacial gain (5% if bifacial and 0% if monofacial)
- $S_{1kWp}$ is the surface area to get 1 kWp.
- $D_{panel}$ corresponds to the degradation of the panel in year i. This degradation is 1% the first year and then 0.35% per year. $D_{panel}=0.99 \times (1-0.35\%)^{i-1}$

As a result, the following chart illustrates the electricity produced:

| Solar irradiance for electricity production | Unit | Value |
|---|---|---|
| 1000 kWh/m²/year | kWh/m² (30 years) | 5 176 |
| 1100 kWh/m²/year | kWh/m² (30 years) | 6 211 |
| 1200 kWh/m²/year | kWh/m² (30 years) | 6 729 |
| 1300 kWh/m²/year | kWh/m² (30 years) | 6 729 |
| 1400 kWh/m²/year | kWh/m² (30 years) | 7 247 |
| 1500 kWh/m²/year | kWh/m² (30 years) | 7 764 |
| 1600 kWh/m²/year | kWh/m² (30 years) | 8 282 |
| 1700 kWh/m²/year | kWh/m² (30 years) | 8 799 |

## Maintenance (B2)/Repair (B3)

| | Unit | Value |
|---|---|---|
| Water consumption | kg | 6,000E-01 |
| Towel | kg | 1,750E-01 |

The modules need to be soft cleaned with water and a towel once a year. The hypotheses taken are detailed:

- 1 towel was used for 60 m² of panel;
- 20 cl for 1 m² of module.

## Replacement (B4)/Refurbishment (B5)

No repair, replacement, or refurbishment is required during the module lifetime.

## Operational energy (B6) and water consumption (B7)

The products do not require any energy or water consumption.

## End of Life (C1, C3, C4)

| | Unit | Value |
|---|---|---|
| Recycling | kg | 1,153E+01 |
| Energy recovery | kg | 1,057E+00 |
| To landfill (ashes) | kg | 1,231E+00 |

The modules are considered as removed by hand. Different parts are either recycled or incinerated with energy recovery, as specified in the PCR Part B for each product type. For the recycled parts, the following recycling rates are used:

- The laminate is shredded and recycled at 95%
- The frame is removed and recycled at 100%
- The cable and junction box are recycled at 100%

## Transport to waste processing (C2)

| Transport from production place to assembly/user (C2) | Capacity utilisation (incl. return) [%] | Distance [km] | Fuel/Energy consumption | Unit | Value |
|---|---|---|---|---|---|
| Truck | 50% | 50 | Diesel (4.44E-2 l/tkm) | tkm | 6,108E-01 |

It has been assumed that the modules are collected by truck and sent for recycling. 50 km is considered from the site to the recycling factory as proposed in PCR part B.

## Benefits and loads beyond the system boundaries (D)

Benefits and loads have been based solely on glass and aluminium frame recycling. Energy recovery from A4-A5 and C1-C4 modules is included.

The benefits of exported energy from energy recovery in a treatment facility are calculated with the substitution of the Norwegian electricity market mix and heat production from wood chip burning plants in Norway. Conversion factors for efficiencies and losses from waste to delivered energy are included.

| Item | Unit | Value |
|---|---|---|
| Glass | Kg | 6,902E+00 |
| Aluminium | Kg | 7,962E-01 |
| Copper | Kg | 1,160E-01 |
| Substitution of electrical energy | MJ | 1,255E+00 |
| Substitution of thermal energy | MJ | 4,490E+01 |

# LCA: Results

The result tables are given using a location-based approach for foreground system (A3)
More information about transparent reporting of electricity in the additional requirements section.

