Environmental Product Declaration

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

LONGI Hi-MO X6 Photovoltaic Modules

LR7-72HTH (595-630 Wp)
LR7-60HTB (495-520 Wp)
LR7-60HTH (500-525 Wp)
LR7-54HTB (450-470 Wp)
LR7-54HTH (450-475 Wp)
LR5-72HTDR (565-590 Wp)

from

LONGi Green Energy Technology Co., Ltd.

Programme:	The International EPD® System, www.environdec.com
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EPD of multiple products, based on a representative product (LR7-54HTH-475Wp).
An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

Programme information

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

Product Category Rules (PCR)	
Product category rules (PCR):	PCR 2019: 14 PCR Construction products v1.3.4 c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27 NPCR 029 version 1.2)
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: Claudia Peña, DDERE Research & Technology
LCA accountability:	Hongyu Tian, TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification	
Third party verifier:	Marcel Gómez Ferrer – Marcel Gomez Environmental Consulting – Info@marcelgomez.com
Approved by:	*The International EPD® System*
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 may not be comparable. For two EPDs to be comparable, they shall be based on the same PCR (including the same version number up to the first two digits) 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 characterization factors); have equivalent content declarations; and be valid at the time of comparison. For more information on comparability, see EN 15804 and ISO 14025.

Company information

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Description of the Company:
Founded in 2000, LONGi Green Energy Technology Co., Ltd. (LONGi) is committed to being the most valuable solar technology company in the world. At present, LONGi has been rated as AAA for its Module Bankability Ratings for 7 consecutive times and rated as 100 Percent "Bankable" Solar Module Brand by BNEF for 3 consecutive times, obtained the Highest Altman-Z Score Among PV Companies Worldwide. Up to now, it has applied for 2525 related patents. LONGi's RCZ silicon crystal-growing technology is widely used in the solar industry and features large charging capacity, high-speed crystal growth, and multiple loading capabilities.

Committed to the responsible and efficient use of solar energy, LONGi is developing solutions for large-scale power plants, for different industries and households with its innovation-focused development.

Product information

Product name: Below are list of LONGi Hi-MOX6 series
1) LR7-72HTH (595-630 Wp)
2) LR7-60HTB (495-520 Wp)
3) LR7-60HTH (500-525 Wp)
4) LR7-54HTB (450-470 Wp)
5) LR7-54HTH (450-475 Wp)
6) LR5-72HTDR (565-590 Wp)

In this study, we use LR7-54HTH (475 Wp) as representative product because of its high sales amount.

UN CPC code:
461 Electric motors, generators and transformers, and parts thereof

Geographical scope: Global (Sweden is used as a case study, the product can be installed and used worldwide)

Product description and application:

LONGi Hi-MO X6 is a new product family based on efficient Hybrid Passivated Back Contact (HPBC) cell technology. It has the characteristics of aesthetic, efficiency, reliability and intelligence. According to the functional characteristics and application scenarios of the product, it is divided into four series: Explorer, Scientist, Guardian and Artist. Hi-MO X6 has been greatly upgraded in appearance, performance, reliability and intelligence function with HPBC high-efficiency cell. In terms of appearance, Hi-MO X6 simplifies the complexity and redefines the aesthetic concept of photovoltaic modules. In terms of performance, Hi-MO X6 greatly improves the photoelectric conversion capacity of the module by comprehensive optimization. In terms of reliability, HPBC cell adopts full back welding technology to effectively improve the resistance to micro cracking of modules. At the same time, the anti-dust design improves power generation yield and reduces cleaning frequency and cost. The anti-humidity & heat design, featuring dual glass double POE, offers superior degradation resistance in humid and hot conditions, ensuring greater reliability. The new Artist (Ultra Black) adheres to the "Technology leads aesthetics", illuminating a future where energy meets elegance.

