Environmental Product Declaration

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

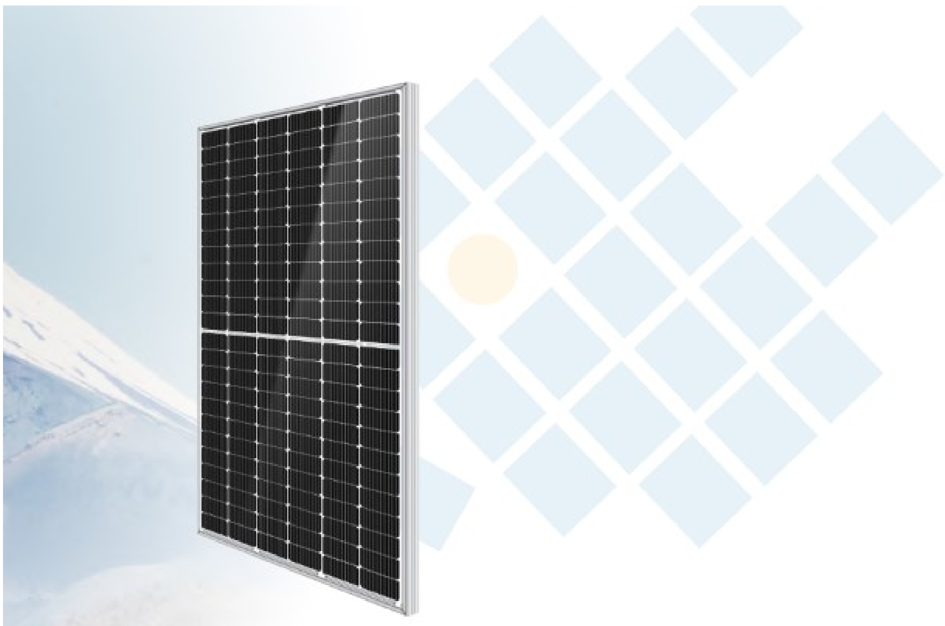
[*Photovoltaic Modules*]

from

[Leapton Solar (Changshu) Co. Ltd]

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	S-P-12377
Publication date:	2024-04-07
Valid until:	2029-04-04
	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

Statement: EPD of multiple products, based on worst case results. The list of the products covered is : LP182*182-M-54-NB-XXXW, LP182*182-M-60-NB-XXXW, LP182*182-M-72-NB-XXXW, LP182*182-M-78-NB-XXXW



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 v1.3.2* *c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)*
PCR review was conducted by: *<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: *<YiXiao Zhang, TÜV NORD (Hangzhou) Co., 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: *<Ik Kim, SMaRT-Eco Co., and signature of the third-party verifier>* Approved by: The International EPD® System
OR
Independent third-party verification of the declaration and data, according to ISO 14025:2006, via: ☐ EPD verification by accredited certification body Third-party verification: *<name, organisation>* is an approved certification body accountable for the third-party verification The certification body is accredited by: *<name of accreditation body & accreditation number, where applicable>*
OR

Independent third-party verification of the declaration and data, according to ISO 14025:2006 via:

☐ EPD verification by EPD Process Certification*

Internal auditor: *<name, organisation>*

Third-party verification: *<name, organisation>* is an approved certification body accountable for third-party verification

Third-party verifier is accredited by: *<name of accreditation body & accreditation number, where applicable>*

*For EPD Process Certification, an accredited certification body certifies and reviews the management process and verifies EPDs published on a regular basis. For details about third-party verification procedure of the EPDs, see GPI.

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

☐ Yes ☒ No

[Procedure for follow-up the validity of the EPD is at minimum required once a year with the aim of confirming whether the information in the EPD remains valid or if the EPD needs to be updated during its validity period. The follow-up can be organized entirely by the EPD owner or together with the original verifier via an agreement between the two parties. In both approaches, the EPD owner is responsible for the procedure being carried out. If a change that requires an update is identified, the EPD shall be re-verified by a verifier]

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 excluded 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

Company information

Owner of the EPD:

Leapton Solar (Changshu) Co., Ltd
Website: https://www.leaptonpv.com/

Contact:

Name: Fangyuan Xu, Tel:13962336381 Email: fangyuan.xu@leaptonenergy.com

Description of the organisation:

The headquarter - LEAPTON ENERGY CO.,LTD is founded in Kobe, Japan in 2012. It is not only focusing on R&D and sales of the solar power system, solar modules, mounting system and ground screw in Japan, but also focusing on the development, management and after-maintenance of the solar power station. We have built more than 60 own solar power stations all over Japan relying on our own resources. In 2015, a branch was established in Tokyo, which is focusing on the sales of solar pv products.

In 2012, Leapton establish China headquarter in Shanghai - LEAPTON ENGINEERING TECHNOLOGY(SHANGHAI) CO.,LTD, which focus on Chinese PV System development and sales.

The module factory - LEAPTON SOLAR(Changshu) CO.,LTD is established in Changshu, Jiangsu in 2017, which is focusing on the production and sales of the solar modules all over the world. With the most advanced automated production line in the world, the module annual capacity was 600MW in 2020. The products are strictly manufactured according to the Japanese industry standard, which is one of the top ten Japanese module brands and ranked in the Bloomberg Tier1 list for many consecutive years, .In 2019, the project will be divided into two phases, covering a total area of 72,000 sqm. By the beginning of 2021, the first phase of the 2GW plant has been completed and Leapton solar enter the GW era. The second phase of 3GW plant will be completed in 2023.

Product-related or management system-related certifications:

Name and location of production site(s):

Address: No.9 Sunshine Avenue, Changshu, Suzhou city, Jiangsu province, 215500, P. R. China.

Product information

Product name:

LP182*182-M-78-NB-XXXW
LP182*182-M-72-NB-XXXW
LP182*182-M-60-NB-XXXW
LP182*182-M-54-NB-XXXW

Product identification:

Table1 Technical Specifications for the PV modules

Serious (brand name)	Power output range (W)	Dimensions (mm^3)	Weight (kg)	Cell number	Annual average degradation
LP182*182-M-78-NB-XXXW	580~625	2465*1134*35/30	34.1	78	0.4%

Serious (brand name)	Power output range (W)	Dimensions (mm³)	Weight (kg)	Cell number	Annual average degradation
LP182*182-M-72-NB-XXXW	555~605	2334*1134*30	32.3	72	0.4%
LP182*182-M-60-NB-XXXW	460~505	1955*1134*30	27.2	60	0.4%
LP182*182-M-54-NB-XXXW	410~450	1762*1134*30	24.6	54	0.4%

Product description:
Leapton's high performance N-type modules. It applies the N-type MBB cell with a new circuit design. The new technology can increase the output power of 10W-20W. The module can maintain its high performance under low light environment. Module adopts 182*182mm half cells, bifcial module provides an additional 5%-25% output. The module is expected to withstand harsh environments including strict salt spray and ammonia corrosion. Leapton Solar provides a 30 year warranty for its power and 25 year warranty for its quality. The average annual degradation rate is 0.4% for all of these N-type modules.

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

Geographical scope: China

LCA information

Functional unit / declared unit:
1 Wp of manufactured photovoltaic module, from cradle-to-grave over RSL. The converting factor to convert the results related to the functional unit to declared unit (1 m2 PV module) is listed in the following table

Table 1 The conversion factor for functional unit to the declared unit

PV modules	Unit	Value
LP182*182-M-78-NB-XXXW	Wp/m²	154
LP182*182-M-72-NB-XXXW	Wp/m²	172
LP182*182-M-60-NB-XXXW	Wp/m²	207
LP182*182-M-54-NB-XXXW	Wp/m²	215

Reference service life:
25 years

Time representativeness:
The PV module manufacturing data were collected between April.2023-December 2023.
Steps were taken to ensure that the LCI data were reliable and representative. The data type used is clearly stated in the Inventory analysis, measured or calculated from primary sources or whether data are from the LCI databases. In this study, the data quality requirements were as follows:
Specific data of the considered system (such as material or energy flows that enter the production system). These data were calculated and submitted by Leapton.