## Results per functional unit (Wp)

### Core environmental impact indicators (per functional unit -Wp)

| Indicator | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| GWP - total | kg CO2 eq | 5,82E-01 | 1,09E-02 | 1,58E-03 | 7,39E-06 | 0 | 3,91E-04 | 2,52E-03 | 1,09E-03 | -8,17E-02 |
| GWP - fossil | kg CO2 eq | 5,79E-01 | 1,09E-02 | 1,15E-03 | 7,37E-06 | 0 | 3,91E-04 | 2,42E-03 | 1,04E-03 | -8,13E-02 |
| GWP - biogenic | kg CO2 eq | 2,36E-03 | 2,29E-06 | 4,34E-04 | 3,22E-09 | 0 | 8,63E-08 | 9,21E-05 | 4,79E-05 | -2,69E-04 |
| GWP - luluc | kg CO2 eq | 5,88E-04 | 3,59E-06 | 2,72E-07 | 2,37E-08 | 0 | 1,36E-07 | 3,47E-06 | 3,17E-07 | -2,03E-04 |
| ODP | kg CFC11 eq | 5,03E-08 | 2,37E-10 | 1,46E-11 | 1,17E-13 | 0 | 8,59E-12 | 2,55E-11 | 4,87E-12 | -8,81E-10 |
| AP | molc H+ eq | 3,56E-03 | 3,48E-05 | 3,49E-06 | 3,44E-08 | 0 | 1,80E-06 | 1,19E-05 | 3,44E-06 | -8,62E-04 |
| EP- freshwater | kg P eq | 1,85E-04 | 7,95E-08 | 2,24E-08 | 1,26E-10 | 0 | 2,97E-09 | 1,03E-07 | 1,86E-08 | -2,01E-06 |
| EP -marine | kg N eq | 7,56E-04 | 1,16E-05 | 3,42E-06 | 1,21E-08 | 0 | 7,00E-07 | 2,91E-06 | 1,11E-06 | -1,19E-04 |
| EP - terrestrial | molc N eq | 7,71E-03 | 1,28E-04 | 1,45E-05 | 1,32E-07 | 0 | 7,69E-06 | 3,00E-05 | 1,17E-05 | -1,45E-03 |
| POCP | kg NMVOC eq | 2,31E-03 | 5,28E-05 | 5,02E-06 | 4,54E-08 | 0 | 2,70E-06 | 1,00E-05 | 3,37E-06 | -4,08E-04 |
| ADP-M&M[2] | kg Sb-Eq | 1,37E-05 | 3,75E-08 | 2,18E-09 | 2,61E-11 | 0 | 1,31E-09 | 6,77E-09 | 4,43E-09 | -3,39E-06 |
| ADP-fossil[2] | MJ | 6,79E+00 | 1,54E-01 | 9,71E-03 | 1,07E-04 | 0 | 5,64E-03 | 2,85E-02 | 6,22E-03 | -7,96E-01 |
| WDP[2] | $m^3$ | -2,36E-01 | 6,06E-04 | 5,48E-05 | 9,17E-05 | 0 | 2,37E-05 | -2,62E-03 | -2,49E-04 | -1,11E-02 |

***GWP-total:*** *Global Warming Potential;* ***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:*** *Depletion potential of the stratospheric ozone layer;* ***AP:*** *Acidification potential, Accumulated Exceedance;* ***EP-freshwater:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment; See "additional Norwegian requirements" for indicator given as PO4 eq.* ***EP-marine:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment;* ***EP-terrestrial:*** *Eutrophication potential, Accumulated Exceedance;* ***POCP****: Formation potential of tropospheric ozone;* ***ADP-M&M****: Abiotic depletion potential for non-fossil resources (minerals and metals);* ***ADP-fossil:*** *Abiotic depletion potential for fossil resources;* ***WDP:*** *Water deprivation potential, deprivation weighted water consumption*

Reading example: 9.0 E-03 = $9.0*10^{-3}$ = $9.0*\frac{1}{10}*\frac{1}{10}*\frac{1}{10}$=0.009  9.0 E+03 = $9.0*10^{3}$ = 9.0*10*10*10=9000

