ASTRONERGY

EPD®
THE INTERNATIONAL EPD® SYSTEM

epd-norway
Global Program Operator

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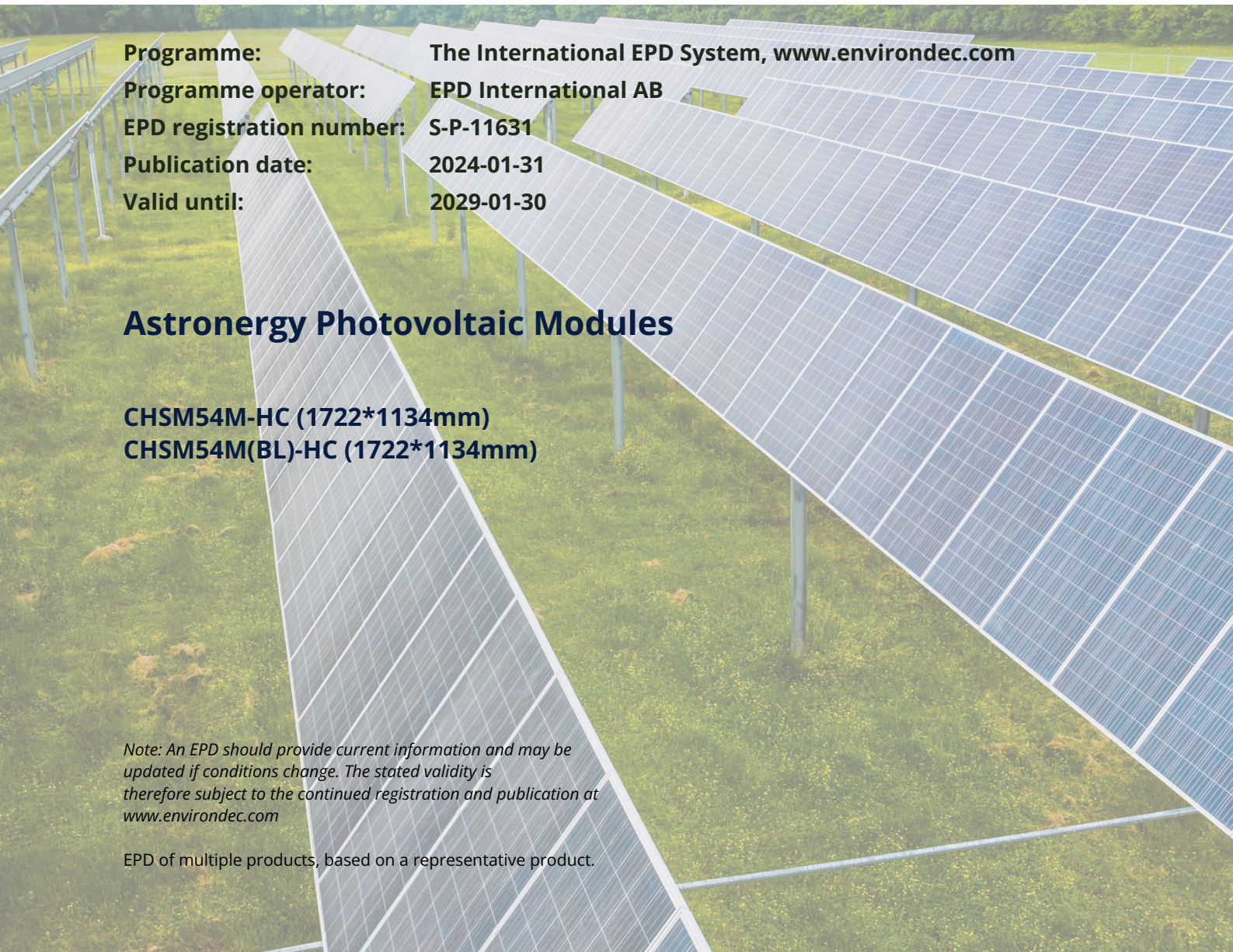
ECO PLATFORM EPD VERIFIED

Environmental Product Declaration

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



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Astronergy Photovoltaic Modules

CHSM54M-HC (1722*1134mm)
CHSM54M(BL)-HC (1722*1134mm)

Note: 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

EPD of multiple products, based on a representative product.

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)	
CEN standard EN 15804 serves as the Core Product Category Rules (PCR)	
PCR 2019: 14 PCR Construction products v1.3.1 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
LCA Practitioner:	Dandan LI Star Talers Environmental Technology Co., Ltd. dandan.li@startalers.cn
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

Owner of the EPD:

Chint New Energy Technology Co., Ltd.