Figure 1 LONGi Hi-MO X6 PV module

Product identification:

Table 1 Product technical specifications

Series (brand name)	LR7-72HTH	LR7-60HTB	LR7-60HTH	LR7-54HTB	LR7-54HTH	LR5-72HTDR
Power output range (Wp)	595-630	495-520	500-525	450-470	450-475	565-590
Dimensions(mm^3)	2382*1134*30	1990*1134*30	1990*1134*30	1800*1134*30	1800*1134*30	2278*1134*30
Area (m^2)	2.70	2.26	2.15	2.04	2.04	2.58
Module efficiency (%)	22.0-23.3	22.0-23.0	22.2-23.0	22.1-23.0	22.3-23.3	21.9-22.8
Weight (kg)	28.5	24.8	24.8	21.6	21.6	31.8
Weight (incl. package)	30.0	26.0	27.5	22.8	22.8	34.5
First year degradation (%)	1	1	1	1	1	1
Annual degradation (%)	0.4	0.4	0.4	0.4	0.4	0.35
Type of cell/technology	HPBC	HPBC	HPBC	HPBC	HPBC	HPBC
Cells configuration	144 cells (6×24)	120 cells (6×20)	120 cells (6×20)	108 cells (6×18)	108 cells (6×18)	144 cells (6×24)

HPBC: Hybrid Passivated Back Contact

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 LR7-54HTH (450-475 Wp) is shown here as representative product.

Table 2 Raw materials compositions- LR7-54HTH

Product components	Weight, kg per module	Post-consumer recycled materials, weight -%	Biogenic material, weight-% and kg C/kg
Frame	2.102±10%	0	-
Backsheet	0.880±10%	0	-
Glass	16.191±10%	0	-
Cell	0.685±10%	0	-
Ribbon	0.270±10%	0	-
EVA	1.640±10%	0	-
POE	-	0	-
Junctionbox	0.210±10%	0	-
Flux	0.001±10%	0	
Silicone	0.320±10%	0	
Resin	0.032±10%	0	
Solder paste	0.006±10%	0	
Total weight	21.6±10%		
Packaging materials	**Weight, kg**	**Weight -% (versus the product)**	**Weight biogenic carbon, kg C/kg**
Wood pallet	0.956±10%	4.05%	4.72E-1
Corrugated box	0.206±10%	0.88%	4.50E-1
Packaging bag	0.03240±10%	0.14%	0
Packaging film	0.01650±10%	0.07%	0
Steel plate	0.029±10%	0.12%	0
Total weight	1.2±10%	5.26%	5.44E-1

No substance in the product greater than 0.10% by weight is present on the "List of Potentially Hazardous Substances" candidates for authorization under the REACH legislation.

Manufacturing Process:

The manufacturing process of PV modules is illustrated in Figure 2.

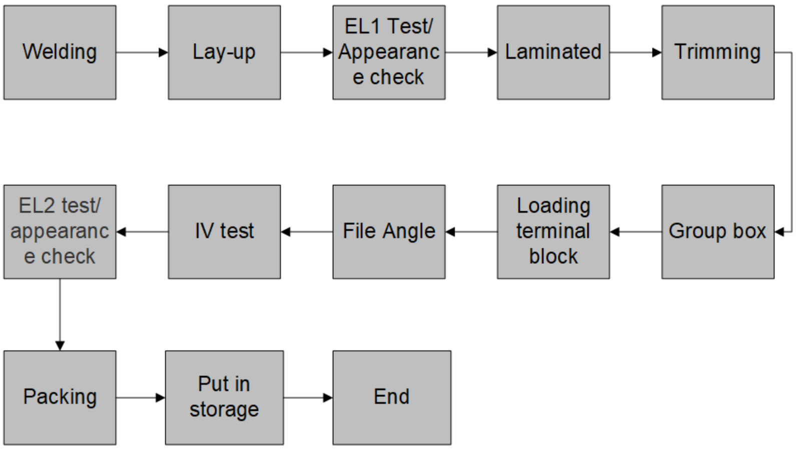

Figure 2 Manufacturing process

Step 1: Welding

Positive and negative electrodes of single-welded batteries are soldered together to form battery strings. Non-conforming strings are repaired as needed.

