Environmental Product Declaration

In accordance with ISO 14025:2006 and EN 15804:2012+A2:2019/AC:2021 for:

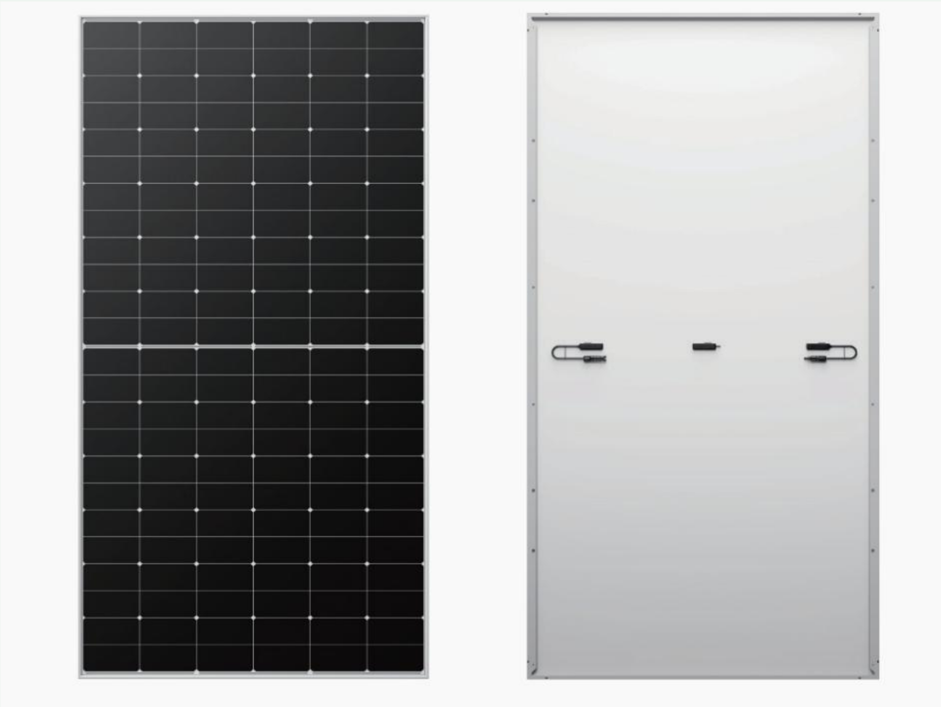
Photovoltaic modules

from

LONGi Green Energy Technology Co., Ltd.

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	S-P-06192
Publication date:	2024-02-05
Valid until:	2029-01-21

Statement: EPD of multiple products, based on worst-case results.



General information

Programme information

Programme:	The International EPD® System
Address:	EPD International AB Box 210 60 SE-100 31 Stockholm Sweden
Website:	www.environdec.com
E-mail:	info@environdec.com

Accountabilities for PCR, LCA and independent, third-party verification
Product Category Rules (PCR)
CEN standard EN 15804 serves as the Core Product Category Rules (PCR)
Product Category Rules (PCR): PCR 2019: 14 PCR Construction products v1.3.1 PCR 2019:14-c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)
PCR review was conducted by the Technical Committee of the International EPD® System. A full list of members available on www.environdec.com. The review panel may be contacted via info@environdec.com Chair of the PCR review: No appointed chair
Life Cycle Assessment (LCA)
LCA accountability: *<Peter Y.F. Chen, TÜV Rheinland (China) Ltd.>*
Third-party verification
Independent third-party verification of the declaration and data, according to ISO 14025:2006, via: ☒ EPD verification by individual verifier Third-party verifier: <Daniel Böckin, Miljögiraff AB > Approved by: The International EPD® System

Owner of the EPD	LONGi Green Energy Technology Co., Ltd.
Website	https://www.longi.com/cn/
Address	Block B, No.8989 Shangji Road, Economic & Technological Development Zone, Xi'an, Shaanxi, China
Email	market@longi.com

Procedure for follow-up of data during EPD validity involves third party verifier:

☒ Yes ☐ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but registered in different EPD programmes, or not compliant with EN 15804, may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison. For further information about comparability, see EN 15804 and ISO 14025.

Statement

EPD of multiple products, based on worst-case results. The system boundaries on manufacturing of infrastructure/capital goods and for employees are exclued in the product system. The estimated impact results from EPD report are only relative statements, which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins and/or risks

Disclaimer

This report are subject to several limitations and uncertainties, and caution should be taken when using the results for comparison or making commitments based on them. The results are only informational for the analyzed PV modules in this report and referenced year and may not be representative of other PV modules or production processes outside the studied scope.

The indicator Ionising radiation 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.

The use of the results of modules A1-A3 without considering the results of module C is discouraged.