No.1 Jisheng Road, Jianshan New Zone, Haining, Zhejiang Province, P. R. China

Website: www.astro-energy.com

Manufacturing site:

Chint New Energy Technology (Yancheng) Co., Ltd.

No.1 Tonghui Road, Dafeng District, Yancheng City, Jiangsu Province, P. R. China

About Us

Under the CHINT Group, Astronergy is an intelligent manufacturing enterprise focusing on photovoltaic modules. Founded in 2006, Astronergy is one of the earliest private enterprises to set foot in the PV field, its business footprints are all over 140 countries and regions in the world. Astronergy is committed to being the most competitive photovoltaic modules supplier worldwide with its mission of creating a sustainable and net-zero carbon world with solar power. Focusing on R&D, production and sales of high-efficiency crystalline silicon PV cells and PV modules, with intelligent manufacturing bases at Haining in Zhejiang, Yancheng in Jiangsu, Jiuquan in Gansu, Songyuan in Jilin and in Thailand.

ASTRONERGY for A Greener World

Taking promoting sustainable development as a long-lasting persistence, Astronergy's ESG committee mainly manages three groups - environmental governance, social responsibility and corporate governance, to further respond to the risks and opportunities brought by changes in climate, environment and market policies, and to enhance the work of the company in areas of the environment, social responsibility and corporate governance. We're striving to enable the company with premier competitive advantages of green, high-efficiency, low-carbon and sustainability.

PRODUCT INFORMATION

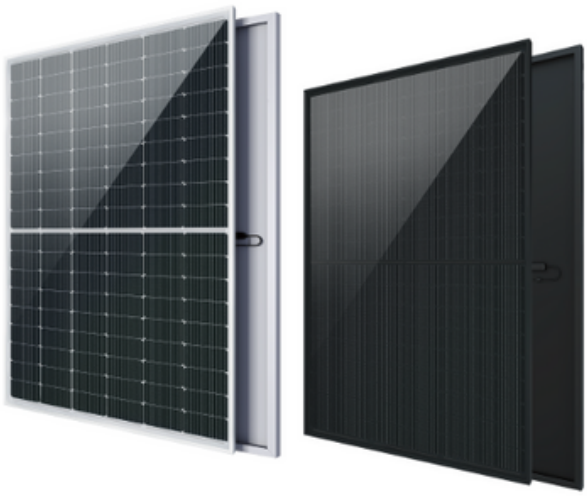
Product name:
CHSM54M-HC (1722*1134mm)
CHSM54M(BL)-HC (1722*1134mm)

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

Geographical scope:
Global

Description

Astronergy PV modules can be widely used in rooftop and ground solar farms. Astronergy strengthens technological innovation and R&D investment, and continues to launch ASTRO series of high-efficient modules, covering ASTRO monocrystalline bifacial series and ASTRO monocrystalline mono-facial series, using a number of advanced photovoltaic technologies such as large-format silicon wafers, half-cutting, MBB, non-destructive cutting to increase module power and efficiency, and have obtained certifications in many mainstream markets including China, Europe, Australia, Japan, South Korea, Israel, Brazil, the United States, etc., with metrics reaching the international first-class level. With a reliable and technology-leading brand, Astronergy has won the honor of PVEL/DNV GL "Top Performer" top module manufacturer for seven times, and has been listed as the world's Tier 1 supplier of photovoltaic modules by Bloomberg, an international authoritative financial company, for many times.



PRODUCT INFORMATION

Identification

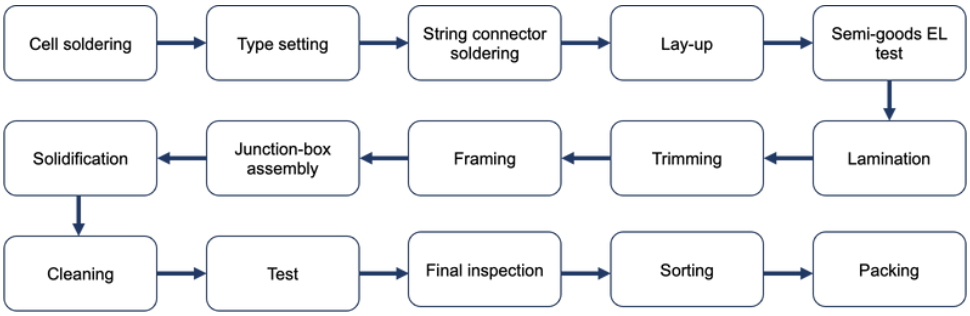
Series (brand name)	CHSM54M-HC	CHSM54M (BL)-HC
Power output range (W)	395-420	395-420
Area	1722*1134mm	1722*1134mm
Module efficiency (%)	21.50	21.50
Weight (kg)	21.24	21.24
Weight (incl. package)	22.37	22.37
First year degradation (%)	2	2
Annual degradation (%)	0.55%	0.55%
Type of cell/technology	Mono-Si	Mono-Si
Cells configuration	54x2	54x2
Reference service life (years)	25	25
Convertion factor (Wp/m^2)	215.08	215.08