### Additional environmental impact indicators (per functional unit -Wp)

| Indicator | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| PM | Disease incidence | 4,65E-08 | 8,64E-10 | 6,41E-11 | 6,86E-13 | 0 | 3,84E-11 | 1,30E-10 | 3,74E-11 | -9,05E-09 |
| IRP[1] | kBq U235 eq. | 9,24E-03 | 6,64E-05 | 7,70E-06 | 1,08E-07 | 0 | 2,52E-06 | 1,27E-04 | 4,04E-06 | -2,03E-04 |
| ETP-fw[2] | CTUe | 1,12E+01 | 2,04E-02 | 2,29E-02 | 2,05E-05 | 0 | 7,41E-04 | 1,67E-02 | 1,24E-02 | -5,21E-01 |
| HTP-c[2] | CTUh | 1,86E-09 | 1,84E-12 | 3,21E-13 | 2,40E-15 | 0 | 9,98E-14 | 2,84E-12 | 1,14E-12 | -6,74E-11 |
| HTP-nc[2] | CTUh | 8,87E-08 | 9,59E-11 | 1,32E-11 | 1,01E-13 | 0 | 3,92E-12 | 2,96E-11 | 2,25E-11 | -3,30E-09 |
| SQP[2] | Dimensionless | 2,34E+00 | 9,10E-02 | 7,37E-03 | 7,77E-05 | 0 | 4,21E-03 | 2,59E-02 | 6,83E-03 | -5,32E-01 |

***PM:*** *Particulate matter emissions;* ***IRP:*** *Ionising radiation, human health;* ***ETP-fw:*** *Ecotoxicity (freshwater);* ***ETP-c:*** *Human toxicity, cancer effects;* ***HTP-nc:*** *Human toxicity, non-cancer effects;* ***SQP:*** *Land use related impacts / soil quality*

[1] 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.

[2] The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator

## Resource use (per functional unit -Wp)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| PERE | MJ | 8,43E-01 | 2,51E-03 | 2,63E-04 | 3,41E-06 | 0 | 9,38E-05 | 4,36E-03 | 2,78E-04 | -1,00E-01 |
| PERM | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PERT | MJ | 8,43E-01 | 2,51E-03 | 2,63E-04 | 3,41E-06 | 0 | 9,38E-05 | 4,36E-03 | 2,78E-04 | -1,00E-01 |
| PENRE | MJ | 6,78E+00 | 1,54E-01 | 9,70E-03 | 1,07E-04 | 0 | 5,64E-03 | 2,83E-02 | 6,21E-03 | -7,98E-01 |
| PENRM | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PENRT | MJ | 6,78E+00 | 1,54E-01 | 9,70E-03 | 1,07E-04 | 0 | 5,64E-03 | 2,83E-02 | 6,21E-03 | -7,98E-01 |
| SM | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RSF | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRSF | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FW | $m^3$ | -4,76E-03 | 1,92E-05 | -1,79E-06 | 2,15E-06 | 0 | 7,44E-07 | -5,20E-05 | -5,53E-06 | -2,23E-04 |

***PERE*** *Renewable primary energy resources used as energy carrier;* ***PERM*** *Renewable primary energy resources used as raw materials;* ***PERT*** *Total use of renewable primary energy resources;* ***PENRE*** *Nonrenewable primary energy resources used as energy carrier;* ***PENRM*** *Nonrenewable primary energy resources used as materials;* ***PENRT*** *Total use of non-renewable primary energy resources;* ***SM*** *Use of secondary materials;* ***RSF*** *Use of renewable secondary fuels;* ***NRSF*** *Use of non-renewable secondary fuels;* ***FW*** *Use of net fresh water.*

## End of life – Waste (per functional unit -Wp)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| HWD | kg | 1,41E-03 | 4,74E-06 | 2,58E-04 | 4,14E-09 | 0 | 1,81E-07 | 4,65E-06 | 2,24E-07 | -2,51E-05 |
| NHWD | kg | 6,31E-01 | 9,05E-03 | 1,94E-03 | 7,87E-06 | 0 | 4,11E-04 | 2,36E-02 | 9,48E-03 | -1,59E-01 |
| RWD | kg | 6,47E-06 | 4,53E-08 | 5,74E-09 | 8,16E-11 | 0 | 1,72E-09 | 1,01E-07 | 2,61E-09 | -8,56E-08 |