Generic data related to the life cycle impacts the material or energy flows that enter the production system. These data were sourced from the databases in SimaPro 9.5

Database(s) and LCA software used:
Database: Ecoinvent 3.9.1, Ecoinvent 3 – allocation, cut-off by classification – unit
LCA Software: Simapro 9.5

Description of system boundaries:
The system boundary considered in this LCA study is "cradle to gate with options, modules C1-C4, module D with optional modules (A1–A3 + A4 + C + D)".
A1-A3: Product stage (raw material acquisition, transport to manufacturing site and manufacturing)
A4: Transport to user site
A5: Installation
C1-C4: End-of-life stage (deconstruction, transport, waste processing and disposal)
D: Reuse, recovery and/or recycling potentials

A1 Raw materials extraction
Raw materials extraction includes materials needed to produce ingot, wafer, cell and PV module. Ingot, wafer and cell can be regarded as the intermediate products along the PV module production line. The raw materials extraction for the four types Leapton PV modules are similar. The PV cells as well as the upstream ingot and wafer are manufactured by JA Solar Co. Ltd., a major PV cells supplier in China. Ingot, wafer and cell processings are sourced from the Ecoinvent datasets "silicon production, single crystal, Czochralski process, photovoltaics RoW", "single-Si wafer production, photovoltaic RoW" and photovoltaic cell production, single-Si wafer RoW, respectively. The only changed thing is the electricity demand based on the IEA report for the Chinese situation.

A2 Raw materials transport
Concerning the raw material transportation, all the raw materials are sourced from domestic suppliers and are transported by truck, EURO5 is used for modelling in this study. The 16-32t transportation type scenario is assumed. The study applies an aggregated approach for the raw materials transportation summarizing all the transport data through multiplying the weight and the transportation distance.

A3 Module Assembly
The PV module products under study includes 4 types. All the products share similar manufacturing processes and life cycle stages. The main stages of manufacturing are presented in the flowchart. The production inventory is from March 1st 2023-Feb 29th 2024. T

Table 2 Energy sources for the product manufacturing processes

	LP182*182-M-54-NB-XXXW	LP182*182-M-60-NB-XXXW	LP182*182-M-72-NB-XXXW	LP182*182-M-78-NB-XXXW
Manufacturing site location	Changshu, Jiangsu			
Underlying ecoinvent dataset	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off, U			
GWP-GHG (kg CO_2 eq. / kWh	0.857			

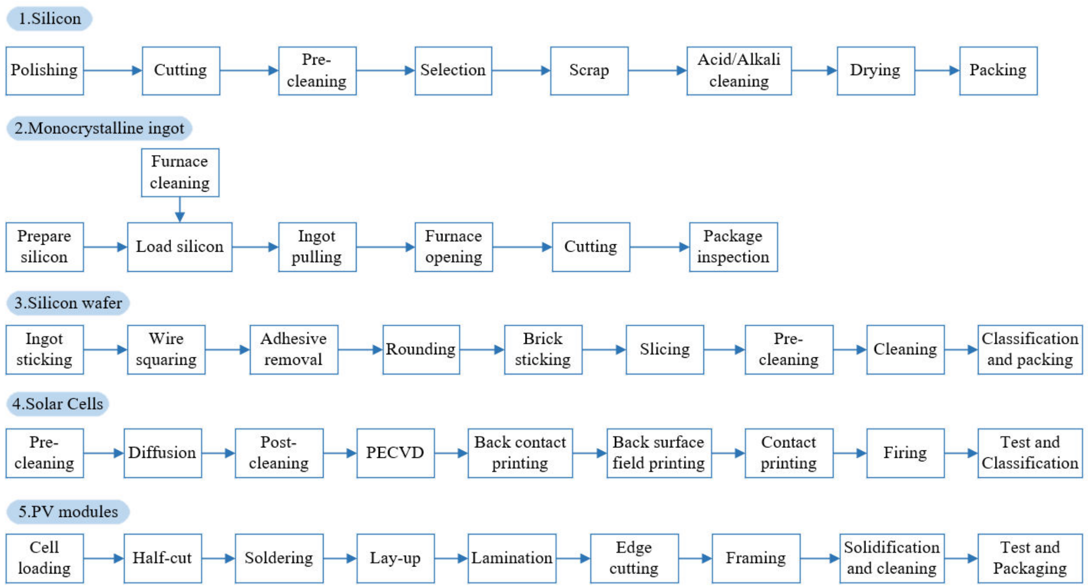


Figure 1 PV module manufacturing process

A4 Product distribution

The products are assumed to be transported at a distance of 500km according to the PCR for domestic market

A5 Installation

The packaging materials of the PV modules are mostly wooden pallet and paper, and are assumed to be recycled. The transport distance for the packaging materials to the recycling site is assumed to be 50km. The scaling method is clearly listed in Table 2 . Other materials including the mounting system, cables, inverts are not considered based on the requirements listed in the PCR.

Table 3 Energy inputs for PV module installation

Construction consumption process (per kWp capacity)		
Electricity	36.033 kWh electricity for 570kWp as in the Ecoinvent dataset	0.06 kWh/kWp is applied
Diesel	7673MJ diesel for 570kWp as in the Ecoinvent dataset	13.4MJ/kWp is applied

B1-B7 modules

B1 -use of the installed product, service, or appliance There isn't any energy and material consumption in this stage in the site.

.B2-maintenance of product The only maintenance for PV panels is cleaning. It is assumed to be cleaned once per month with an application rate of 0.76L water per m^2 PV panel.

No require (B3), replacement (B4) or refurbishment (B5) are needed for the PV panels.

B6 – operational energy. The product doesn't consume energy during the whole service life. It produces the energy.

B7 – operational water use This operational stage, there isn't any water consumption.

Electricity generation can be calculated according to the following mechanism. The site information for the simulation has the following characteristics

Table 4 Power station information for simulation

Item	Value

Location	Changshu, China
Peak power of the plant	1MW
Latitude	31°40′4.12″N
Longitude:	120°46′13.2″°E
Altitude	7
Nominal solar irradiance	1436 kWh/m2/year

Energy production in the first year of operation:

E1 = Srad * NominalWatt* PR * (1- deg1) ---------------------------------- （1）

E1--- Energy produced in the first year of operation, kWh/year

Srad--- Site specific annual average solar radiation on module (shadings not included), hours/year, in this situation, annual peak hours are 1436.