Content declaration

Product components	Weight, kg	Post-consumer recycled materials, weight -%	Biogenic material, weight-% and kg C/kg
Glass	15.310	0	-
Frame	2.004	0	-
EVA	1.835	0	-
backsheet	0.846	0	-
Solder	0.164	0	-
Junction box	0.115	0	-
Silicone gel	0.294	0	-
Cell	0.656	0	-
Flux	0.016	0	-
Sum	**21.24**	**0**	-
Packaging materials	**Weight, kg**	**Weight -% (versus the product)**	**Weight biogenic carbon, kg C/kg**
Wood pallet	0.978	4.60%	4.72E-1
Corrugated box	0.100	0.47%	4.50E-1
Packaging film	0.052	0.24%	0

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



Step 1: Cell soldering
Cells prepared on the feed port are heated by infrared tubes. Transmit the heat to ribbons to fusing the stannum on the cells.

Step 2: Type-setting/ soldering/ lay up
Lay up glass, EVA, cell strings automatically, use tape to fix the cell strings, solder cross connectors to form a circuitry, meanwhile lay up EVA, back sheet, paste the SN label. At last, record information into AMES system.

Step 3: Semi-goods EL Test
Scan SN label and take photos automatically. Operators inspect the EL pictures according the EL standard. AI intelligent judgment.

Step 4: Lamination
The semi-goods flow to laminator automatically. Put 4 pieces of semi-goods once regardless of 72pcs or 54pcs cells.

Step 5: Trimming
Trimming the edge of semi-goods automatically to ensure the edge is smooth.

Step 6: Framing
Put Aluminum rails on the feed port, inject silicone gel into the groove. Then mechanical arm grabs glued frames and compresses to the module automatically.

Step 7: J-Box Assemble
Fix junction box to glue machine, glue silicone to cover the bottom of J-box. Its appearance should be smooth.

Step 8: J-Box glue
Fill the AB gel to the J-Box. After solidifying it can protect the metal component from the humidity to ensure electrical function.

Step 9: Solidification
The modules are placed on the conveyor by mechanical arm, and then transferred into the solidification room.

Step 10: Module Cleaning
Operators use 99% industrial alcohol to clean the module. And assemble the J-Box lid.

Step 11: Power Test
Simulate outside light, guarantee the consistency of result under a series of standard condition. Use xenon light as source, and the light shapes as pulse to decrease the power loss as much as possible. Specific data is pasted on the label of back sheet.

Step 12: Final EL Test
Utilize electroluminescence technology to detect a number of defects, such as micro cracks, grain boundaries, broken contacts and shunts.

Step13: Final Inspection
Modules enter final inspection where inspectors check for visual defects, EL pictures and related module size and so on. AI intelligent assisted judgment.

Step 14: Sorting
According to different power, currents, colors and ranks, modules are distinguished automatically.

Step 15: Packing
Modules which have passed the final inspection are transported to packing area, each module of pallets turns over of 90° and 180° in order, and then cover the box, strap and wrap automatically. Present packing type is vertical.

Step 16: Entering warehouse
Transport the packaged modules to the warehouse and get prepared for delivery to customers.

LCA INFORMATION

The study is developed according to ISO 14040/14044, and follows the International EPD® System: *PCR 2019: 14 PCR Construction products v1.3.1, c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)*, and General Programme Instructions (GPI) v4.0.

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 year 2022.

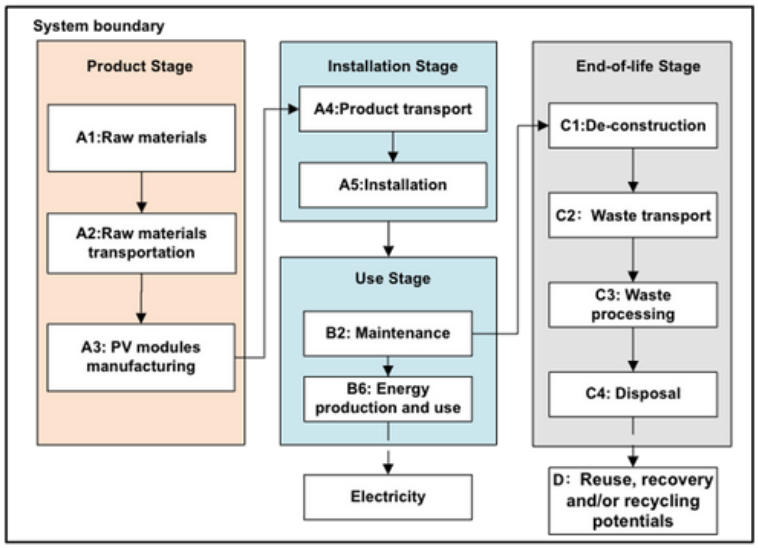
Database(s) and LCA software used:
In the context of this study, the activity data are mainly of 'primary type', i.e. collected with the support of the company for the specific production sites. Generic data related to the life cycle impacts of the material or energy flows that enter and leave the production system is sourced from Ecoinvent 3.9 "allocation, cut-off by allocation - unit" database. Secondary data such as silicon ingot and silicon wafer production are taken from IEA PVPS Task 12, 2020 report. LCA-software SimaPro version 9.5 was used.