Step 2: Lay-up

Soldered battery strings are connected with busbars. Glass, EVA film, and glass back plate are positioned to protect the battery assembly.

Step 3: EL1 test/Appearance check

Appearance and Electroluminescent (EL) imaging inspections are conducted on the PV modules.

Step 4: Laminated

EVA is melted and solidified at specific temperatures. This process significantly influences the final product quality.

Step 5: Trimming

Laminated components are trimmed in preparation for framing.

Step 6: Group box

Profiles and junction boxes are mounted with sealed silicone on laminates. Aluminum frames and junction boxes are installed to increase component strength, further seal the battery assembly, and extend service life.

Step 7: Loading terminal block

Junction boxes are secured with silicone to the back of the assembly. Lead-out wires are welded to establish connectivity. AB glue is applied for potting.

Step 8: File Angle

Four corners of the component are fixed and polished.

Step 9: IV test

Output power of the battery component is verified, output characteristics are tested, and power levels are determined.

Step 10: Insulation withstand voltage and ground continuity test
Insulation is tested between current-carrying parts and the frame. Voltage withstand tests are performed on insulation materials and structures. Grounding is verified to ensure safety conductors can handle fault currents.

Step 11: EL2 test/appearance check
Battery cells are examined for issues such as hidden cracking, fragments, or black plates. Component EL levels are determined.

Step 12: Packing
Finished components are packaged in specified quantities for transportation and sale.

Step 13: Put in storage
Packaged components are transferred to warehouse storage.

Distribution Process:

Table 3 Information on the distribution stage

Vehicles	Capacity utilization (incl. return) %	Type of vehicle	Distance km	Fuel/energy consumption per tkm (kg/tkm)	Fuel/energy consumption per km (kg/km)
Truck (Within China)	36.7	EURO6 16-32 ton	376	Diesel: 0.0366	8.36E-4~1.22E-3
Ship (to Sweden)	70	Container ship	20157	Heavy oil: 0.0025	5.71E-5~8.30E-5
Truck (Within Sweden)	36.7	EURO6 16-32 ton	162	Diesel: 0.0366	8.36E-4~1.22E-3

Note: Range of fuel consumption per km (kg/km) due to different product+packaging weights

Product installation:

The PV module can be installed both as rooftop and ground-mounted type. According to the 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. Waste generation and treatment of packaging materials are considered in this stage. The waste generated from the product packaging, mainly consisting of waste wood pallets, is accounted for in this stage, transportation of waste is assumed as 200km. The treatment of the waste wood pallets is modeled as 75% recycling and 25% incineration. Other packaging materials, including paper and plastic film, are modeled as 100% incineration.

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 used for cleaning to maintain the performance is considered, 0.23L water used per module each time, and 2 times in a year are assumed. During the operation of PV module, no repair (B3), replacement (B4), and refurbishment (B5) is required.

It is assumed that 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:

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

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 take into consideration the specific inclination (slope, tilt) and orientation.
A = Area of module, m^2.
y = Module yield: electrical power, kWp for standard test conditions (STC) of the module divided by the area of the module.
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:

$$E_2 = E_1 * (1 - \text{deg})$$

Energy production n year of operation:

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

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

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

End-of-Life:

For end-of-life (EoL) stage, assumptions are made due to a lack of data. Decommissioning stage (C1) of PV modules is assumed to be taken with same energy and fuel consumption as for installation stage. Transportation distance from the plant site to the waste treatment site (C2) is assumed to be 50km. Waste processing (C3) stage is assumed to be mechanically treated to yield the bulk materials with an electricity consumption of 0.277kWh/kg module, based on data from the IEA.