***HWD*** *Hazardous waste disposed;* ***NHWD*** *Non-hazardous waste disposed;* ***RWD*** *Radioactive waste disposed.*

## End of life – output flow (per functional unit -Wp)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| CRU | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MFR | kg | 0 | 0 | 0 | 0 | 0 | 0 | 4,90E-02 | 0 |
| MER | kg | 0 | 0 | 0 | 0 | 0 | 0 | 4,50E-03 | 0 |
| EEE | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 2,91E-03 | 0 |
| EET | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 1,04E-01 | 0 |

***CRU*** *Components for reuse;* ***MFR*** *Materials for recycling;* ***MER*** *Materials for energy recovery;* ***EEE*** *Exported electric energy;* ***EET*** *Exported thermal energy.*

## Information describing the biogenic carbon content at the factory gate (per functional unit -Wp)

| Biogenic carbon content | Unit | Value |
|---|---|---|
| Biogenic carbon content in product | kg C | 0,00E+00 |
| Biogenic carbon content in the accompanying packaging | kg C | 1,80E-03 |

Note: 1 kg biogenic carbon is equivalent to 44/12 (approx. 3.67) kg $CO_2$

# Results per declared unit ($m^2$)

## Core environmental impact indicators (per declared unit -$m^2$)

| Indicator | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| GWP - total | kg CO2 eq | 1,37E+02 | 2,55E+00 | 3,72E-01 | 1,74E-03 | 0 | 9,19E-02 | 5,92E-01 | 2,56E-01 | -1,92E+01 |
| GWP - fossil | kg CO2 eq | 1,36E+02 | 2,55E+00 | 2,70E-01 | 1,73E-03 | 0 | 9,19E-02 | 5,70E-01 | 2,45E-01 | -1,91E+01 |
| GWP - biogenic | kg CO2 eq | 5,56E-01 | 5,37E-04 | 1,02E-01 | 7,57E-07 | 0 | 2,03E-05 | 2,16E-02 | 1,13E-02 | -6,32E-02 |
| GWP - luluc | kg CO2 eq | 1,38E-01 | 8,45E-04 | 6,39E-05 | 5,58E-06 | 0 | 3,19E-05 | 8,16E-04 | 7,45E-05 | -4,76E-02 |
| ODP | kg CFC11 eq | 1,18E-05 | 5,57E-08 | 3,44E-09 | 2,75E-11 | 0 | 2,02E-09 | 5,99E-09 | 1,15E-09 | -2,07E-07 |
| AP | molc H+ eq | 8,36E-01 | 8,19E-03 | 8,22E-04 | 8,09E-06 | 0 | 4,23E-04 | 2,80E-03 | 8,08E-04 | -2,03E-01 |
| EP-freshwater | kg P eq | 4,35E-02 | 1,87E-05 | 5,28E-06 | 2,97E-08 | 0 | 6,98E-07 | 2,42E-05 | 4,38E-06 | -4,72E-04 |
| EP -marine | kg N eq | 1,78E-01 | 2,73E-03 | 8,03E-04 | 2,85E-06 | 0 | 1,64E-04 | 6,83E-04 | 2,62E-04 | -2,80E-02 |
| EP - terrestrial | molc N eq | 1,81E+00 | 3,00E-02 | 3,40E-03 | 3,10E-05 | 0 | 1,81E-03 | 7,06E-03 | 2,74E-03 | -3,41E-01 |
| POCP | kg NMVOC eq | 5,43E-01 | 1,24E-02 | 1,18E-03 | 1,07E-05 | 0 | 6,35E-04 | 2,35E-03 | 7,92E-04 | -9,59E-02 |
| ADP-M&M[2] | kg Sb-Eq | 3,21E-03 | 8,82E-06 | 5,12E-07 | 6,14E-09 | 0 | 3,08E-07 | 1,59E-06 | 1,04E-06 | -7,97E-04 |
| ADP-fossil[2] | MJ | 1,60E+03 | 3,62E+01 | 2,28E+00 | 2,51E-02 | 0 | 1,33E+00 | 6,71E+00 | 1,46E+00 | -1,87E+02 |
| WDP[2] | $m^3$ | -5,55E+01 | 1,42E-01 | 1,29E-02 | 2,16E-02 | 0 | 5,58E-03 | -6,15E-01 | -5,85E-02 | -2,61E+00 |