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 Astronergy 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.

System diagram:

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	ND	X	ND	ND	ND	X	ND	X	X	X	X	X
Geography	CN			GLO		-	-	-	-	-	-	-	GLO				GLO
Specific data used	>90%					-	-	-	-	-	-	-	-	-	-	-	-
Variation-products	<10%					-	-	-	-	-	-	-	-	-	-	-	-
Variation-sites	0%					-	-	-	-	-	-	-	-	-	-	-	-

System boundary of this study is cradle to gate with options, modules C1–C4, module D and with optional modules (A1–A3 + C + D and A4-A5, B2, B6), as illustrated below.



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.
- 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:

Categories	Items	Assumptions
Manufacturing stage (A1-A3)	Silicon wafer	Life cycle inventory (LCI) data of silicon ingot and 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
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
	Operational energy use and production (B6)	No operational energy is required for PV module, the energy production is calculated
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.

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

Cut-off allocation
Cut-off allocation is applied at the system boundary. The underlying philosophy of this approach is that primary (first) production of materials is always allocated to the primary user of a material. If a 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 PV modules, 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.

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 of solar cells and PV modules takes place in Jiangsu Province, China, where the Eastern China grid electricity mix is used. On the other hand, the end-of-life stage, which involves PV module waste disposal and recycling, taking European market as a case study, where the European average grid electricity mix is used.

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.

Electricity mix	Unit	GWP-GHG
CO_2 Emissions	kg CO2-eq/kWh	0.850

LCA Scenarios

A4 Transport

The transport in A4 covers the transport from the factory in China to the installation site globally by sea and road.

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: 6.61E-2 L/100 km. Ship: Fuel consumption: 5.31E-3 L/100 km
Distance	Ship: 7183 km Truck: 419 km
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

Note: Range of fuel consumption per km due to different product weights.

A5 Installation

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: 9.94E-4 kg/FU

The PV modules can be installed both as rooftop and ground-mounted type. According to the product category rules (PCR), mounting structures like inverter, wiring, etc., are not considered in this study.

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.

B Use stage

PARAMETER	VALUE/DESCRIPTION
Auxiliary materials for use phase	N/A
Use of water	2.74E-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

For the use stage (B1) of the PV moduless, 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 modules, 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:

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

Where:

E1= 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:

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

C End of life stage

PARAMETER	VALUE/DESCRIPTION
Waste collection process specified by type	Non-hazardous waste: 5.06E-2 kg/FU
Recovery system specified by type - Energy recovery	Incineration with energy recovery: 2.69E-4 kg/FU
Recovery system specified by type - Recycling	Materials recycling: 3.50E-2 kg/FU
Disposal Characteristic performance, Disposal specified by type	Inert materials landfill: 6.88E-3 kg/FU

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. 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.

Benefits and loads beyond the system boundary

Metal scrap (aluminium, copper, and silver) and 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.

ENVIRONMENTAL PERFORMANCE

Results of CHSM54M(BL)-HC (1722*1134 mm) 420W (representative results) are selected to cover 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.