Company information

Owner of the EPD

Description of the organisation

Founded in 2000, LONGi Green Energy Technology Co., Ltd. (LONGi) is committed to being the most valuable solar technology company in the world. Under the mission of "To make the best of solar energy to build a green world" with a brand positioning of "The most trusted, reliable solar company that blazes the trail for green technology,"LONGi is developing solutions for large-scale power plants, for different industries and households with its innovation-focused development. Eventually, we will also supply "Green Power + Green Hydrogen" solutions for global zero-carbon development.

Figure 1 LONGi Green Energy Technology Co., Ltd.

Product-related or management system-related certifications

IEC 61215,IEC 61730,UL61730

ISO9001:2015:ISO Quality Management System

IS014001:2015:1SO Environment Management System

IS045001:2018:Occupational Health and Safety

IEC62941:Guideline for module design qualification and type approval

Name and location of production site(s)

Name of production site(s)	Location of production site(s)
LONGi Photovoltaic Technology (Wuhu) Co., Ltd.	1-57, No. 5, Qijing 1st Road, Longshan Street, Wuhu Area, Pilot Free Trade Zone, Anhui Province, China
LONGi Photovoltaic Technology	No.130 Ruifeng Street, Gaozhao Subdistrict, Xiuzhou

(Jiaxing) Co., Ltd.	District, Jiaxing City, Zhejiang Province, China
LONGi Solar Technology （Taizhou） Co., Ltd.	NO.8 Taikang Road, Hailing District, Taizhou City, Jiangsu Provice, China.

Product information

Product name

LONGi photovoltaic modules

Product identification

LR5-66HTH

LR5-72HTH

LR5-72HTHF

Product description

The LONGi photovoltaic modules under analysis integrate various advanced technologies like half-cut cells and Gallium doped wafer, with the highest power up to 560W and up to 21.8% module efficiency. Besides, the unique circuit design of half-cut cells can reduce temperature coefficient. Moreover, the gallium-doped technology overcomes the light attenuation of the module and ensures the long-term power generation stability of the module. Application of this modules can remarkably reduce the number of modules employed in a power station, thus lowering the corresponding cost of supports, cables, construction and land, improving the return on investment. It should be noted that LR5-72HTHF are used in dusty environments, it is mainly the difference in the sealing method of the frame, compared with LR5-72HTH and all other materials and components are the same. All LCA results for LR5-72HTH also apply to LR5-72HTHF.

UN CPC code

461 Electric motors, generators and transformers, and parts thereof

Geographical scope

A1-A3: China

A4 and A5: Global

Module B) and end-of-life (module C) of the product's performance: Global

Product description and application

The LONGi Solar's PV modules under analysis integrate various advanced technologies like half-cut cells and Gallium doped wafer, with the highest power up to 580W and up to 22.5% module efficiency.The components are mainly made of monocrystalline silicon as the material. Besides, the unique circuit design of half-cut cells can reduce temperature coefficient. Moreover, the gallium-doped technology overcomes the light attenuation of the module and ensures the long-term power generation stability of the module

LR5-66HTH LR5-72HTH/LR5-72HTHF

Figure 2 LONGi Green Energy's PV module

Product identification

Table 1 Product technical specifications

Series (brand name)	LR5-66HTH	LR5-72HTH/LR5-72HTHF
Averaged output (Wp)	527.5	570
Power output range (W)	520-535	560-580
Dimensions(mm3)	2094*1134*35	2278*1134*35
Module efficiency (%)	22.5	22.5
Weight (kg)	26	27.5
Reference service life (years)	25	25
First year degradation (%)	<1.5	<1.5