NominalWatt – the maximum power output of the module at STC

PR--- Performance ratio, coefficient for losses. 75.5% in our case

Deg1--- first year degradation rate, in our case 1%

Energy production n year of operation:

$$En = E1 * (1-deg)^{n-1}$$ ---------------------------------- (2)

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

$$E_{RSL} = E_1 * \left(1 + \sum_{n=1}^{RSL-1}(1-deg)^n\right)$$ -------------------------------- (3)

Table 5 Total electricity generation over RSL

Serious (brand name)	Maximum power output range（W）	PR ratio	deg-first year	deg-after first year	E_{RSL}/kwh
LP182*182-M-78-NB-XXXW	430	75.5%	1%	0.4%	11001.2
LP182*182-M-72-NB-XXXW	480	75.5%	1%	0.4%	12280.4
LP182*182-M-60-NB-XXXW	580	75.5%	1%	0.4%	14838.8
LP182*182-M-54-NB-XXXW	600	75.5%	1%	0.4%	15350.5

C1-C4 modules

For the end-of-life stage, De-construction (C1) of the PV plant during the disposal stage is assumed mainly consuming electricity, and the electricity consumption is assumed the same as the construction stage (A5), 50km transportation distance from plant site to waste treatment site (C2) is assumed according to the PCR (Product category rules EN 15804 +A2 NPCR 029). For waste processing (C3) and final waste disposal (C4) of PV modules, 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

Module D

According to the PCR, Module D assesses the impact of the net flows of recovered materials (recycled or reused) from the life cycle stages A to C, the net flow can be described by the difference between $M_{MR\ in}$ and $M_{MR\ out}$, taking the material yield (here designated with Y) into account.

$$Netflow = \Sigma\ (M_{MR\ out} - Y \cdot M_{MR\ in})$$

In this LCA study, no secondary material was used in the production stage, so the $M_{MR\ in}$ is zero. As it is referred above (Table 6), the Netflow is Aluminium, copper, silver scraps and metallurgical siliconThe data is based on the FRELP process.

Table 6 Waste processing and final waste disposal

Netflow	Unit	Value	Applied datasets
Aluminum scrap	Kg/kg PV modules	0.182	Aluminium, primary, ingot {CN}| aluminium production, primary, ingot | Cut-off, U
Glass scrap	Kg/kg PV modules	0.686	Glass cullet, sorted {RoW}| market for glass cullet, sorted | Cut-off, U
Copper scrap	Kg/kg PV modules	0.00438	Copper-rich materials {GLO}| market for copper-rich materials | Cut-off, U
Silver scrap	Kg/kg PV modules	0.0005	Silver, unrefined {GLO}| market for silver, unrefined | Cut-off, U
MG Silicon	Kg/kg PV modules	0.03468	Silicon, metallurgical grade {RoW}| silicon production, metallurgical grade | Cut-off, U

Electricity mix

Different electricity mix datasets are modelled based on the current Ecoinvent database. The detailed information can be found in Table 7

Table 7 Electricity profiles applied in the LCA

Province involved	Process	Production mix	Technology year
Yun'nan	Ingot， wafer and cell production	Electricity, medium voltage {CSG}| market for electricity, medium voltage | Cut-off, U	2022
Jiangsu	Module assembly	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off, U	2022

Excluded Processes

The following steps/stages are not included in the system boundary for the reason that the elements below are considered irrelevant or can be omitted according to the PCR

- Production and disposal of the infrastructure and capital equipment (buildings, machines, transport media, roads, etc.) during products manufacturing, installation, and maintenance;
- The load and benefit of recycling waste solar module as well as waste equipment from solar plant are excluded from the analysis
- The packaging for ingot, wafer and solar cell is reused internally and its impact was excluded from the system
- Storage phases and sales of PV modules
- Product losses due to abnormal damage such as natural disasters or fire accidents. These losses would mostly be accidental;
- The recycling process of defective products as it is reused internally for the manufacturing process;
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.

Key assumptions

Table 8 Key assumptions applied for the LCA

Categories	Items	Assumptions
Raw materials extraction (A1)	Ingot, wafer and cell production	The electricity demands for Ingot, wafer and cell are sourced from literature "Life Cycle Inventories and Life Cycle Assessment of Photovoltaics Systems 2020 Task 12 PV sustainability" with a Chinese production representation
Transportation stage (A2, and A4)	Transportation vehicle type	For transport without detailed information, EURO 5 type vehicle with 16-32 ton capacity is used
Installation stage (A5)	PV module and infrastructures	No construction waste is considered Packaging materials for PV modules are assumed to be recycled. Energy consumption for the construction process is sourced from the Ecoinvent dataset "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.
	Maintenance (B2)	Water used for cleaning the PV panels is assumed 0.76L/m^2 for 12 times per year[13]
	Repair, Replacement, Refurbishment, Operational water and energy use (B3-B7)	No replacement for the module as the module has RSL>25 years. No operational water and energy are needed for PV module
End-of-life (C1-C4)	De-construction (C1)	The de-construction of PV plant is assumed to be consuming the same energy as the installation stage
	Waste transportation (C2)	Waste transportation distance from the de-installation plant to the waste treatment facilities is assumed to be 50 km according to the PCR
	Waste processing (C3)	This project follows a developed 'FRELP ("Full Recovery End of Life Photovoltaic – 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.

System diagram:

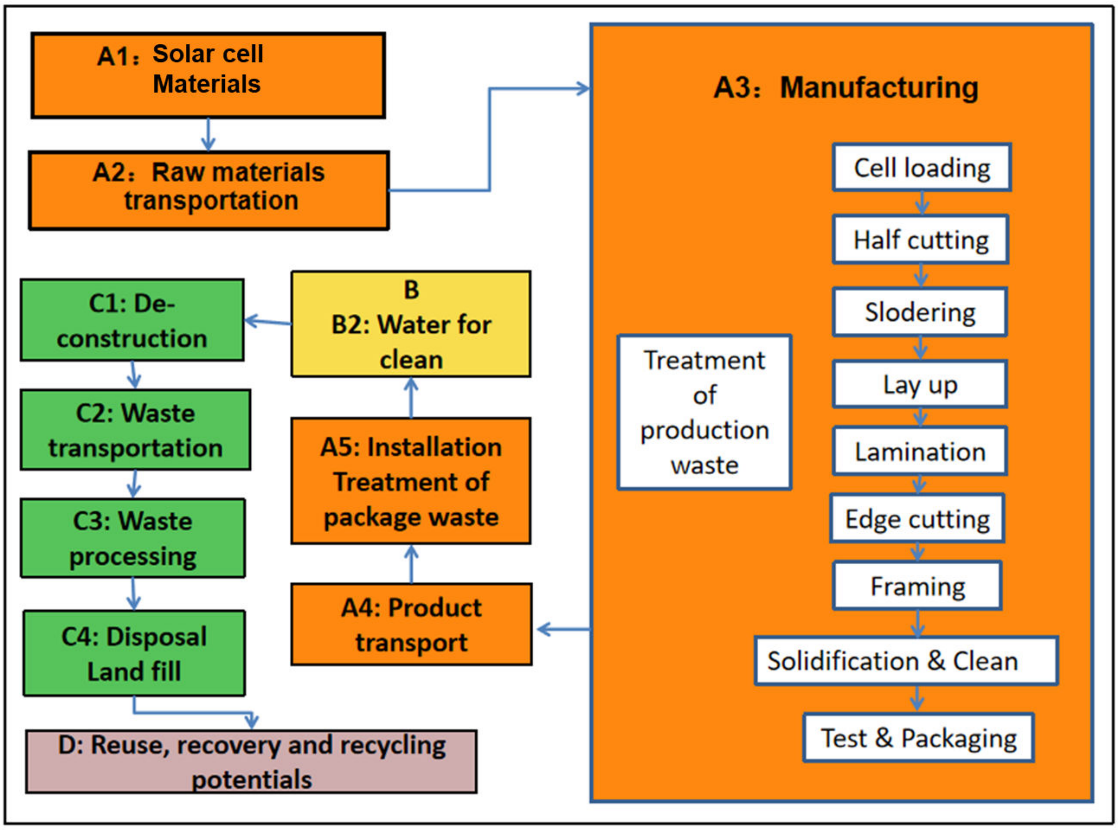


Figure 2 System boundary for this EPD

Modules declared, geographical scope, share of specific data (in GWP-GHG results) and data variation (in GWP-GHG results):

	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	ND	x	ND	ND	ND	ND	ND	x	x	x	x	x
Geography	CN	CN	CN	CN	CN		CN						CN	CN	CN	CN	CN
Specific data used	4.5%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	<10%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	0%					-	-	-	-	-	-	-	-	-	-	-	-

Content information

According to the PCR, for EPD with multiple products, three options can be chosen. This EPD follows the approach for "worst case" scenario since the production volume of the four types of PV modules follows the exact same manufacturing process and supplied with a similar production volumes. The LP182*182-M-54-NB-XXXW is used.