Mandatory impact category indicators according to EN 15804 (per Wp)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP- total	kg CO_2 eq.	4.36E-01	1.24E-02	3.10E-03	ND	2.37E-05	ND	ND	ND	0.00E+00	ND	1.38E-03	4.68E-04	5.06E-03	6.00E-04	-6.93E-02
GWP-fossil	kg CO_2 eq.	4.37E-01	1.24E-02	1.87E-03	ND	2.35E-05	ND	ND	ND	0.00E+00	ND	1.38E-03	4.67E-04	4.87E-03	5.99E-04	-7.00E-02
GWP-biogenic	kg CO_2 eq.	-1.25E-03	4.92E-06	1.23E-03	ND	1.30E-07	ND	ND	ND	0.00E+00	ND	5.38E-07	4.28E-07	1.80E-04	1.61E-06	8.63E-04
GWP- luluc	kg CO_2 eq.	4.83E-04	7.26E-06	3.04E-07	ND	3.76E-08	ND	ND	ND	0.00E+00	ND	2.43E-07	2.31E-07	1.22E-05	6.56E-08	-1.51E-04
ODP	kg CFC11 eq	3.81E-08	2.21E-10	2.48E-11	ND	3.65E-12	ND	ND	ND	0.00E+00	ND	2.15E-11	1.02E-11	8.76E-11	1.31E-11	-8.86E-10
AP	mol H+ eq	2.51E-03	1.30E-04	1.31E-05	ND	1.26E-07	ND	ND	ND	0.00E+00	ND	1.26E-05	1.02E-06	2.45E-05	6.33E-07	-4.21E-04
EP-freshwater	kg P eq.	1.32E-04	7.82E-07	7.41E-08	ND	1.03E-08	ND	ND	ND	0.00E+00	ND	6.12E-08	3.32E-08	4.45E-06	2.53E-08	-2.32E-05
EP-marine	kg N eq	5.63E-04	3.24E-05	5.96E-06	ND	2.54E-08	ND	ND	ND	0.00E+00	ND	5.78E-06	2.58E-07	4.35E-06	2.34E-07	-9.09E-05
EP-terrestrial	mol N eq	5.53E-03	3.55E-04	6.46E-05	ND	2.56E-07	ND	ND	ND	0.00E+00	ND	6.28E-05	2.62E-06	3.84E-05	2.30E-06	-1.05E-03
POCP	kg NMVOC eq.	1.64E-03	1.11E-04	1.92E-05	ND	8.35E-08	ND	ND	ND	0.00E+00	ND	1.86E-05	1.59E-06	1.24E-05	8.51E-07	-2.93E-04
ADP-minerals & metals*	Kg Sb eq.	1.96E-05	3.18E-08	8.80E-10	ND	1.09E-10	ND	ND	ND	0.00E+00	ND	5.07E-10	1.53E-09	9.70E-09	3.78E-10	-4.52E-06
ADP-fossil*	MJ	5.29E+00	1.68E-01	1.96E-02	ND	3.01E-04	ND	ND	ND	0.00E+00	ND	1.81E-02	6.64E-03	1.12E-01	1.92E-03	-8.79E-01
WDP*	m^3	5.58E-01	6.26E-04	5.61E-05	ND	1.10E-03	ND	ND	ND	0.00E+00	ND	4.52E-05	2.74E-05	1.16E-03	7.04E-05	-1.03E-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.

Additional mandatory and voluntary impact category indicators (per Wp)

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.	4.37E-01	1.24E-02	1.87E-03	ND	2.35E-05	ND	ND	ND	0.00E+00	ND	1.38E-03	4.67E-04	4.89E-03	5.99E-04	-7.02E-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 (per Wp)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PERE	MJ	1.08E+00	2.09E-03	2.91E-02	ND	3.21E-05	ND	ND	ND	0.00E+00	ND	1.70E-04	1.04E-04	2.15E-02	1.20E-04	-1.23E-01
PERM	MJ	2.89E-02	0.00E+00	-2.89E-02	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.11E+00	2.09E-03	1.96E-04	ND	3.21E-05	ND	ND	ND	0.00E+00	ND	1.70E-04	1.04E-04	2.15E-02	1.20E-04	-1.23E-01
PENRE	MJ	6.07E+00	1.64E-01	1.91E-02	ND	3.20E-04	ND	ND	ND	0.00E+00	ND	1.75E-02	6.41E-03	5.21E-02	2.13E-01	-9.57E-01
PENRM	MJ	2.11E-01	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	-2.11E-01	0.00E+00
PENRT	MJ	6.28E+00	1.64E-01	1.91E-02	ND	3.20E-04	ND	ND	ND	0.00E+00	ND	1.75E-02	6.41E-03	5.21E-02	1.85E-03	-9.57E-01
SM	kg	3.45E-03	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	1.46E-02	2.13E-05	2.25E-06	ND	2.64E-05	ND	ND	ND	0.00E+00	ND	1.68E-06	9.55E-07	8.77E-05	1.82E-05	-3.99E-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 (per Wp)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	kg	8.48E-04	1.01E-06	1.30E-07	ND	8.43E-10	ND	ND	ND	0.00E+00	ND	1.19E-07	4.22E-08	1.42E-07	1.00E-08	7.11E-06
NHWD	kg	4.07E-02	6.19E-03	1.07E-04	ND	3.48E-06	ND	ND	ND	0.00E+00	ND	2.77E-05	3.30E-04	3.66E-02	1.44E-02	-9.03E-03
RWD	kg	6.37E-06	3.83E-08	3.91E-09	ND	7.34E-10	ND	ND	ND	0.00E+00	ND	3.47E-09	2.18E-09	8.17E-07	1.59E-09	-1.61E-06
Acronyms	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed															