***GWP-total:*** *Global Warming Potential;* ***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:*** *Depletion potential of the stratospheric ozone layer;* ***AP:*** *Acidification potential, Accumulated Exceedance;* ***EP-freshwater:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment; See "additional Norwegian requirements" for indicator given as PO4 eq.* ***EP-marine:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment;* ***EP-terrestrial:*** *Eutrophication potential, Accumulated Exceedance;* ***POCP****: Formation potential of tropospheric ozone;* ***ADP-M&M****: Abiotic depletion potential for non-fossil resources (minerals and metals);* ***ADP-fossil:*** *Abiotic depletion potential for fossil resources;* ***WDP:*** *Water deprivation potential, deprivation weighted water consumption*

Reading example: 9.0 E-03 = $9.0*10^{-3} = 9.0*\frac{1}{10}*\frac{1}{10}*\frac{1}{10}=0.009$ 9.0 E+03 = $9.0*10^{3} = 9.0*10*10*10=9000$

## Additional environmental impact indicators (per declared unit -$m^2$)

| Indicator | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| PM | Disease incidence | 1,09E-05 | 2,03E-07 | 1,51E-08 | 1,61E-10 | 0 | 9,03E-09 | 3,06E-08 | 8,79E-09 | -2,13E-06 |
| IRP[1] | kBq U235 eq. | 2,17E+00 | 1,56E-02 | 1,81E-03 | 2,53E-05 | 0 | 5,93E-04 | 2,99E-02 | 9,50E-04 | -4,77E-02 |
| ETP-fw[2] | CTUe | 2,63E+03 | 4,80E+00 | 5,40E+00 | 4,82E-03 | 0 | 1,74E-01 | 3,93E+00 | 2,92E+00 | -1,23E+02 |
| HTP-c[2] | CTUh | 4,37E-07 | 4,33E-10 | 7,55E-11 | 5,65E-13 | 0 | 2,35E-11 | 6,67E-10 | 2,68E-10 | -1,58E-08 |
| HTP-nc[2] | CTUh | 2,08E-05 | 2,25E-08 | 3,11E-09 | 2,38E-11 | 0 | 9,22E-10 | 6,96E-09 | 5,30E-09 | -7,76E-07 |
| SQP[2] | Dimensionless | 5,50E+02 | 2,14E+01 | 1,73E+00 | 1,83E-02 | 0 | 9,89E-01 | 6,08E+00 | 1,60E+00 | -1,25E+02 |

***PM:*** *Particulate matter emissions;* ***IRP:*** *Ionising radiation, human health;* ***ETP-fw:*** *Ecotoxicity (freshwater);* ***ETP-c:*** *Human toxicity, cancer effects;* ***HTP-nc:*** *Human toxicity, non-cancer effects;* ***SQP:*** *Land use related impacts / soil quality*

[1] 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.

[2] The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator

## Resource use (per declared unit -$m^2$)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| PERE | MJ | 1,98E+02 | 5,89E-01 | 6,18E-02 | 8,02E-04 | 0 | 2,20E-02 | 1,03E+00 | 6,54E-02 | -2,35E+01 |
| PERM | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PERT | MJ | 1,98E+02 | 5,89E-01 | 6,18E-02 | 8,02E-04 | 0 | 2,20E-02 | 1,03E+00 | 6,54E-02 | -2,35E+01 |
| PENRE | MJ | 1,59E+03 | 3,62E+01 | 2,28E+00 | 2,51E-02 | 0 | 1,33E+00 | 6,66E+00 | 1,46E+00 | -1,88E+02 |
| PENRM | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PENRT | MJ | 1,59E+03 | 3,62E+01 | 2,28E+00 | 2,51E-02 | 0 | 1,33E+00 | 6,66E+00 | 1,46E+00 | -1,88E+02 |
| SM | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RSF | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRSF | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FW | $m^3$ | -1,12E+00 | 4,52E-03 | -4,20E-04 | 5,05E-04 | 0 | 1,75E-04 | -1,22E-02 | -1,30E-03 | -5,25E-02 |