Table 9 LP182*182-M-54-NB-XXXW

Product components	Weight, kg	Post-consumer material, weight	Biogenic material, weight- and kg C/product
Cells	5.44E-01	0%	0
Front Glass	9.91E+00	0%	0
Back Glass	9.91E+00	0%	0
EVA	1.59E+00	0%	0
Frame	2.08E+00	0%	0
Solder	1.97E-01	0%	0
Junction Box	9.37E-02	0%	0
Silicon Gel	2.81E-01	0%	0
Soldering Flux	2.86E-03	0%	0
Seal Tape	9.22E-03	0%	0
TOTAL	2.46E+1	0%	0
Packaging materials	**Weight, kg**	**Weight- (versus the product)**	**Weight biogenic carbon, kg C/product**
Pallet	6.25E-01	3%	0.294
Paper Box	2.49E-01	1%	0.106
Plastic film	3.66E-02	0.1%	0
TOTAL	9.10E-01	3.7%	0.400

No dangerous substances from the candidate list of SVHC for Authorisation for LP182*182-M-54-NB-XXXW

Results of the environmental performance indicators

Mandatory impact category indicators according to EN 15804

Table 9 LP182*182-M-54-NB-XXXW

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
GWP-fossil	kg CO2 eq	4.29E-01	5.71E-03	1.69E-03	9.15E-04	1.39E-03	5.51E-04	2.05E-02	4.29E-01	-2.73E-01
GWP-biogenic	kg CO2 eq	2.28E-03	1.92E-06	3.41E-03	5.05E-06	-5.79E-08	1.86E-07	-3.37E-05	2.28E-03	-7.03E-04
GWP-luluc	kg CO2 eq	4.91E-04	2.94E-06	1.82E-07	1.47E-06	1.52E-07	2.83E-07	2.86E-06	4.91E-04	-7.04E-05
GWP-total	kg CO2 eq	4.31E-01	5.71E-03	1.69E-03	9.22E-04	1.39E-03	5.51E-04	2.05E-02	4.31E-01	-2.74E-01
AP	mol H+ eq	2.67E-03	2.02E-05	1.29E-05	4.90E-06	1.27E-05	1.95E-06	4.52E-05	2.67E-03	-1.84E-03
EP-aquatic freshwater	kg P eq	1.91E-04	4.63E-07	6.07E-08	4.01E-07	5.22E-08	4.47E-08	1.36E-06	1.91E-04	-6.67E-05
EP-aquatic marine	kg N eq	4.96E-04	6.64E-06	5.88E-06	9.89E-07	5.78E-06	6.40E-07	1.04E-05	4.96E-04	-3.09E-04
EP-terrestrial	mol N eq	5.24E-03	7.04E-05	6.37E-05	9.98E-06	6.28E-05	6.79E-06	1.20E-04	5.24E-03	-3.27E-03
POCP	kg NMVOC eq	1.93E-03	2.72E-05	1.88E-05	3.25E-06	1.86E-05	2.62E-06	3.10E-05	1.93E-03	-9.80E-04

ODP	kg CFC11 eq	2.70E-08	8.54E-11	2.20E-11	1.42E-10	2.13E-11	8.23E-12	6.79E-11	2.70E-08	-2.10E-09
ADP - minerals& metals*	kg Sb eq	2.61E-05	1.82E-08	5.82E-10	4.26E-09	5.02E-10	1.76E-09	9.63E-09	2.61E-05	-1.65E-06
ADP – fossil*	MJ	8.03E-02	1.85E-02	1.17E-02	1.79E-02	7.74E-03	7.96E-02	7.03E-03	8.03E-02	0.00E+00
WDP	m3	3.99E-01	3.56E-04	4.91E-05	4.28E-02	4.36E-05	3.43E-05	3.70E-03	3.99E-01	-3.23E-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									

Additional mandatory and voluntary impact category indicators

Table 10 GWP-GHG impact categories

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
GWP-GHG [1] for LP182*182 -M-54-NB-XXXW	kg CO_2 eq.	4.31E-01	5.71E-03	1.69E-03	9.19E-04	1.39E-03	5.51E-04	2.05E-02	2.52E-03	-2.74E-01

Disclaimer: According to the PCR, a supplementary indicator for climate impact (GWP-GHG) shall be reported. This indicator includes all greenhouse gas excluding biogenic carbon uptake and emissions and biogenic carbon stored in the product.

Resource use indicators

Table 11 LP182*182-M-54-NB-XXXW

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
PERE	MJ	1.03E+00	1.02E-03	1.47E-04	1.25E-03	1.62E-04	9.84E-05	7.51E-03	7.49E-05	-2.10E-01
PENRE	MJ	5.33E+00	8.03E-02	1.85E-02	1.17E-02	1.79E-02	7.74E-03	7.96E-02	7.03E-03	-2.44E+00
PERM	MJ	7.44E-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
PENRM	MJ	1.37E-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
PERT	MJ	1.04E+00	1.02E-03	1.47E-04	1.25E-03	1.62E-04	9.84E-05	7.51E-03	7.49E-05	-2.10E-01
PENRT	MJ	5.47E+00	8.03E-02	1.85E-02	1.17E-02	1.79E-02	7.74E-03	7.96E-02	7.03E-03	-2.44E+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
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
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
FW	m^3	1.50E-02	1.12E-05	1.69E-06	1.03E-03	1.51E-06	1.08E-06	1.05E-04	4.18E-06	-8.44E-04

[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.

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 indicators

Table 11 LP182*182-M-54-NB-XXXW

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
Hazardous waste disposed	kg	5.25E-04	2.01E-06	3.23E-06	6.90E-07	1.70E-07	1.94E-07	1.29E-04	6.15E-07	-3.57E-04
Non-hazardous waste disposed	kg	3.89E-03	4.84E-05	1.36E-04	2.95E-05	3.75E-04	1.02E-03	2.12E-02	-4.99E-02	0.00E+00
Radioactive waste disposed	kg	9.32E-06	1.63E-08	2.40E-09	2.86E-08	1.93E-09	1.57E-09	7.33E-08	1.24E-09	-9.69E-07

Output flow indicators

Table 12 LP182*182-M-54-NB-XXXW

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E-03	0.00E+00	0.00E+00
Material for recycling	kg	1.38E-03	0.00E+00	2.03E-03	0.00E+00	0.00E+00	0.00E+00	6.56E-03	0.00E+00	0.00E+00
Components for re-use	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
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-02	0.00E+00	0.00E+00

Additional environmental information

None

Information related to Sector EPD

This EPD is not sectorial

Differences versus previous versions

This EPD is a new submission

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.

[4] 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. (2023). PCR 2019:14, Version 1.3.2, Construction product

[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.