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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	8.17E-04	0.00E+00	1.75E-03	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	3.50E-02	0.00E+00	0.00E+00
MER	kg	1.83E-06	0.00E+00	5.82E-04	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	2.55E-04	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	1.65E-03	0.00E+00
Acronyms	CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy															

ADDITIONAL ENVIRONMENTAL INFORMATION

Results of CHSM54M(BL)-HC (1722*1134 mm) per m^2 are presented in this chapter using the conversion factor 215.08 Wp/m^2. Note that the results are relative expressions and do not predict impacts on endpoint categories, exceedance of certain levels, safety margins or risks.

Impact category indicators according to EN 15804 (per m^2)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP- total	kg CO_2 eq.	9.38E+01	2.67E+00	6.67E-01	ND	5.10E-03	ND	ND	ND	0.00E+00	ND	2.97E-01	1.01E-01	1.09E+00	1.29E-01	-1.49E+01
GWP-fossil	kg CO_2 eq.	9.40E+01	2.67E+00	4.02E-01	ND	5.05E-03	ND	ND	ND	0.00E+00	ND	2.97E-01	1.00E-01	1.05E+00	1.29E-01	-1.51E+01
GWP-biogenic	kg CO_2 eq.	-2.69E-01	1.06E-03	2.65E-01	ND	2.80E-05	ND	ND	ND	0.00E+00	ND	1.16E-04	9.21E-05	3.87E-02	3.46E-04	1.86E-01
GWP- luluc	kg CO_2 eq.	1.04E-01	1.56E-03	6.54E-05	ND	8.09E-06	ND	ND	ND	0.00E+00	ND	5.23E-05	4.97E-05	2.62E-03	1.41E-05	-3.25E-02
ODP	kg CFC11 eq	8.19E-06	4.75E-08	5.33E-09	ND	7.85E-10	ND	ND	ND	0.00E+00	ND	4.62E-09	2.19E-09	1.88E-08	2.82E-09	-1.91E-07
AP	mol H+ eq	5.40E-01	2.80E-02	2.82E-03	ND	2.71E-05	ND	ND	ND	0.00E+00	ND	2.71E-03	2.19E-04	5.27E-03	1.36E-04	-9.05E-02
EP-freshwater	kg P eq.	2.84E-02	1.68E-04	1.59E-05	ND	2.22E-06	ND	ND	ND	0.00E+00	ND	1.32E-05	7.14E-06	9.57E-04	5.44E-06	-4.99E-03
EP-marine	kg N eq	1.21E-01	6.97E-03	1.28E-03	ND	5.46E-06	ND	ND	ND	0.00E+00	ND	1.24E-03	5.55E-05	9.36E-04	5.03E-05	-1.96E-02
EP-terrestrial	mol N eq	1.19E+00	7.64E-02	1.39E-02	ND	5.51E-05	ND	ND	ND	0.00E+00	ND	1.35E-02	5.64E-04	8.26E-03	4.95E-04	-2.26E-01
POCP	kg NMVOC eq.	3.53E-01	2.39E-02	4.13E-03	ND	1.80E-05	ND	ND	ND	0.00E+00	ND	4.00E-03	3.42E-04	2.67E-03	1.83E-04	-6.30E-02
ADP-minerals & metals*	Kg Sb eq.	4.22E-03	6.84E-06	1.89E-07	ND	2.34E-08	ND	ND	ND	0.00E+00	ND	1.09E-07	3.29E-07	2.09E-06	8.13E-08	-9.72E-04
ADP-fossil*	MJ	1.14E+03	3.61E+01	4.22E+00	ND	6.47E-02	ND	ND	ND	0.00E+00	ND	3.89E+00	1.43E+00	2.41E+01	4.13E-01	-1.89E+02
WDP*	m^3	1.20E+02	1.35E-01	1.21E-02	ND	2.37E-01	ND	ND	ND	0.00E+00	ND	9.72E-03	5.89E-03	2.49E-01	1.51E-02	-2.22E+00
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.