This study refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under the EU scenario. The required recycling rate for waste PV modules is 85% according to 2012/19/EU-Article 11 & ANNEX V. According to the IEA report, the recycling rate of PV modules is above 85% in the main EU countries. Therefore, it is safe to use 85% as a recycling rate for waste PV modules. 15% of the waste components (cells, glass, and waste plastics) end up to disposal stage (C4). The plastic will be sent to incineration, while the cell and unrecovered glass will be treated as inert materials for landfilling. In this study, bulk materials (glass and aluminium) are recovered, while plastic components will be incinerated for energy recovery. It is assumed that 100% metal components and 85% glass will be recycled. 15% of contaminated glass and other unrecyclable materials will go to landfill, while the plastic components will go to incineration.

Benefits and loads beyond the system boundary:

95% metal scrap (aluminium and silver) and 85% of glass scrap will be recycled. The plastic components are incinerated with energy recovery. Efforts required by secondary production, loss of materials and quality are considered.

LCA information

The study is developed according to ISO 14040/14044, and follows the International EPD® System: *PCR 2019: 14 PCR Construction products v1.3.4, C-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27),* and General Programme Instructions (GPI) v5.0.1.

Functional unit:
1 Wp of manufactured photovoltaic module, with activities needed for a study period for a defined reference service life (≥80% of the labelled power output, estimated at 25 years).

Time representativeness:
The study used primary data collected from Dec. 2023 to Nov. 2024.

Database(s) and LCA software used:
In the context of this study, the activity data are mainly of 'primary type', i.e. collected with the support of the company for the specific production sites. 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 3.10 "allocation, cut-off by allocation - unit" database. Secondary data such as silicon ingot, silicon wafer, and solar cell production are taken from IEA PVPS Task 12, 2020 report. LCA-software SimaPro version 9.6 was used, EF 3.1 method is used for impact results calculation.

Internal follow-up procedures:
In order to keep the LCA data representative and reliable, input data for the LCA model as well as information in the EPD, such as raw material acquisition, transportation modes, manufacturing processes, changes in product design etc. will be checked annually by Jolywood internally. If there would be any significant changes taking place, the LCA model, LCA report and EPD report would be updated accordingly and summited for review.

A4 Transport
The scenarios included are currently in use and are representative for one of the most probable alternatives.

PARAMETER	VALUE/DESCRIPTION
Fuel type and consumption of vehicle or vehicle type used for transport e.g. long distance truck, boat, etc.	Truck of 16- 32 ton: Fuel consumption: 2.05E-1~2.42E-1 L/100 km. Ship: Fuel consumption: 1.32E-2~1.56E-2 L/100 km
Distance	Ship: 20157 km Truck: 376 km (domestic), 162 km (oversea)
Capacity utilization (including empty returns)	Truck: 36.7 % (full + empty return) Ship: 70 % (full + empty return)
Bulk density of transported products	N/A
Volume capacity utilization factor	1

A5 Installation
The scenarios included are currently in use and are representative for one of the most probable alternatives. During PV module installation, there is no installation loss.

PARAMETER	VALUE/DESCRIPTION
Auxiliary materials for installation	N/A
Use of water	0
Use of other resources	N/A
Quantitative description of the type of energy (regional mix) and the consumption during the installation process	Electricity: 6.0E-5 kWh/FU Diesel: 3.0E-4 kg/FU
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	Non-hazardous waste: For Incineration: 8.35E-3~9.92E-3 kg/FU For recycle: 1.38E-3~1.66E-3 kg/FU

B Use stage

The scenarios included are currently in use and are representative for one of the most probable alternatives.

PARAMETER	VALUE/DESCRIPTION
Auxiliary materials for use phase	N/A
Use of water	9.13E-3~1.22E-2 kg/FU
Use of other resources	N/A
Quantitative description of the type of energy (regional mix) and the consumption during use	No energy consumption during use
Wastage of materials on the building site before waste processing, generated during use	No waste generation

C End of life stage

The scenarios included are currently in use and are representative for one of the most probable alternatives.