Annual degradation (%)	0.4	0.4

Manufacturing process

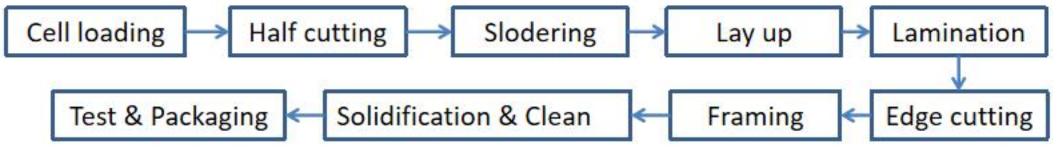


Figure 3 Manufacturing process flowchart for PV modules

Step 1Cell loading: The industrial robot places single solar cells into the production line.
Step 2 Half-cut: Because the resistance of half-sliced cell modules is smaller than that of uncut cell modules, the cell is cut in half by a spline-machine according to the technical requirements.
Step 3 Soldering: Soldering machine is used to weld tin-plated belt on the main grid line using multi-point form. Soldering heat source is generated from an infrared lamp.
Step 4 Laminated lay: Solar cell string, glass, EVA (Ethylene vinyl acetate) and TPT (Tedlar/PET/Tedlar) are laid accordingly for preparation of lamination. A layer of primer is pasted on the glass to strengthen bonding strength. Solar cell string, glass and other materials are properly positioned to prepare for lamination process.
Step 5 Lamination: Solar string is laid into the laminating machine. The air between layers will be extracted out by vacuum process. A heating process is applied to melt EVA, cell string and TPT so that they are bonded together.
Step 6 Edge cutting: The stacked cells, EVA, and TPT from the previous step are arranged and cut to the desired size for the component model, ready for installation of the frame**.**
Step 7 Framing: Aluminium frame is installed to the laminated piece to enhance the module strength and form a good sealing. The gap between aluminium frame and glass is filled with silicone glue. A horn button is used to connect frames. A junction box is welded on the back of solar module.
Step 8 Solidification & Clean: After waiting for the silicone to cure from the previous step, the surface of the module is cleaned with alcohol.
Step 9 Test & Packing: High-pressure test is conducted to test the pressure resistance and insulation strength of module. IV test is also conducted to calibrate the power output rate of module. The tested modules will be packed into a carton, and put them on the wooden pallet, so that they are convenient for storage and shipment.

Content declaration

Raw materials of the different PV modules are mostly the same, including solar cells, solar glass, frame, silicone gel, junction box and packaging etc. The compositions of raw materials are listed in Table 2.

Table 2 Raw materials compositions

Materials	Unit	LR5-66HTH	Compositions	LR5-72HTH/LR5-72HTHF	Compositions
PV cells	kg	0.75	2.96%	0.82	2.94%
EVA	kg	1.06	4.18%	1.15	4.13%
POE	kg	0.84	3.31%	0.91	3.28%
Green glue	kg	0.05	0.19%	0.02	0.07%
Grey glue	kg	0.02	0.10%	0.02	0.07%
Ribbon	kg	0.02	0.08%	0.29	1.06%
Busbar	kg	0.04	0.15%	0.07	0.26%
Backsheet	kg	1.04	4.10%	1.13	4.06%
Frame	kg	2.72	10.74%	2.96	10.64%
Solar glass	kg	18.45	72.79%	20.07	72.20%
Junction box	kg	0.26	1.02%	0.28	1.01%
Silicone product	kg	0.09	0.36%	0.08	0.27%

Package materials	Weight, kg/component	Weight, biogenic carbon, kg C/component
Pallet	1.23	0.58015
Corrugated box	0.23	0.10356
Packaging film	1.02E-02	0
Bead	0.19	0
Packaging bandage	1.33E-02	0

Distribution Process

The product distribution comprises a scenario of transportation from the manufacturing site to the installation site, which in this study, is Germany. The PV modules, as well as other mounting structures and electrical equipment, are firstly transported from the manufacturing site to Xiamen Port. Domestic transport for LR5-66HTH, LR5-72HTH and LR5-72HTHF is provided as 20 km according to LONGi export data. This report assumed that no product loss during transportation.

Subsequently, all the components for installation are transported through container ship from Xiamen Port to Rotterdam Port. The oceanic transportation distance is 19399 km exported from LONGi data.

Energy used in manufacturing

The component manufacturing factory is located in eastern China, and the power consumption of each component is shown in Table 3.

Table 3 Energy consumption during component manufacturing

	LR5-66HTH	LR5-72HTH/ LR5-72HTHF
Electricity process type	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off,U	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off,U
Consumption of electricity (kwh)	10.66	11.56
Climate change GWP(kg CO2 eq)	9.08	9.85

Product Installation

According to the product category rules (PCR), mounting structures like inverter, wiring, etc., are not considered in this study. The electricity and diesel consumption have been derived from the ecoinvent database process for a photovoltaic plant installation with a capacity of 570 kWp, and these values have been downscaled to the power output of different modules analyzed in this study.

Use & maintenance

For the use stage (B1) of the PV products, no energy and materials inputs, or emissions are involved. As for the maintenance stage (B2), water is used for PV module cleaning to maintain its performance. From the literature, it is known that the water used for cleaning the PV panels is assumed 0.23L per module per time, and the cleaning frequency is 2 times a year.

During the operation of PV module, no repair (B3), replacement (B4), and refurbishment (B5) is required.

There is no operational electricity (B6) or water consumption (B7). To calculate the expected energy production over the lifetime of the panels, the following formula may be used:

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

Where:

E_1= Energy produced in the first year of operation, kWh/year

S_{rad} = Site-specific annual average solar radiation on module (shadings not included), kWh/kWp/year. The annual radiation must consider the specific inclination (slope, tilt) and orientation.