Additional impact category indicators (per m²)

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.	9.40E+01	2.67E+00	4.02E-01	ND	5.05E-03	ND	ND	ND	0.00E+00	ND	2.97E-01	1.00E-01	1.05E+00	1.29E-01	-1.51E+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 (per m²)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PERE	MJ	2.32E+02	4.50E-01	6.26E+00	ND	6.90E-03	ND	ND	ND	0.00E+00	ND	3.66E-02	2.24E-02	4.62E+00	2.58E-02	-2.65E+01
PERM	MJ	6.22E+00	0.00E+00	-6.22E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.39E+02	4.50E-01	4.22E-02	ND	6.90E-03	ND	ND	ND	0.00E+00	ND	3.66E-02	2.24E-02	4.62E+00	2.58E-02	-2.65E+01
PENRE	MJ	1.31E+03	3.53E+01	4.11E+00	ND	6.88E-02	ND	ND	ND	0.00E+00	ND	3.76E+00	1.38E+00	1.12E+01	4.58E+01	-2.06E+02
PENRM	MJ	4.54E+01	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	-4.54E+01	0.00E+00
PENRT	MJ	1.35E+03	3.53E+01	4.11E+00	ND	6.88E-02	ND	ND	ND	0.00E+00	ND	3.76E+00	1.38E+00	1.12E+01	3.98E-01	-2.06E+02
SM	kg	7.42E-01	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	3.14E+00	4.58E-03	4.84E-04	ND	5.68E-03	ND	ND	ND	0.00E+00	ND	3.61E-04	2.05E-04	1.89E-02	3.91E-03	-8.58E-02
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 (per m^2)

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	kg	1.82E-01	2.17E-04	2.80E-05	ND	1.81E-07	ND	ND	ND	0.00E+00	ND	2.56E-05	9.08E-06	3.05E-05	2.15E-06	1.53E-03
NHWD	kg	8.75E+00	1.33E+00	2.30E-02	ND	7.48E-04	ND	ND	ND	0.00E+00	ND	5.96E-03	7.10E-02	7.87E+00	3.10E+00	-1.94E+00
RWD	kg	1.37E-03	8.24E-06	8.41E-07	ND	1.58E-07	ND	ND	ND	0.00E+00	ND	7.46E-07	4.69E-07	1.76E-04	3.42E-07	-3.46E-04
Acronyms	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed															

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	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.76E-01	0.00E+00	3.76E-01	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	7.53E+00	0.00E+00	0.00E+00
MER	kg	3.94E-04	0.00E+00	1.25E-01	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	5.48E-02	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00	3.55E-01	0.00E+00
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

Results of CHSM54M-HC (1722*1134mm) are the same as CHSM54M(BL)-HC (1722*1134mm).

CHSM54M(BL)-HC (1722*1134mm) 420W has been chosen as representative product for its 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.

Rated power output range (Wp)	**395**	**400**	**405**	**410**	**415**
Conversion factor	1.063	1.050	1.037	1.024	1.012

INTERPRETATION OF RESULTS

Contribution analysis of the whole life cycle environmental impacts shows that the impacts come mainly from A1-A3 stage. For the impact category GWP-Total, A1-A3 stages account for around 95% of the total amount, and A1 stage accounts for 97% of A1-A3. Upon further analysis of the A1 raw material stage, it is possible to identify environmental impact hotspots. Solar cells accounts for around 70% of raw material extraction stage, which is followed by frame, and glass.

INFORMATION RELATED TO SECTORIAL EPD

This EPD is not sectorial.

DIFFERENCES WITH PREVIOUS VERSIONS

First version of EPD.

REFERENCES

LCA for Astronergy PV modules

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.

PCR 2019:14 Construction Products, Version 1.3.1

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 14021:2016/Amd 1:2021 Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)

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)