PARAMETER	VALUE/DESCRIPTION
Waste collection process specified by type	Non-hazardous waste: 4.52E-2~5.39E-2 kg/FU
Recovery system specified by type	Incineration with energy recovery: 4.25E-3~6.59E-3 kg/FU
Waste processing Recovery system specified by type Recovery system specified by type	Materials recycling: 3.06E-2~4.82E-2 kg/FU
Disposal Characteristic performance, Disposal specified by type	Inert materials landfill: 1.42E-3~7.92E-3 kg/FU

System diagram:

Table 2 LCA stages

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; ND = MODULE NOT DECLARED)																	
	Product Stage			Construction process stage		Use Stage							End of life stage				Resource recovery stage
	Raw Material	Transport	Manufacturing	Transport	Assembly / Install	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction and 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	X	X	X	X	X	X	X	X	X	X
Geography	CN			SE		SE							SE				SE
Specific data used	8%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation-products	<10%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation-sites	<10%			-	-	-	-	-	-	-	-	-	-	-	-	-	-

System boundary of this study is cradle to grave with module D, as illustrated jn Figure 3.

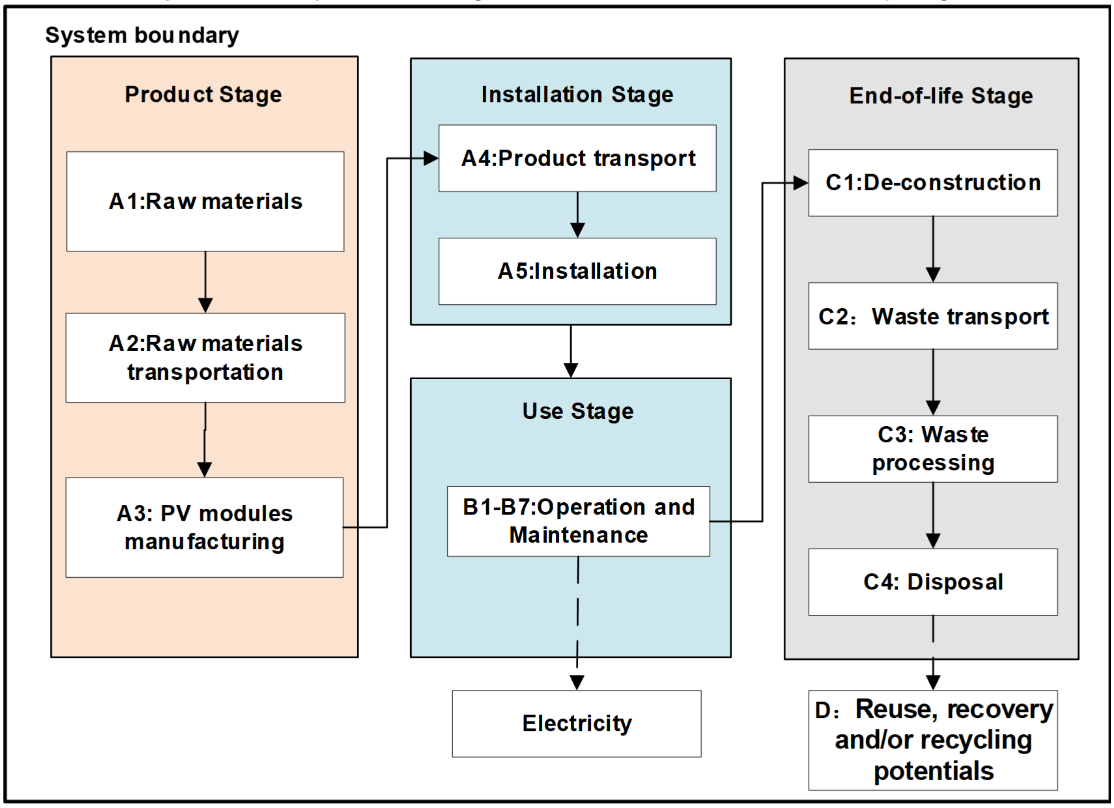

Figure 3 System boundary

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:

- The packaging for silicon wafer and solar cells is reused internally and its impact was excluded from the system;
- Emissions during the PV module installation and 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.
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.
- Research and development activities.
- Long-term emissions.