EPD®

www.environdec.com

Environmental Product Declaration

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

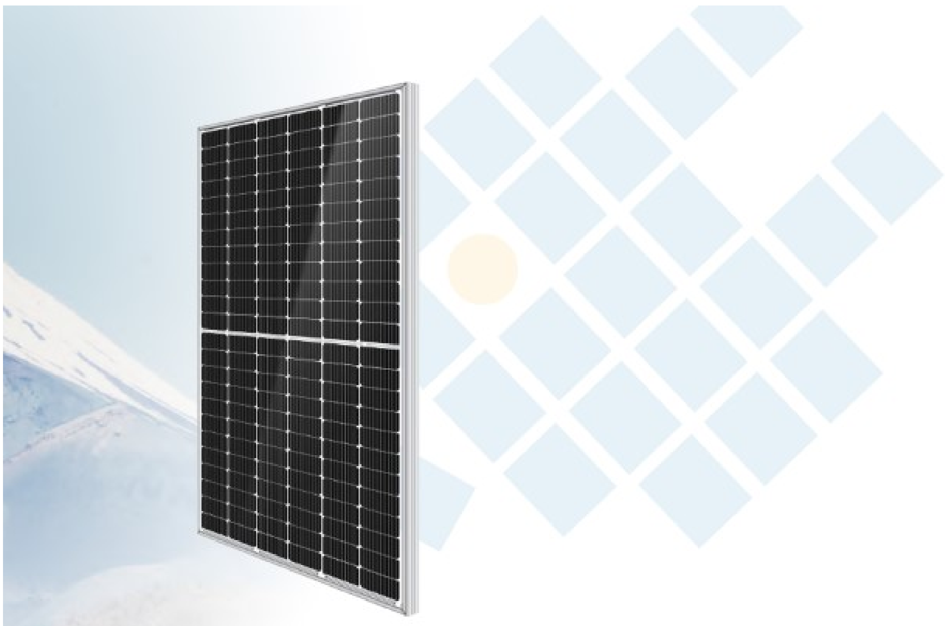
[*Photovoltaic Modules*]

from

[Leapton Solar (Changshu) Co. Ltd]

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	EPD-IES-0016181
Publication date:	2024-08-26
Valid until:	2029-08-26
	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

Statement: EPD of multiple products, based on worst case results. The list of the products covered is : LP182*210-M-48-NB-XXXW, LP182*210-M-54-NB-XXXW, LP182*210-M-60-NB-XXXW, LP182*210-M-66-NB-XXXW



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 Construction Products, version 1.3.4, 2024-04-30, and C-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)*

PCR review was conducted by: *<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: *<YiXiao Zhang, TÜV NORD (Hangzhou) Co., 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: *<Ik Kim, SMaRT-Eco Co., and signature of the third-party verifier>*

Approved by: The International EPD® System

OR

Independent third-party verification of the declaration and data, according to ISO 14025:2006, via:

☐ EPD verification by accredited certification body

Third-party verification: *<name, organisation>* is an approved certification body accountable for the third-party verification

The certification body is accredited by: *<name of accreditation body & accreditation number, where applicable>*

OR

Independent third-party verification of the declaration and data, according to ISO 14025:2006 via: ☐ EPD verification by EPD Process Certification* Internal auditor: *<name, organisation>* Third-party verification: *<name, organisation>* is an approved certification body accountable for third-party verification Third-party verifier is accredited by: *<name of accreditation body & accreditation number, where applicable>* *For EPD Process Certification, an accredited certification body certifies and reviews the management process and verifies EPDs published on a regular basis. For details about third-party verification procedure of the EPDs, see GPI.
Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☒ No [Procedure for follow-up the validity of the EPD is at minimum required once a year with the aim of confirming whether the information in the EPD remains valid or if the EPD needs to be updated during its validity period. The follow-up can be organized entirely by the EPD owner or together with the original verifier via an agreement between the two parties. In both approaches, the EPD owner is responsible for the procedure being carried out. If a change that requires an update is identified, the EPD shall be re-verified by a verifier]

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 excluded 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

Company information

Owner of the EPD:

Leapton Solar (Changshu) Co., Ltd

Website: https://www.leaptonpv.com/

Contact:

Name: Fangyuan Xu, Tel:13962336381 Email: fangyuan.xu@leaptonenergy.com

Description of the organisation:

The headquarter - LEAPTON ENERGY CO.,LTD is founded in Kobe, Japan in 2012. It is not only focusing on R&D and sales of the solar power system, solar modules, mounting system and ground screw in Japan, but also focusing on the development, management and after-maintenance of the solar power station. We have built more than 60 own solar power stations all over Japan relying on our own resources. In 2015, a branch was established in Tokyo, which is focusing on the sales of solar pv products.

In 2012, Leapton establish China headquarter in Shanghai - LEAPTON ENGINEERING TECHNOLOGY(SHANGHAI) CO.,LTD, which focus on Chinese PV System development and sales.

The module factory - LEAPTON SOLAR(Changshu) CO.,LTD is established in Changshu, Jiangsu in 2017, which is focusing on the production and sales of the solar modules all over the world. With the most advanced automated production line in the world, the module annual capacity was 600MW in 2020. The products are strictly manufactured according to the Japanese industry standard, which is one of the top ten Japanese module brands and ranked in the Bloomberg Tier1 list for many consecutive years, .In 2019, the project will be divided into two phases, covering a total area of 72,000 sqm. By the beginning of 2021, the first phase of the 2GW plant has been completed and Leapton solar enter the GW era. The second phase of 3GW plant will be completed in 2023.

Product-related or management system-related certifications:

ISO9000 and 14000 series

Name and location of production site(s):

Address: No.9 Sunshine Avenue, Changshu, Suzhou city, Jiangsu province, 215500, P. R. China.

Product information

Product name:

LP182*210-M-48-NB-XXXW
LP182*210-M-54-NB-XXXW
LP182*210-M-60-NB-XXXW
LP182*210-M-66-NB-XXXW

Product identification:

Table 1 Technical Specifications for the PV modules

Serious (brand name)	Power output range (W)	Dimensions (mm^3)	Weight (kg)	Cell number	Annual average degradation
LP182*210-M-48-NB-XXXW	435~455	1762*1134*30	25	48	0.4%

Serious (brand name)	Power output range (W)	Dimensions (mm^3)	Weight (kg)	Cell number	Annual average degradation
LP182*210-M-54-NB-XXXW	490~510	1961*1134*30	27	54	0.4%
LP182*210-M-60-NB-XXXW	550~570	2172*1134*30	32	60	0.4%
LP182*210-M-66-NB-XXXW	610~630	2382*1134*30	34	66	0.4%

Product description:
Leapton's high performance N-type modules. It applies the N-type TOPCon battery cell with the highest efficiency. The module can maintain its high performance under low light environment. Module adopts 182*210mm half cells, bifcial module provides an additional 5%-25% output. The module is expected to withstand harsh environments including strict salt spray and ammonia corrosion. Leapton Solar provides 30 years warranty for its power and 25 years warranty for its quality. The average annual degradation rate is 0.4% for all of these N-type modules.

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

Geographical scope: China

LCA information

Functional unit: 1 Wp of manufactured photovoltaic module, from cradle-to-grave over RSL. The converting factor to convert the results related to the functional unit to declared unit (1 m^2 PV module) is listed in the following table 2

Table 2 The conversion factor for functional unit to the declared unit

PV modules	Watt range (Wp)	Nominal Watt(Wp)	Weight(Kg)	Dimension(m2)	Mass per functional unit(g/Wp)	Conversion from functional to declared unit (W/m2)
LP182*210-M-48-NB-XXXW	420-455	455	25	2.00	54.9	227.5
LP182*210-M-54-NB-XXXW	475-515	515	27	2.22	52.4	232.0
LP182*210-M-60-NB-XXXW	530-570	570	32	2.65	56.1	215.1
LP182*210-M-66-NB-XXXW	580-630	630	35	2.80	55.6	225.0

Reference service life:
25 years

Time representativeness:
The PV module manufacturing data were collected between 2023-04-01 and 2024-03-30
Steps were taken to ensure that the LCI data were reliable and representative. The data type used is clearly stated in the Inventory analysis, measured or calculated from primary sources or whether data are from the LCI databases. In this study, the data quality requirements were as follows:

Specific data of the considered system (such as material or energy flows that enter the production system). These data were calculated and submitted by Leapton.