A = Area of module, from functional unit (FU), m^2 (stated in the EPD).

y = Module yield: electrical power, kWp for standard test conditions (STC) of the module divided by the area of the module (stated in the EPD).

STC: The ratio is given for standard test conditions: irradiance 1000 W/m^2, cell temperature 25 °C, wind speed 1 m/s, AM1.5.

PR = Performance ratio, coefficient for losses. Site specific performance ratio can be modelled with PV simulation software tools, such as PVSYST or similar.

Energy production second year of operation:

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

Energy production n year of operation:

$$E_n = E_1 * (1 - \deg)^{n-1}$$

Energy production over reference service life of module, assuming linear annual degradation:

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

De-construction and transport (C1-C2)

For end-of-life (EoL) stage, assuming that the de-construction and installation stage of the power station is the same, and the energy (electrisity and diesel) used is the same. Waste transportation distance from the de-installation plant to the waste treatment facilities (C2) is assumed to be 50 km for simplification purposes.

End-of-Life Stage (recycle and disposal C3, C4, D)

Modelling of disposal stage (C4) refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under the EU scenario. In 2012/19/EU-Article 11 & ANNEX V, the required recycling rate for waste PV module is 85%. It was assumed that 100% metal components and 85% glass would be recycled. 15% of the waste components (cells, glass, and waste plastics) end up to disposal stage (C4).

To clarify the End-of-Life process, of a waste PV module, including waste processing and recycling, a “Full Recovery End-of-Life Photovoltaic-FRELP” process is referenced. This process has been developed in a pilot scale recycling plant and, subsequently, designed an industrial scale plant with a processing capacity of 1t/h up to 8000t/year of crystalline-silicon waste PV panels.

Input/output	Quantity	Unit	Note
Input			
PV waste panels	1000	kg	
Electricity	113.55	kW h	Required in various treatment processes as: disassembly, glass separation, module cutting, sieving, leaching, electrolysis.
Diesel fuel	1.14	l	Forklift work
Water	309.71	kg	Water consumption for acid leaching, electrolysis, and neutralization process
HNO_3	7.08	kg	Acid leaching process
$Ca(OH)_2$	36.5	kg	Neutralization of acid solution
Output, recovered materials			
Aluminium scrap	182.65	kg	
Glass scrap	686	kg	
Copper scrap	4.38	kg	
Silicon metal (Metallurgical Grade)	34.68	kg	
Silver	0.5	kg	
Output, energy recovery			
Electricity	248.84	MJ	Produced by the incineration of PV Encapsulation, back-sheet layer and polymers from cables
Thermal Energy	502.84	MJ	Produced by the incineration of PV Encapsulation, back-sheet layer and polymers from cables
Output, waste to landfill			
Contaminated glass	14	kg	Disposal in landfill
Fly ash (hazardous waste)	2	kg	Disposal in hazardous waste landfill
Liquid waste	306.13	kg	Disposal in landfill
Sludge (hazardous waste)	50.25	kg	Contains metallic residue, disposal in special landfill
Output, emission to air			
NO_x	2	kg	Emission from electrolysis

Figure 3 Summary of input and outputs of the “FRELP” process for the recycling of 1000kg of silicon PV waste panels.

Referring to the FRELP model, the recovered output substances and energy in the final D stage will be considered, as shown in the following Table 4 below.

Table4 Output materials and energy during the recycling phase

	Unit	LR5-66HTH	LR5-72HTH/ LR5-72HTHF
Aluminium scrap	kg	2.72	2.95
Glass scrap	kg	15.37	16.72
Copper scrap	kg	0.10	0.10
Silicon metal (Metallurgical Grade)	kg	0.77	0.81
Silver	kg	0.01	0.01
Recovery electricity	MJ	6.47	6.84
Recovery Heat	MJ	13.07	13.83

LCA information

Functional unit

1 Wp of manufactured photovoltaic module, from cradle-to-gate with options modules C1–C4, module D and with optional modules A4, A5, B1, B2 and B4, with activities needed for a study period for a RSL of 25 years. The converting factor to convert the results related to the functional unit to declared unit (1 m2 PV module) is 222.14 Wp/m2 for LR5-66HTH and 220.65 Wp/m2 for LR5-72HTH/LR5-72HTHF.