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. The assumptions made are listed below:

Table 3 List of assumptions

Categories	Items	Assumptions
Manufacturing stage (A1-A3)	Solar cell, Silicon wafer, silicon ingot	Life cycle inventory (LCI) data of silicon ingot, silicon wafer, and solar cells is difficult to obtain at the stage, thus an average LCI data for China in IEA PVPS Task 12, 2020 is used for modelling
Transportation stage (A2 & A4)	Transportation vehicle type	For the vehicle used in raw materials and product transportation, CN6 type vehicles are used, which are aligned with the EURO6 standards, EURO 6 type vehicle with 16-32 ton capacity is assumed for modelling.
Installation stage (A5)	Electricity and materials use	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 analysed in this study
Use & Maintenance	Use (B1)	The use stage requires no energy and materials inputs, and has no emissions.
	Maintenance (B2)	Water used for cleaning in 25 years is assumed with 0.23L per 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 modules is assumed to be done manually, no electricity and materials use 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.
	Waste processing (C3)	The electricity consumption during this stage is 0.277kWh/kg module based on the data from IEA.
	Disposal (C4)	Disposal scenarios is based on the WEEE

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

The allocation of electricity and emissions during the manufacturing stage of PV module are allocated by power output ratio. The transportation of raw materials is allocated by mass ratio. For product manuafactrued in different plants, inputs and outputs are allocated based on the production volume of different plants.

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 solar PV module products, polluter-pays-principle (PPP) is followed. As for the load and benefit of reuse, recycling, and recovery processes (Module D), it is reported separately following the PCR's recommendation. End-of-life approach with 100/0 allocation is adopted in this analysis. This approach is based on the assumption that material recycled into secondary material at end-of-life substitutes an equivalent amount of virgin material (losses considered). Hence a credit is given to account for this material substitution. However, this also means that burdens equivalent to this credit should be assigned to scrap used as an input to the production process. which means that the environmental impact of the recycled material is the same as that of the virgin material. This approach rewards end-of-life recycling but does not reward the use of recycled content.

In cases where materials are sent to waste incineration, the study accounts for waste composition, heating value, and regional efficiencies, and assigns credits for power and heat outputs using the regional grid mix and thermal energy from natural gas, resulting in a conservative estimate of the benefits of energy recovery.

Cut-off rules:

The following procedure was followed for the exclusion of inputs and outputs:

- All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented;
- According to PCR, life cycle inventory data shall according to EN 15804 include a minimum of 95% of total inflows (mass and energy) per module. In addition, if less than 100% of the inflows are accounted for, proxy data or extrapolation should be used to achieve 100% completeness.

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 PV module takes place in three sites: Jiaxing, Zhejiang Province; Taizhou, Jiangsu Province; and Wuhu, Anhui Province; where the East China Power grid is used. In Taizhou plant, electricity produced from rooftop PV is used during PV module manufacturing, electricity production from solar PV is used for modelling. On the other hand, the installation stage and the end-of-life stage, taking Sweden market as a case study, where the Sweden grid electricity mix is used.

Electrcity mixes	Unit	Value
Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off, U, ecoinvent 3.10	kg CO2 eq/kWh	0.857

Electricity, low voltage {CN-SH}| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | Cut-off, U	kg CO2 eq/kWh	0.0885

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.