Generic data related to the life cycle impacts the material or energy flows that enter the production system. These data were sourced from the databases in SimaPro 9.5

Database(s) and LCA software used:
Database: Ecoinvent 3.9.1, Ecoinvent 3 – allocation, cut-off by classification – unit
LCA Software: Simapro 9.5

Description of system boundaries:
The system boundary considered in this LCA study is “cradle to gate with options, modules C1-C4, module D with optional modules (A1–A3 + A4 + A5 + C + D)”.
A1-A3: Product stage (raw material acquisition, transport to manufacturing site and manufacturing)
A4: Transport to user site
A5: Installation
C1-C4: End-of-life stage (deconstruction, transport, waste processing and disposal)
D: Reuse, recovery and/or recycling potentials

A1 Raw materials extraction
Raw materials extraction includes materials needed to produce ingot, wafer, cell and PV module. Ingot, wafer and cell can be regarded as the intermediate products along the PV module production line. The raw materials extraction for the four types Leapton PV modules are similar. The PV cells as well as the upstream ingot and wafer are manufactured by JA Solar Co. Ltd., a major PV cells supplier in China. Ingot, wafer and cell processings are sourced from the Ecoinvent datasets “silicon production, single crystal, Czochralski process, photovoltaics RoW”, “single-Si wafer production, photovoltaic RoW” and photovoltaic cell production, single-Si wafer RoW, respectively. The only changed thing is the electricity demand based on the IEA report for the Chinese situation.

A2 Raw materials transport
Concerning the raw material transportation, all the raw materials are sourced from domestic suppliers and are transported by truck, EURO5 is used for modelling in this study. The 16-32t transportation type scenario is assumed. The study applies an aggregated approach for the raw materials transportation summarizing all the transport data through multiplying the weight and the transportation distance.

A3 Module Assembly
The PV module products under study includes 4 types. All the products share similar manufacturing processes and life cycle stages. The main stages of manufacturing are presented in the flowchart. The production inventory is from 2023-04-01 to 2024-03-30

Table 3 Energy sources for the product manufacturing processes

	LP182*210-M-48-NB-XXXW	LP182*210-M-54-NB-XXXW	LP182*210-M-60-NB-XXXW	LP182*210-M-66-NB-XXXW

Manufacturing site location	Changshu, Jiangsu			
Electricity (kwh/pcs)	6.40E+00	7.14E+00	8.63E+00	8.93E+00
Water (ton/pcs)	8.26E-03	9.22E-03	1.11E-02	1.15E-02
Solid waste transport (kgkm)	2.06E+01	2.06E+01	2.06E+01	2.06E+01
Solid waste flows				
Hazardous waste (kg/pcs)	8.73E-03	9.74E-03	1.18E-02	1.22E-02
Solid waste (kg/pcs)	5.95E-1	5.95E-1	5.95E-1	5.95E-1

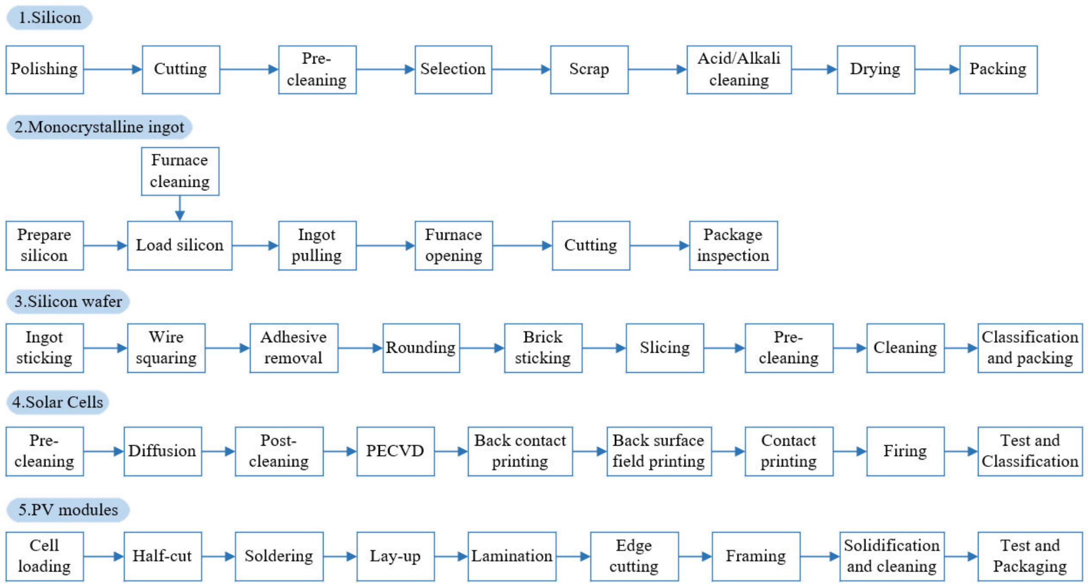


Figure 1 PV module manufacturing process

A4 Product distribution

The products are assumed to be transported at a distance of 500km according to the PCR for domestic market

A5 Installation

The packaging materials of the PV modules are mostly wooden pallet and paper, and are assumed to be recycled. The transport distance for the packaging materials to the recycling site is assumed to be 50km. The scaling method is clearly listed in Table 3. Other materials including the mounting system, cables, inverts are not considered based on the requirements listed in the PCR.

Table 4 Energy inputs for PV module installation

Construction consumption process (per kWp capacity)		
Electricity	36.033 kWh electricity for 570kWp as in the Ecoinvent dataset	0.06 kWh/kWp is applied
Diesel	7673MJ diesel for 570kWp as in the Ecoinvent dataset	13.4MJ/kWp is applied

B1-B7 modules

B1 -use of the installed product, service, or appliance There isn't any energy and material consumption in this stage in the site.

.B2-maintenance of product The only maintenance for PV panels is cleaning. It is assumed to be cleaned once per month with an application rate of 0.76L water per m^2 PV panel.

No require (B3), replacement (B4) or refurbishment (B5) are needed for the PV panels.

B6 – operational energy. The product doesn't consume energy during the whole service life. It produces the energy.

B7 – operational water use This operational stage, there isn't any water consumption.

Electricity generation can be calculated according to the following mechanism. The site information for the simulation has the following characteristics

Table 5 Power station information for simulation

Item	Value
Location	Changshu, China
Peak power of the plant	1MW
Latitude	31°40′4.12″N
Longitude:	120°46′13.2″°E
Altitude	7
Nominal solar irradiance	1436 kWh/m2/year

Energy production in the first year of operation:

$$E1 = Srad * NominalWatt * PR * (1- deg1) \quad (1)$$

E1--- Energy produced in the first year of operation, kWh/year

Srad--- Site specific annual average solar radiation on module (shadings not included), hours/year, in this situation, annual peak hours are 1436.