Reference service life

25 Years

Time & geographical representativeness

Series (brand name)	Name of production site(s)	Referenced Period
LR5-66HTH	LONGi Photovoltaic Technology (Wuhu) Co., Ltd.	September 2022 to August 2023
LR5-72HTH/ LR5-72HTHF (50% of total production)	LONGi Photovoltaic Technology (Jiaxing) Co., Ltd.	January 2022 to December 2022
LR5-72HTH/ LR5-72HTHF (50% of total production)	LONGi Solar Technology （Taizhou）Co., Ltd.	September 2022 to August 2023

Database(s) and LCA software used

For the LCA study, the primary data are collected from the manufacturers. Generic data related to the life cycle impacts of the material or energy flows that enter and leave the production system is sourced from Ecoinvent 3.9 "allocation, cut-off by allocation - unit" database. Secondary data such as silicon wafer production are taken from IEA PVPS Task 12, 2020 report. LCA-software SimaPro version 9.5 was used.

Description of system boundaries

Cradle-to-gate with options, modules C1 – C4, module D and with optional modules A4, A5, B1, B2 and B4

System diagram

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling potential
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Modules declared	X	X	X	X	X	X	X	ND	X	ND	ND	ND	X	X	X	X	X
Geography	CN	CN	CN	GLO	GLO	GLO	GLO	ND	GLO	ND	ND	ND	GLO	GLO	EU	EU	EU
Specific data used	47.9%			0%	0%	0%	0%	ND	0%	ND	ND	ND	0%	0%	0%	0%	0%
Variation products	<10%				-	-	-	-	-	-	-	-	-	-	-	-	-
Variation sites	<10%				-	-	-	-	-	-	-	-	-	-	-	-	-

System boundaries(X=included, ND=module not declared)

Figure 5 System boundaries and life cycle stages within this study

The system boundary for this LCA study of LONGi's PV modules encompasses the entire life cycle of the product, from cradle-to-gate with options modules C1–C4, module D and with optional modules A4, A5, B1, B2 and B4, as defined in the PCR. The system boundaries on manufacturing of infrastructure/capital goods and for employees are exclued in the product system.

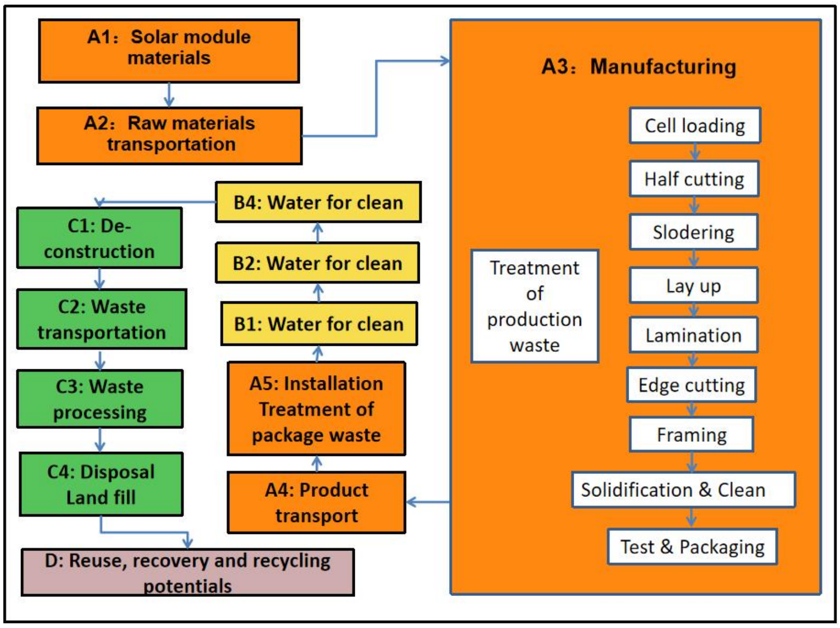


Figure 5 System boundary

The geographical boundary is set up with the production of raw materials and components, as well as the manufacturing of PV modules taking place in mainland China.

Datasets have been selected according to the actual processes used by the manufacturer. For generic products where no upstream data is available, such as packaging, manufacturing has been modelled according to current industry practices.

Excluded Processes

The following steps/stages are not included in the system boundary due to the reason that the elements below are considered irrelevant or not within the boundary to the LCA study:

- Impacts related to the production, transportation and installation of capital goods (buildings, infrastructure, machinery, internal transport packaging) and general operations (staff travel, marketing and communication actions) that cannot be directly allocated to products are excluded from the LCA study.
- The packaging for silicon wafer and solar cells is reused internally and its impact was excluded from the system;
- Direct emissions during the PV module operation due to no obvious emission observable.

- Storage phases and sales of PV products due to no observable impact. Product losses due to abnormal damage such as natural disasters or fire accidents would occur at a rather low frequency.
- The recycling process of defective products is reused internally for the manufacturing process.
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.

Assumptions

In general, this LCA study is subject to certain assumptions and limitations, which have been made in a conservative manner following the LCA standard and related specifications listed in the PCR. It should be noted that caution should be taken when comparing the results of PV modules in this report with those from other studies.