Environmental performance

Results of LR7-54HTH-475Wp (as representative results) are selected to cover the all products in this EPD. Note that the results are relative expressions and do not predict impacts on endpoint categories, exceedance of certain levels, safety margins or risks.

Table 4 Mandatory impact category indicators according to EN 15804

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP-fossil	kg CO_2 eq.	3.93E-01	1.48E-02	1.79E-03	0.00E+00	7.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-03	4.32E-04	3.20E-04	1.37E-02	-8.55E-02
GWP-biogenic	kg CO_2 eq.	-3.53E-03	0.00E+00	3.53E-03	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	0.00E+00
GWP- luluc	kg CO_2 eq.	3.32E-04	7.09E-06	3.79E-07	0.00E+00	1.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.43E-07	1.43E-07	4.49E-05	5.69E-08	-1.29E-04
GWP- total	kg CO_2 eq.	3.90E-01	1.49E-02	5.32E-03	0.00E+00	7.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-03	4.32E-04	3.65E-04	1.37E-02	-8.56E-02
ODP	kg CFC11 eq	3.26E-08	2.23E-10	2.30E-11	0.00E+00	1.04E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-11	8.59E-12	9.47E-12	5.89E-12	-2.13E-09
AP	mol H+ eq	2.22E-03	3.02E-04	1.26E-05	0.00E+00	3.89E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-05	9.00E-07	1.80E-06	3.24E-06	-4.33E-04
EP-freshwater	kg P eq.	1.92E-05	8.17E-08	5.84E-09	0.00E+00	4.81E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.81E-09	3.37E-09	1.21E-08	3.43E-09	-2.54E-06
EP-marine	kg N eq	5.08E-04	7.49E-05	5.80E-06	0.00E+00	6.38E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.64E-06	2.11E-07	3.96E-07	1.54E-06	-9.23E-05
EP-terrestrial	mol N eq	4.89E-03	8.33E-04	6.35E-05	0.00E+00	7.21E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-05	2.33E-06	4.92E-06	1.59E-05	-1.12E-03
POCP	kg NMVOC eq.	1.52E-03	2.34E-04	1.91E-05	0.00E+00	2.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-05	1.50E-06	1.24E-06	4.15E-06	-3.24E-04
ADP-minerals & metals*	Kg Sb eq.	2.49E+00	1.20E-02	1.12E-03	0.00E+00	8.66E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.73E-04	5.05E-04	5.16E-02	4.11E-04	-4.71E-01
ADP-fossil*	MJ	2.05E-05	2.57E-08	8.79E-10	0.00E+00	3.97E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.18E-10	1.41E-09	7.37E-09	6.10E-10	-4.24E-06
WDP*	m^3	4.52E-01	5.86E-04	5.14E-05	0.00E+00	1.04E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.18E-05	2.52E-05	7.18E-04	-1.25E-04	-1.24E-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															

* 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.

Table 5 Additional environmental impacts

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP-GHG [1]	kg CO_2 eq.	3.94E-01	1.49E-02	1.79E-03	0.00E+00	7.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-03	4.32E-04	3.65E-04	1.37E-02	-8.56E-02

[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

Table 6 Resource use

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PERE	MJ	8.81E-01	1.91E-03	3.21E-04	0.00E+00	2.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.89E-04	1.05E-04	3.60E-02	3.30E-02	-1.45E-01
PERM	MJ	3.29E-02	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	0.00E+00	-3.29E-02	0.00E+00
PERT	MJ	9.14E-01	1.91E-03	3.21E-04	0.00E+00	2.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.89E-04	1.05E-04	3.60E-02	1.49E-04	-1.45E-01
PENRE	MJ	3.17E+00	1.57E-02	1.84E-01	0.00E+00	4.78E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.22E-04	5.65E-04	1.15E-03	3.68E-04	-5.61E-01
PENRM	MJ	1.83E-01	0.00E+00	-1.83E-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	0.00E+00	0.00E+00
PENRT	MJ	3.35E+00	1.57E-02	1.09E-03	0.00E+00	4.78E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.22E-04	5.65E-04	1.15E-03	3.68E-04	-5.61E-01
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	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	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	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	1.18E-02	1.84E-05	2.47E-06	0.00E+00	2.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-06	8.41E-07	6.87E-05	1.23E-05	-4.28E-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 production and output flows