***PERE*** *Renewable primary energy resources used as energy carrier;* ***PERM*** *Renewable primary energy resources used as raw materials;* ***PERT*** *Total use of renewable primary energy resources;* ***PENRE*** *Nonrenewable primary energy resources used as energy carrier;* ***PENRM*** *Nonrenewable primary energy resources used as materials;* ***PENRT*** *Total use of non-renewable primary energy resources;* ***SM*** *Use of secondary materials;* ***RSF*** *Use of renewable secondary fuels;* ***NRSF*** *Use of non-renewable secondary fuels;* ***FW*** *Use of net fresh water.*

## End of life – Waste (per declared unit -$m^2$)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|
| HWD | kg | 3,32E-01 | 1,11E-03 | 6,06E-02 | 9,72E-07 | 0 | 4,25E-05 | 1,09E-03 | 5,27E-05 | -5,91E-03 |
| NHWD | kg | 1,48E+02 | 2,13E+00 | 4,56E-01 | 1,85E-03 | 0 | 9,67E-02 | 5,54E+00 | 2,23E+00 | -3,73E+01 |
| RWD | kg | 1,52E-03 | 1,06E-05 | 1,35E-06 | 1,92E-08 | 0 | 4,04E-07 | 2,38E-05 | 6,14E-07 | -2,01E-05 |

***HWD*** *Hazardous waste disposed;* ***NHWD*** *Non-hazardous waste disposed;* ***RWD*** *Radioactive waste disposed.*

## End of life – output flow (per declared unit -$m^2$)

| Parameter | Unit | A1-A3 | A4 | A5 | B2 - B3 | C1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| CRU | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MFR | kg | 0 | 0 | 0 | 0 | 0 | 0 | 1,15E+01 | 0 |
| MER | kg | 0 | 0 | 0 | 0 | 0 | 0 | 1,06E+00 | 0 |
| EEE | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 6,85E-01 | 0 |
| EET | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 2,45E+01 | 0 |

***CRU*** *Components for reuse;* ***MFR*** *Materials for recycling;* ***MER*** *Materials for energy recovery;* ***EEE*** *Exported electric energy;* ***EET*** *Exported thermal energy.*

## Information describing the biogenic carbon content at the factory gate (per declared unit -$m^2$)

| Biogenic carbon content | Unit | Value |
|---|---|---|
| Biogenic carbon content in product | kg C | 0,00E+00 |
| Biogenic carbon content in the accompanying packaging | kg C | 4,22E-01 |

Note: 1 kg biogenic carbon is equivalent to 44/12 (approx. 3.67) kg $CO_2$

# Additional requirements

## Transparent reporting of energy

The EPD provides, in the main result tables, environmental impact categories based on a location-based approach. The information below is provided so EPD users are able to understand the effect of these methodological choices.

The table below shows calculation of GWP-total for energy resources used in the manufacturing process (A3) for each approach.

The energy for the supply chain from MG-Si to the cell is coming from the Chinese national mix (Electricity, medium voltage {CN}| market group for electricity, medium voltage | Cut-off, U )

| Energy source | Data source | Amount* | Unit | $GWP_{total}$ [kg $CO_2$ -eq/unit] | SUM [kg $CO_2$ -eq] |
|---|---|---|---|---|---|
| ***Location based approach*** | | | | | |
| *Electricity, medium voltage {HR}\| market group for electricity, medium voltage \| Cut-off, U (module)* | Ecoinvent 3.11 | 5,758E+00 | kWh | 0,41003742 | 2,361 E+00 |
| ***Market based approach*** | | | | | |
| *Electricity, medium voltage {HR}\| electricity, medium voltage, residual mix \| Cut-off, U* | Ecoinvent 3.11 | 5,758E+00 | kWh | 0,71957487 | 4,143E+00 |