NominalWatt – the maximum power output of the module at STC

PR--- Performance ratio, coefficient for losses. 75.5% in our case

Deg1--- first year degradation rate, in our case 1%

Energy production n year of operation:

$$En = E1 * (1-deg)^{n-1} \quad (2)$$

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

$$E_{RSL} = E_1 * \left(1 + \sum_{n=1}^{RSL-1} (1-deg)^n\right) \quad (3)$$

Table 6 Total electricity generation over RSL

Serious (brand name)	Maximum power output range（W）	deg-first year	deg-after first year	PR	Srad	Ersl

LP182*210-M-48-NB-XXXW	455	1%	0.40%	75.50%	1436	11640.8
LP182*210-M-54-NB-XXXW	510	1%	0.40%	75.50%	1436	13047.9
LP182*210-M-60-NB-XXXW	570	1%	0.40%	75.50%	1436	14582.9
LP182*210-M-66-NB-XXXW	630	1%	0.40%	75.50%	1436	16118.0

C1-C4 modules

For the end-of-life stage, De-construction (C1) of the PV plant during the disposal stage is assumed mainly consuming electricity, and the electricity consumption is assumed the same as the construction stage (A5), 50km transportation distance from plant site to waste treatment site (C2) is assumed according to the PCR (Product category rules EN 15804 +A2 NPCR 029). For waste processing (C3) and final waste disposal (C4) of PV modules, 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

Module D

According to the PCR, Module D assesses the impact of the net flows of recovered materials (recycled or reused) from the life cycle stages A to C, the net flow can be described by the difference between $M_{MR\ in}$ and $M_{MR\ out}$, taking the material yield (here designated with Y) into account.

$$Netflow = \Sigma\ (M_{MR\ out} - Y \cdot M_{MR\ in})$$

In this LCA study, no secondary material was used in the production stage, so the $M_{MR\ in}$ is zero. As it is referred above (Table 6), the Netflow is Aluminium, copper, silver scraps and metallurgical siliconThe data is based on the FRELP process.

Table 7 Waste processing and final waste disposal

Netflow	Unit	Value	Applied datasets
Aluminum scrap	Kg/kg PV modules	0.182	Aluminium, primary, ingot {CN}| aluminium production, primary, ingot | Cut-off, U
Glass scrap	Kg/kg PV modules	0.686	Glass cullet, sorted {RoW}| market for glass cullet, sorted | Cut-off, U
Copper scrap	Kg/kg PV modules	0.00438	Copper-rich materials {GLO}| market for copper-rich materials | Cut-off, U
Silver scrap	Kg/kg PV modules	0.0005	Silver, unrefined {GLO}| market for silver, unrefined | Cut-off, U
MG Silicon	Kg/kg PV modules	0.03468	Silicon, metallurgical grade {RoW}| silicon production, metallurgical grade | Cut-off, U

Electricity mix

Different electricity mix datasets are modelled based on the current Ecoinvent database. The detailed information can be found in Table 8

Table 8 Electricity profiles applied in the LCA

Province involved	Process	Production mix	Technology year	GHG-GWP
Yun’nan	Ingot， wafer and cell production	Electricity, medium voltage {CSG}| market for electricity, medium voltage | Cut-off, U	2022	0.625

Jiangsu	Module assembly	Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage | Cut-off, U	2022	0.857

Excluded Processes

The following steps/stages are not included in the system boundary for the reason that the elements below are considered irrelevant or can be omitted according to the PCR

- Production and disposal of the infrastructure and capital equipment (buildings, machines, transport media, roads, etc.) during products manufacturing, installation, and maintenance;
- The load and benefit of recycling waste solar module as well as waste equipment from solar plant are excluded from the analysis
- The packaging for ingot, wafer and solar cell is reused internally and its impact was excluded from the system
- Storage phases and sales of PV modules
- Product losses due to abnormal damage such as natural disasters or fire accidents. These losses would mostly be accidental;
- The recycling process of defective products as it is reused internally for the manufacturing process;
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.

Key assumptions

Table 9 Key assumptions applied for the LCA

Categories	**Items**	**Assumptions**
Raw materials extraction (A1)	Ingot, wafer and cell production	The electricity demands for Ingot, wafer and cell are sourced from literature “Life Cycle Inventories and Life Cycle Assessment of Photovoltaics Systems 2020 Task 12 PV sustainability” with a Chinese production representation
Transportation stage (A2, and A4)	Transportation vehicle type	For transport without detailed information, EURO 5 type vehicle with 16-32 ton capacity is used
Installation stage (A5)	PV module and infrastructures	No construction waste is considered Packaging materials for PV modules are assumed to be recycled. Energy consumption for the construction process is sourced from the Ecoinvent dataset “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.

	Maintenance (B2)	Water used for cleaning the PV panels is assumed 0.76L/m^2 for 12 times per year[13]
	Repair, Replacement, Refurbishment, Operational water and energy use (B3-B7)	No replacement for the module as the module has RSL>25 years. No operational water and energy are needed for PV module
End-of-life (C1-C4)	De-construction (C1)	The de-construction of PV plant is assumed to be consuming the same energy as the installation stage
	Waste transportation (C2)	Waste transportation distance from the de-installation plant to the waste treatment facilities is assumed to be 50 km according to the PCR
	Waste processing (C3)	This project follows a developed 'FRELP ("Full Recovery End of Life Photovoltaic – 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.

System diagram:

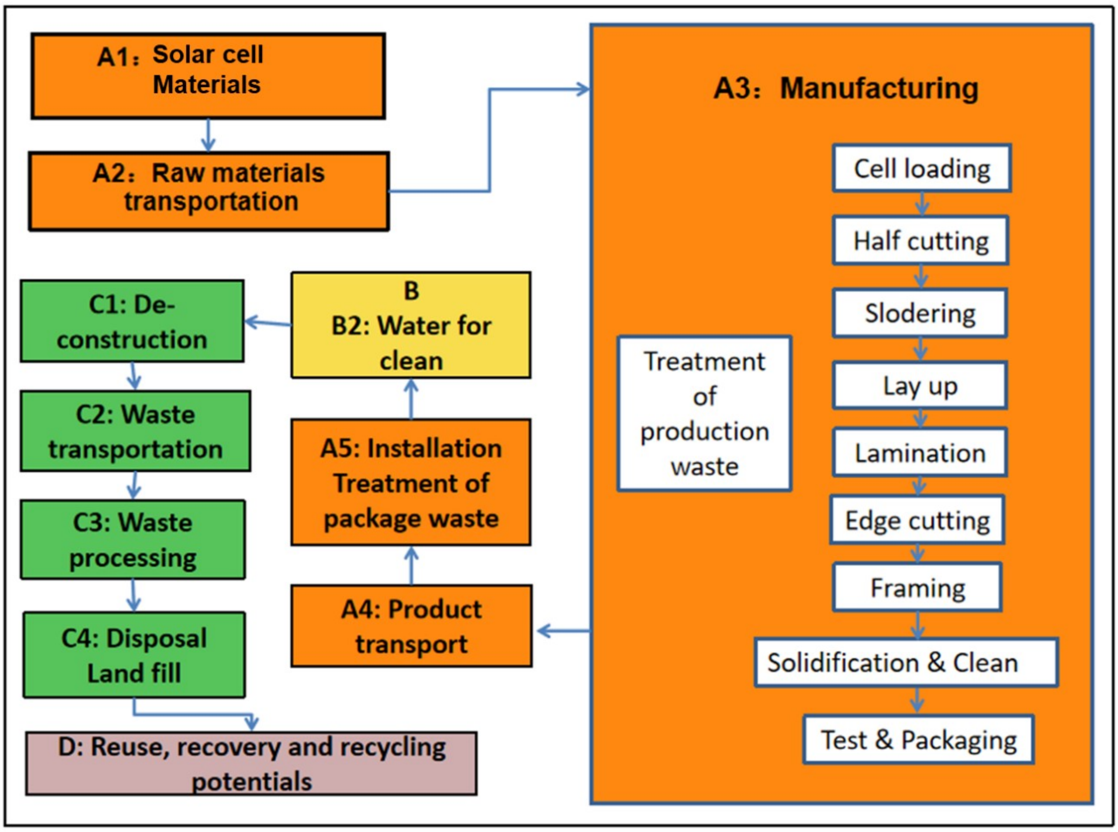


Figure 2 System boundary for this EPD

Modules declared, geographical scope, share of specific data (in GWP-GHG results) and data variation (in GWP-GHG results):