Table 7 Waste production

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	kg	7.01E-04	1.10E-06	1.35E-07	0.00E+00	5.54E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-07	4.09E-08	1.66E-08	6.17E-08	-2.56E-06
NHWD	kg	1.84E-02	3.52E-03	8.45E-05	0.00E+00	1.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-05	2.93E-04	3.82E-02	7.29E-03	-3.93E-03
RWD	kg	5.72E-06	3.00E-08	6.62E-09	0.00E+00	6.81E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.06E-09	1.96E-09	8.21E-07	2.17E-09	-1.55E-06
Acronyms	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed															

Table 8 Output flows

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	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	0.00E+00	0.00E+00	0.00E+00	0.00E+00

MFR	kg	1.20E-03	0.00E+00	1.51E-03	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	3.06E-02	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	9.37E-04	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	5.75E-03	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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-02
Acronyms	CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy															

Information related to EPD of multiple products

The variations found among the multiple products are lesser than 10% for nearly all impact categories and indicators for A-C life cycle stages. Only for the impact category ODP, the variation is above 10%.

Results of ODP for other declared products in this report are presented by its A-C stage results and variation against LR7-54HTH (475 Wp) result.

Table 9 Environmental impacts of other products for the parameter ODP (expressed as A-C variations)

Parameter	Unit	A-C Variations, %				
		LR7-72HTH	LR7-60HTB	LR7-60HTH	LR7-54HTB	LR5-72HTDR
ODP	kg CFC11 eq	1.62%	11.24%	9.78%	2.87%	-89.14%

Note: A significant lower in ODP of LR5-72HTDR compared to other products is due to no use of backsheet

LR7-54HTH (475 Wp) has been chosen as representative products for its respective brand series. To obtain results across various power output ranges for the products, a list of conversion factors has been provided, accounting for different peak power ranges.

Table 10 EPD results conversion factors of various power output ranges for LR7-54HTH series

Rated power output range (Wp)	450	455	460	465	470
Conversion factor	1.056	1.044	1.033	1.021	1.011

Interpretation of results

Manufacturing stage, specifically the raw materials extraction stage, is responsible for most impacts. Three key materials that contribute the most to the environmental impacts in PV module production are solar cells, glass, and frame.

The converting factor to convert the results related to the functional unit to declared unit (1 m^2 PV module) is in Table 11.

Table 11 Conversion factors

Series (brand name)	LR7-72HTH	LR7-60HTB	LR7-60HTH	LR7-54HTB	LR7-54HTH	LR5-72HTDR
Conversion factors (Wp/m2)	233.33	234.51	244.19	230.39	232.84	228.68

Additional environmental information

None

Information related to sectorial EPD

This EPD is not sectorial.

Differences with previous versions

This is the first version.

References

LCA for LONGi PV modules 2025-04, version 2.0.

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.

INTERNATIONAL EPD SYSTEM

General Programme Instructions of the International EPD® System. Version 4.0

General Programme Instructions of the International EPD® System. Version 5.0.1

PCR 2019:14 Construction Products, Version 1.3.4

c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)

INTERNATIONAL AND EUROPEAN STANDARDS

EN 15804:2012+A2:2019/AC:2021 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

ISO 14020:2022 Environmental statements and programmes for products: Principles and general

requirements

ISO 14025:2011 Environmental labels and declarations - Type III environmental declarations -Principles and procedures

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

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

WEEE Directive 2012/19/EU Article 4,11&15

LCA SOFTWARE AND DATABASE

SimaPro 9.6, LCA software

Ecoinvent Database 3.10

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