Table 6 LIst of Assumptions

Categories	Items	Assumptions
Manufacturing stage (A1)	Photovoltaic Cell	Life cycle inventory (LCI) data of the silicon wafer is difficult to obtain at the stage, thus an average LCI data for China in IEA PVPS Task 12, 2020 is used for modelling, the LCI for silicon wafer are listed in Appendix 2; Cell uses the Single-Si cell data in the Simapro database：Photovoltaic cell,single-Si wafer{RoW}|photovoltaic cell production, single-Si wafer|Cut-off,U
Transportation stage (A2 - A4)	Transportation vehicle type	For transport without transport, EURO 6 type vehicle with 16-32 ton capacity is used
Installation stage (A5)	PV module and infrastructures	PV waste amount is assumed to be zero during construction . Waste package is recycled during construction . Suppose a 570 kWP plant needs to be constructed. Energy consumption using the Simapro database: Photovoltaics, electric installation for 570kWp module, open ground{GLO}|market for photovoltaics, electric installation for 570kWp module, open ground
Use & Maintenance	Use (B1)	The use stage requires no energy and materials inputs, and has no emissions.
	B2 Maintenance	Water used for cleaning the PV panels is assumed 0.23L (source: www.polywater.com) per module per

		time and two times per year,
	Replacement (B4)	No replacement for the module as the module has RSL>25 years
End-of-life (C1-C4)	De-construction (C1)	The de-construction of PV plant is assumed to be done manually, electricity and materials use the same data like A5 in this stage
	Waste transportation (C2)	Waste transportation distance from the de-installation plant to the waste treatment facilities is assumed to be 50 km for simplification purposes. A sensitivity analysis is conducted in Section 5.3.
	Waste processing (C3)	Disposal scenarios is based on the WEEE. “Full Recovery End of Life Photovoltaic – FRELP” . This project developed the ‘FRELP process’ in a pilot scale recycling plant and, subsequently, designed an industrial scale plant with a processing capacity of 1t/h up to 8000t/year of crystalline-silicon waste PV panels.[12]
	Disposal (C4)	
Benefits and loads beyond the product system boundary (D)	D	

Allocation

The allocation is made in accordance with the provisions of PCR. Allocation refers to the partitioning of input or output flows of a process or a product system between the product systems under study and one or more other product systems. In this study, there are three types of allocation procedures considered:

Multi-input allocation

For data sets in this study, the allocation of the inputs and outputs of solar cell and PV module production are allocated by power output ratio. The transportation of raw materials is allocated by mass ratio.

Multi-output allocation

No other by-products are produced from the production, hence there is no production of by-products that need to be used to allocate the situation.

End-of-life allocation

For end-of-life allocation of background data (energy and materials), the model “allocation cut-off by classification (ISO standard) is used. The underlying philosophy of this approach is that primary (first) production of materials is always allocated to the primary user of a material. If material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials.

Consequently, recyclable materials are available burden-free for recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes.
For end-of-life stage of the inverter products, the polluter pays principle (PPP) is followed in this report. This means that the waste transportation to the treatment site and the waste processing (mainly shredding) is considered in this report, while the benefit, the load from waste treatment for recycling purposes such as de-pollution and crushing, etc., is allocated to the next life cycle of substituted products, but not the primary producers, hence no burden or benefit will be allocated to the primary producer of the electric products (cut-off approach).

Cut-off rules

The default cut-off criteria shall be set to 1% in accordance with the GENERAL PROGRAMME INSTRUCTIONS FOR THE INTERNATIONAL EPD® SYSTEM （version 4.0）A3.3. However, the big environmental impact material shall not allowed to be cut-off, such as a hazardous waste or precious metals. Capital goods and personnel activities shall be ignored
The total of neglected input flows per module, e.g. per module A1-A3, A4-A5, B2, C1-C4 and module D is maximum 5% of energy usage and mass.

Electricity mix

In this LCA study, it is important to note that different electricity grid mixes are used for different stages of the life cycle. Specifically, the production of solar cells and PV modules takes place in Eastern China, Eastern China Grid mix was used for modelling. As for installation, operation, and end-of-life stage, globle market average electricity mix is used.

Consumption type	Electricity process type
Electricity use in manufacturing stage	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off,U
Electricity use in the end-of-life stage	Electricity, medium voltage {GLO}| market for electricity, medium voltage | Cut-off, U

Table 7 Electricity mix used for modelling

It is worth noting that the use of different grid electricity mixes may impact the results of the LCA study, as the environmental impacts associated with electricity generation can vary significantly between different regions and grid mixes. Therefore, it is important to carefully consider the impact of grid mix differences when interpreting the results of the study, and to recognize that the results may not be directly comparable to studies that use different grid mixes.