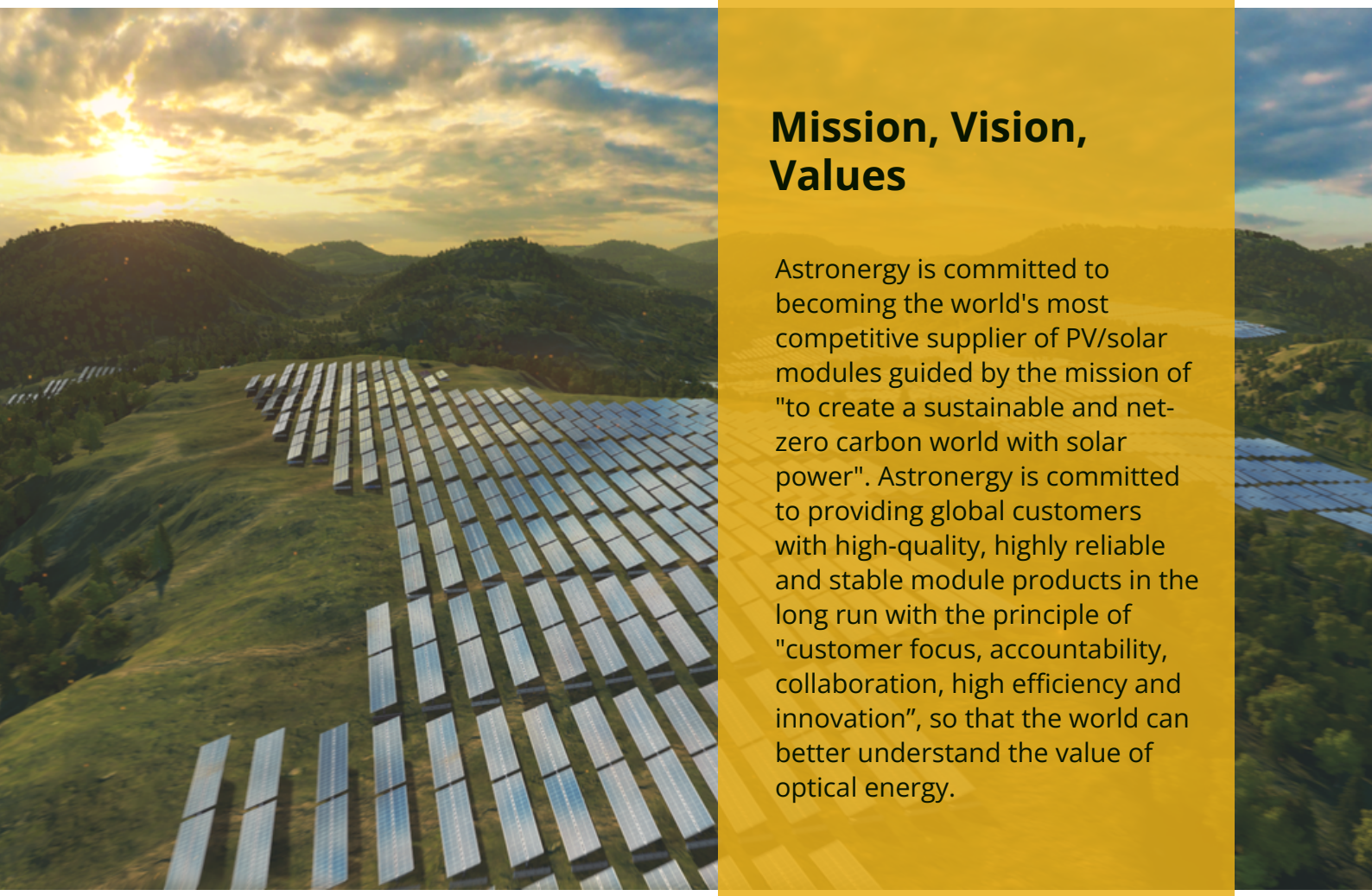
ISO 14044: 2006/Amd 2:2020 Environmental management - Life cycle assessment - Requirements and guidelines Amendment 2 (ISO 2020)

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

LCA SOFTWARE AND DATABASE

SimaPro 9.5, LCA software

Ecoinvent Database 3.9



Mission, Vision, Values

Astronergy is committed to becoming the world's most competitive supplier of PV/solar modules guided by the mission of "to create a sustainable and net-zero carbon world with solar power". Astronergy is committed to providing global customers with high-quality, highly reliable and stable module products in the long run with the principle of "customer focus, accountability, collaboration, high efficiency and innovation", so that the world can better understand the value of optical energy.

CONTACT INFORMATION

EPD Owner

Chint New Energy Technology Co., Ltd.

Email: na.shan@astronergy.com

Website: www.astro-energy.com

LCA Practitioner

Star Talers Environmental Technology Co., Ltd.

Email: info@startalers.cn

Website: www.startalers.org

ANNEX 1

ANNEX 1: Self declaration from EPD owner

Specific requirements

1 Applied electricity data set used in the manufacturing phase

The electricity mix for the electricity used in manufacturing (A3) is the electricity grid mix

<0.236 CO_2 eqv/MJ

2 Transport from the place of manufacture to a central warehouse

Transport distance, and CO_2-eqv./DU from transport of the product from factory gate to central warehouse in Oslo shall be given. The following table shall be included in the EPD:

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy use	Unit	Value (l/t)	Kg CO2-eqv./DU
Boat	70	Container ship	20400	Heavy oil: 0.0026	l/tkm	53.04	1.06E-02 ~ 1.29E-02
Truck	36.7	EURO6 16-32 ton	415	Diesel: 0.0436	l/tkm	18.094	4.0E-03 ~ 4.9E-03
Railway							
Rail							
Air							
Total							1.46E-02 ~ 1.78E-02

3 Impact on the indoor environment

☐ Indoor air emission testing has been performed; specify test method and reference;
M1, _____

☐ No test has being performed

√ Not relevant; specify _This is not relevant to the declared product PV modules___