## Additional environmental impact indicators required for construction products

In order to increase the transparency of biogenic carbon contribution to climate impact, the indicator GWP-IOBC is required as it declares climate impacts calculated according to the principle of instantaneous oxidation. GWP-IOBC is also referred to as GWP-GHG in context to Swedish public procurement legislation.

| Parameter | Unit | 1,36E+02 | 2,55E+00 | 2,70E-01 | 1,73E-03 | 0 | 9,19E-02 | 5,70E-01 | 2,45E-01 | -1,91E+01 |
|---|---|---|---|---|---|---|---|---|---|---|
| GWP-IOBC | kg $CO_2$-eq. | 1,36E+02 | 2,55E+00 | 2,70E-01 | 1,73E-03 | 0 | 9,19E-02 | 5,70E-01 | 2,45E-01 | -1,91E+01 |

***GWP-IOBC*** *Global warming potential calculated according to the principle of instantaneous oxidation.*

## Data Quality Assessment

A **data quality rating** (DQR) is essential for evaluating and maintaining data accuracy and reliability. It ensures the trustworthiness of data, aids in informed decision-making, and supports compliance with regulations. The data quality of the **primary data** collected during the study is reviewed through the following indicators:

- **TeR**: Technological-Representativeness
- **GR**: Geographical-Representativeness
- **TiR**: Time-Representativeness
- **P**: Precision/uncertainty

The DQR is calculated based on a formula that considers the note assigned to each indicator:

$$DQR = \frac{TeR + GR + TiR + P}{4}$$

A DQR must be conducted on all elementary flows that surpass 80% in cumulative GWP impacts. The assigned notes for each indicator are available below:

| EPD 2 | Type of data | GHG impact [kgCO2/m²] | GHG impact [%] | TeR | GR | TiR | P | DQR |
|---|---|---|---|---|---|---|---|---|
| Silicon solar grade | IEA | 7,52 | 2% | 1 | 1 | 2 | | 1,33 |
| Silicon, single crystal | IEA | 34,7 | 9% | 1 | 1 | 2 | | 1,33 |
| Single-Si Wafer | IEA | 65,3 | 18% | 1 | 1 | 2 | | 1,33 |
| Photovoltaic cell | IEA modified | 87,7 | 24% | 1 | 1 | 2 | | 1,33 |
| Aluminium frame | Ecoinvent dataset | 23,7 | 6% | 1 | 2 | 2 | | 1,67 |
| Solar glass | Ecoinvent dataset | 11,0 | 3% | 1 | 3 | 2 | | 2,00 |
| PV module | LCA | 137,0 | 37% | 1 | 1 | 2 | 1 | 1,25 |
| **Total** | | **366,9** | **100%** | | | | | **1,34** |

The DQR calculated for this study is determined as the average of the individual scores from the four indicators. The closer the result is to 1, the better it is. With a result of **1,34**, it is considered **good**.

## Hazardous substances

The declaration is based upon reference to threshold values and/or test results and/or material safety data sheets provided to EPD verifiers. Documentation available upon request to EPD owner.

☒ The product contains no substances given by the REACH Candidate list.

☐ The product contains substances given by the REACH Candidate list that are less than 0,1 % by weight.
☐ The product contains dangerous substances, more then 0,1% by weight, given by the REACH Candidate List, see table.
☐ The product contains no substances given by the REACH Candidate list.
☐ The product is classified as hazardous waste, see table.

## Indoor environment

No tests have been carried out on the product concerning indoor climate

## Carbon footprint

While a carbon footprint analysis has not been conducted for the product separately, the results section does include an evaluation of Global Warming Potential (GWP) with such an analysis. The GWP total results presented in this EPD document represents the carbon footprint of the product studied

# Bibliography


| | |
|---|---|
| ISO 14025:2010 | Environmental labels and declarations - Type III environmental declarations - Principles and procedures |
| ISO 14044:2006 | Environmental management - Life cycle assessment - Requirements and guidelines |
| EN 15804:2012+A2:2019 | Sustainability of construction works - Environmental product declaration - Core rules for the product category of construction products |
| ISO 21930:2017 | Sustainability in building construction - Environmental declaration of building products |


[Text]

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