Results of the environmental performance indicators

Results of LR5-72HTH (worst-case results) are selected to cover the two products in this EPD due to its higher impacts in the majority of impact categories. Note that the results are relative expressions and do not predict impacts on endpoint categories, exceedance of certain levels, safety margins or risks.

Table 8 Mandatory impact category indicators according to EN 15804

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
GWP-fossil	kg CO_2 eq.	6.17E-01	9.69E-03	1.38E-03	0.00E+00	1.73E-05	0.00E+00	1.38E-03	4.54E-04	4.09E-03	4.42E-03	-1.07E-01
GWP-biogenic	kg CO_2 eq.	1.77E-03	1.94E-06	7.65E-03	0.00E+00	3.99E-08	0.00E+00	2.84E-07	1.33E-07	7.94E-06	3.98E-03	-2.64E-04
GWP-luluc	kg CO_2 eq.	3.56E-04	7.43E-06	2.48E-07	0.00E+00	2.77E-08	0.00E+00	2.48E-07	2.39E-07	7.90E-06	1.00E-06	-5.88E-05
GWP-total	kg CO_2 eq.	5.43E-01	9.69E-03	1.38E-03	0.00E+00	1.74E-05	0.00E+00	1.38E-03	4.55E-04	4.12E-03	9.54E-03	-3.74E-04
ODP	kg CFC 11 eq.	8.73E-08	1.47E-10	2.16E-11	0.00E+00	2.69E-12	0.00E+00	2.16E-11	7.17E-12	2.95E-11	6.82E-11	-1.58E-09
AP	mol H^+ eq.	3.89E-03	2.84E-04	1.26E-05	0.00E+00	9.26E-08	0.00E+00	1.26E-05	1.13E-06	2.13E-05	9.36E-05	-7.20E-04
EP-freshwater	kg P eq.	1.99E-04	3.31E-07	6.29E-08	0.00E+00	7.58E-09	0.00E+00	6.29E-08	3.72E-08	1.72E-06	6.00E-07	-3.98E-05
EP-marine	kg N eq.	7.75E-04	7.09E-05	5.78E-06	0.00E+00	1.87E-08	0.00E+00	5.78E-06	2.74E-07	5.02E-06	1.08E-04	-1.14E-04
EP-terrestrial	mol N eq.	7.63E-03	7.84E-04	6.28E-05	0.00E+00	1.89E-07	0.00E+00	6.28E-05	2.82E-06	5.14E-05	3.89E-04	-1.15E-03
POCP	kg NMVOC eq.	2.91E-03	2.12E-04	1.86E-05	0.00E+00	6.15E-08	0.00E+00	1.86E-05	1.50E-06	1.52E-05	9.50E-05	-3.65E-04
ADP-minerals&metals*	kg Sb eq.	3.87E-05	9.77E-09	7.24E-10	0.00E+00	8.06E-11	0.00E+00	7.24E-10	1.48E-09	3.55E-09	1.62E-08	-1.28E-07
ADP-fossil*	MJ	6.16E+00	1.19E-01	1.81E-02	0.00E+00	2.22E-04	0.00E+00	1.81E-02	6.40E-03	5.30E-02	3.07E-02	-1.06E+00
WDP*	m^3	6.69E-01	2.73E-04	4.58E-05	0.00E+00	8.09E-04	0.00E+00	4.58E-05	2.85E-05	6.41E-04	-1.66E-02	-1.79E-02

Acronyms		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; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption	

Table 9 additional environmental impacts

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
GWP-GHG[1]	kg CO_2 eq.	6.17E-01	9.69E-03	1.38E-03	0.00E+00	1.73E-05	0.00E+00	1.38E-03	4.55E-04	4.10E-03	4.42E-03	-1.07E-01

1 According to the PCR, a supplementary indicator for climate impact (GWP-GHG) shall be reported. This indicator includes all greenhouse gases excluding biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product as defined by IPCC AR 6 (IPCC 2021).

Use of resources

The following data was calculated using option A in the PCR construction product.