	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	ND	x	ND	ND	ND	ND	ND	x	x	x	x	x
Geography	CN	CN	CN	CN	CN		CN						CN	CN	CN	CN	CN
Specific data used	4.5%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	<10%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	0%					-	-	-	-	-	-	-	-	-	-	-	-

Content information

According to the PCR, for EPD with multiple products, three options can be chosen. This EPD follows the approach for "worst case" scenario since the production volume of the four types of PV modules follows the exact same manufacturing process and supplied with a similar production volumes. The worst case scenario identified that the impacts of LP182*210-M-48-NB-XXXW is the largest for every impact categories.

Table 10 LP182*210-M-48-NB-XXXW

Product components	Weight, kg	Post-consumer material, weight	Biogenic material, weight- and kg C/product
Cells	5.24E-01	0%	0
Front Glass	9.91E+00	0%	0
Back Glass	9.91E+00	0%	0
EVA	1.59E+00	0%	0
Frame	2.08E+00	0%	0
Solder	1.97E-01	0%	0
Junction Box	9.37E-02	0%	0
Silicon Gel	2.81E-01	0%	0
Soldering Flux	2.86E-03	0%	0
Seal Tape	9.22E-03	0%	0
TOTAL	2.46E+1	0%	0
Packaging materials	**Weight, kg**	**Weight- (versus the product)**	**Weight biogenic carbon, kg C/product**
Pallet	6.25E-01	3%	0.294
Paper Box	2.49E-01	1%	0.106
Plastic film	3.66E-02	0.1%	0
TOTAL	9.10E-01	3.7%	0.400

No dangerous substances from the candidate list of SVHC for Authorisation for LP182*210-M-48-NB-XXXW

Results of the environmental performance indicators

Mandatory impact category indicators according to EN 15804 with EF3.1

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
GWP-fossil	kg CO2 eq	3.91E-01	5.58E-03	1.68E-03	8.65E-04	1.39E-03	5.39E-04	1.97E-02	2.47E-03	-2.67E-01
GWP-biogenic	kg CO2 eq	2.05E-03	1.88E-06	3.22E-03	1.81E-06	-5.79E-08	1.82E-07	-3.31E-05	3.22E-07	-6.82E-04
GWP-luluc	kg CO2 eq	4.46E-04	2.87E-06	1.81E-07	1.39E-06	1.52E-07	2.77E-07	2.79E-06	1.53E-07	-6.89E-05
GWP-total	kg CO2 eq	3.94E-01	5.59E-03	1.68E-03	8.68E-04	1.39E-03	5.40E-04	1.97E-02	2.47E-03	-2.68E-01
AP	mol H+ eq	2.46E-03	1.98E-05	1.29E-05	4.63E-06	1.27E-05	1.91E-06	4.41E-05	1.88E-06	-1.80E-03
EP-aquatic freshwater	kg P eq	1.75E-04	4.53E-07	6.05E-08	3.79E-07	5.22E-08	4.38E-08	1.33E-06	5.56E-08	-6.53E-05
EP-aquatic marine	kg N eq	4.54E-04	6.49E-06	5.87E-06	9.34E-07	5.78E-06	6.27E-07	1.01E-05	2.77E-06	-3.03E-04
EP-terrestrial	mol N eq	4.80E-03	6.88E-05	6.37E-05	9.43E-06	6.28E-05	6.64E-06	1.17E-04	5.72E-06	-3.20E-03
POCP	kg NMVOC eq	1.76E-03	2.66E-05	1.88E-05	3.07E-06	1.86E-05	2.57E-06	3.03E-05	2.75E-06	-9.59E-04
ODP	kg CFC11 eq	2.45E-08	8.35E-11	2.20E-11	1.34E-10	2.13E-11	8.06E-12	6.54E-11	7.92E-12	-2.06E-09

ADP - minerals& metals*	kg Sb eq	2.41E-05	1.78E-08	5.78E-10	4.03E-09	5.02E-10	1.72E-09	9.39E-09	4.83E-10	-1.61E-06
ADP – fossil*	MJ	7.85E-02	1.85E-02	1.11E-02	1.79E-02	7.58E-03	7.78E-02	6.88E-03	-2.39E+00	0.00E+00
WDP	m3	3.62E-01	3.48E-04	4.89E-05	4.04E-02	4.36E-05	3.36E-05	3.56E-03	1.66E-04	-3.16E-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									

Additional mandatory and voluntary impact category indicators

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
GWP-GHG[1]	kg CO_2 eq.	3.92E-01	5.59E-03	1.68E-03	8.66E-04	1.39E-03	5.39E-04	1.97E-02	2.47E-03	-2.67E-01

Disclaimer: According to the PCR, a supplementary indicator for climate impact (GWP-GHG) shall be reported. This indicator includes all greenhouse gas excluding biogenic carbon uptake and emissions and biogenic carbon stored in the product.

Resource use indicators

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
PERE	MJ	9.19E-01	1.09E-03	1.51E-04	1.19E-03	1.62E-04	1.01E-04	7.67E-03	7.68E-05	-2.13E-01
PENRE	MJ	4.75E+00	8.59E-02	1.89E-02	1.12E-02	1.79E-02	7.94E-03	8.12E-02	7.21E-03	-2.50E+00
PERM	MJ	6.87E-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
PENRM	MJ	1.31E-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
PERT	MJ	9.26E-01	1.09E-03	1.51E-04	1.19E-03	1.62E-04	1.01E-04	7.67E-03	7.68E-05	-2.13E-01
PENRT	MJ	4.88E+00	8.59E-02	1.89E-02	1.12E-02	1.79E-02	7.94E-03	8.12E-02	7.21E-03	-2.50E+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
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
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
FW	m^3	1.34E-02	1.20E-05	1.74E-06	9.83E-04	1.51E-06	1.11E-06	9.78E-05	4.28E-06	-8.66E-04
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										

[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.

Waste indicators

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
Hazardous waste disposed	kg	4.61E-04	2.15E-06	3.31E-06	6.59E-07	1.70E-07	1.99E-07	1.19E-04	6.31E-07	-3.66E-04
Non-hazardous waste disposed	kg	4.16E-03	6.59E-05	1.30E-04	2.95E-05	3.85E-04	9.75E-04	2.18E-02	2.18E-02	0.00E+00
Radioactive waste disposed	kg	8.31E-06	1.74E-08	2.47E-09	2.73E-08	1.93E-09	1.61E-09	7.48E-08	1.28E-09	-9.94E-07

Output flow indicators

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
Materials for energy recovery	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
Material for recycling	kg	1.04E-03	0.00E+00	5.61E-04	0.00E+00	0.00E+00	0.00E+00	5.98E-03	0.00E+00	0.00E+00
Components for re-use	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
Exported energy, electric	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-02	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-02	0.00E+00	0.00E+00

Additional environmental information

None

Information related to Sector EPD

This EPD is not sectorial

Differences versus previous versions

This EPD is a new submission

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.

[4] 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. (2023). PCR 2019:14, Construction product, Version 1.3.4

[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.

EPD®

www.environdec.com