Table10 Resource use

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
PERE	MJ	3.01E-01	8.63E-04	1.83E-04	0.00E+00	2.36E-05	0.00E+00	1.83E-04	8.28E-05	5.98E-03	6.81E-03	-1.35E-01
PERM	MJ	1.66E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.96E+00	8.63E-04	1.83E-04	0.00E+00	2.36E-05	0.00E+00	1.83E-04	8.28E-05	5.98E-03	6.81E-03	-1.35E-01
PENRE	MJ	5.76E+00	1.19E-01	1.81E-02	0.00E+00	1.81E-02	0.00E+00	1.81E-02	6.40E-03	5.30E-02	3.07E-02	-1.06E+00
PENRM	MJ	3.99E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] This indicator accounts for all greenhouse gases except biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. As such, the indicator is identical to GWP-total except that the CF for biogenic CO_2 is set to zero.
** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.*

PENRT	MJ	6.16E+00	1.19E-01	1.81E-02	0.00E+00	1.81E-02	0.00E+00	1.81E-02	6.40E-03	5.30E-02	3.07E-02	-1.06E+00
SM	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.37E+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	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	0.00E+00	0.00E+00	0.00E+00
FW	m^3	1.61E-02	9.73E-06	1.70E-06	0.00E+00	1.95E-05	0.00E+00	1.70E-06	9.21E-07	2.65E-05	-1.28E-02	-7.30E-04
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water										

Waste productionand output flows

Table 11 Waste production

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	8.35E-04	1.56E-06	1.80E-07	0.00E+00	1.31E-08	0.00E+00	1.80E-07	1.62E-07	1.57E-06	4.23E-04	-7.15E-05
Non-hazardous waste disposed	kg	4.77E-02	4.20E-04	2.84E-05	0.00E+00	2.57E-06	0.00E+00	2.84E-05	3.16E-04	2.30E-04	1.19E-02	-1.87E-02
Radioactive waste disposed	kg	6.15E-06	1.33E-08	3.53E-09	0.00E+00	5.41E-10	0.00E+00	3.53E-09	1.31E-09	1.32E-07	9.87E-08	-8.39E-07
	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed											

Table 12 Output flows

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	9.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-02	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
EET	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	0.00E+00	0.00E+00	1.20E-02
	CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy											

Additional environmental impact

Table 13 Additional environmental impact

Indicator	Unit	A1-A3	A4	A5	B1	B2	B4	C1	C2	C3	C4	D
PM	Disease incidence	3.34E-08	2.92E-10	3.47E-10	0.00E+00	1.10E-12	0.00E+00	3.47E-10	3.39E-11	2.41E-10	3.64E-10	-8.64E-09
IRP	kBq U235 eq.	2.31E-02	5.81E-05	1.49E-05	0.00E+00	2.18E-06	0.00E+00	1.49E-05	5.51E-06	5.41E-04	4.37E-04	-3.16E-03
ETP-fw	CTUe	6.08E+00	5.89E-02	8.49E-03	0.00E+00	7.52E-05	0.00E+00	8.49E-03	3.52E-03	1.13E-02	2.21E-01	-3.58E-01
HTP-c	CTUh	4.17E-10	4.19E-12	4.23E-13	0.00E+00	4.57E-14	0.00E+00	4.23E-13	2.06E-13	9.49E-13	1.67E-10	-1.26E-10
HTP-nc	CTUh	2.39E-08	3.54E-11	3.43E-12	0.00E+00	6.41E-13	0.00E+00	3.43E-12	4.63E-12	3.15E-11	1.18E-08	-2.41E-09
SQP	Dimensionless	1.17E+01	1.02E-02	1.28E-03	0.00E+00	4.76E-05	0.00E+00	1.28E-03	3.87E-03	7.51E-03	1.96E-02	-2.27E-01

References

[1] Ecoinvent, 2023. Swiss Centre for Life Cycle Assessment, v3.9 (www.ecoinvent.ch).

[2] EN 15804:2012+A2:2019/AC:2021, Sustainability of construction works - Environmental product declaration - Core rules for the product category of construction products.

[3] ISO 14025:2006, Environmental labels and declarations-Type III environmental declarations-Principles and procedures.

[3] ISO 14040: 2006/Amd 1:2020 Environmental management - Life cycle assessment - Principles and framework Amendment 1 (ISO 2020).

[5] ISO 14044: 2006/Amd 2:2020 Environmental management - Life cycle assessment - Requirements and guidelines Amendment 2 (ISO 2020).

[6] ISO 21930:2017, Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.

[7] Latunussa C E L, Ardente F, Blengini G A, et al. Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels[J]. Solar energy materials and solar cells, 2016, 156: 101-111.

[8] EPD International. (2021). GENERAL PROGRAMME INSTRUCTIONS FOR THE INTERNATIONAL EPD® SYSTEM Version 4.0.

[9] EPD International. (2022). PCR 2019:14, Version 1.3.1 Construction Products.

[10] EPD Norway. (2022). 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.

[11] 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.

[12] Cynthia E.L. Latunussa, Fulvio Ardente, Gian Andrea Blengini, Lucia Mancini, Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels, Solar Energy Materials and Solar Cells, Volume 156, 2016, Pages 101-111, ISSN 0927-0248, https://doi.org/10.1016/j.solmat.2016.03.020.