Environmental Product Declaration

In accordance with ISO 14025:2006, ISO 14025:2026 and EN 15804:2012+A2:2019/AC:2021 for:

Leapton 210R four-split dual-glass n-type TOPCon photovoltaic modules

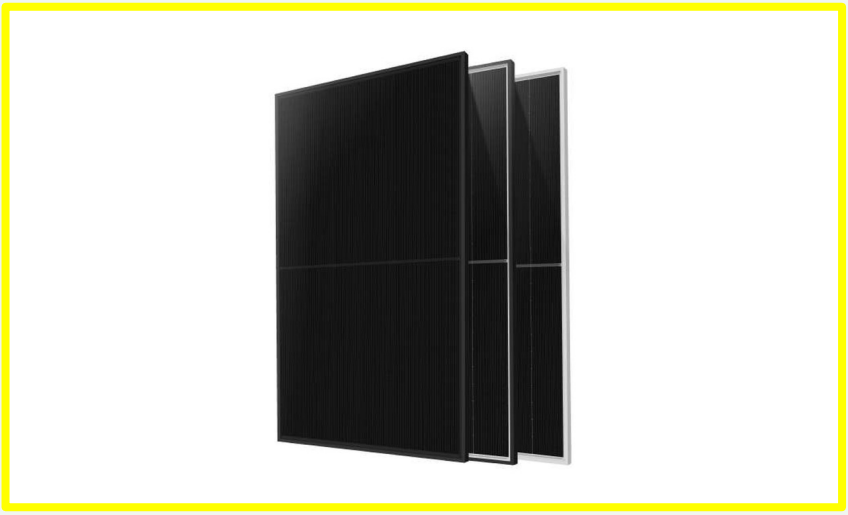
from

Leapton Solar (Changshu) Co., Ltd.

Programme:	The International EPD System, www.environdec.com
Programme operator:	EPD International AB
Licensee:	Not applicable
Type of EPD:	EPD of multiple products, based on the average results of the product group
EPD registration number:	EPD-IES-0036061:001
Version date:	2026-11-12
Validity date:	2031-11-12
	An EPD may be updated or depublished if conditions change. To find the latest version of the EPD and to confirm its validity, see www.environdec.com

Statement:

This EPD covers Leapton 210R four-split dual-glass n-type TOPCon photovoltaic modules, comprising models LP182x210-M-42Q-NB (395–425 W), LP182x210-M-45Q-NB (425–455 W), LP182x210-M-48Q-NB (450–485 W), LP182x210-M-51Q-NB (480–515 W), LP182x210-M-54Q-NB (530–545 W), LP182x210-M-57Q-NB (535–575 W), LP182x210-M-60Q-NB (565–610 W), LP182x210-M-63Q-NB (590–640 W) and LP182x210-M-66Q-NB (620–670 W). The declared results are the unweighted arithmetic mean of the individual results of all nine products.



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:	support@environdec.com

Product Category Rules (PCR)
CEN standard EN 15804 serves as the Core Product Category Rules (PCR)
Product Category Rules (PCR): PCR 2019:14, version 2.0.1; UN CPC 461 Electric motors, generators and transformers, and parts
PCR review was conducted by: Rob Rouwette (chair) and Noa Meron (co-chair), Technical Committee of the International EPD System; the review panel may be contacted via support@environdec.com. Review dates 2025-01-28 to 2025-03-12
c-PCR, if applicable: c-PCR-016 / NPCR 029 Photovoltaic modules, version 1.2

LCA accountability
Commissioner: Leapton Solar (Changshu) Co., Ltd. External LCA responsible person: Jeff Yang, TÜV NORD (Hangzhou) Co., Ltd., Room 410, Building B, No. 9 Jiuhuan Road, Jianggan District, Hangzhou 310019, China; office phone +86 571 8538 6989.
Email: jefyang@tuv-nord.com.

Third-party Verification
Independent third-party verification of the declaration and data, according to ISO 14025:2006 and ISO 14025:2026, via:

☑ **Individual EPD verification without a pre-verified LCA/EPD tool**

Third-party verifier: Ying SU, Freelance

Approved by: International EPD System

**EPD process certification involves an accredited certification body certifying and periodically auditing the EPD process and conducting external and independent verification of EPDs that are regularly published. More information can be found in the General Programme Instructions on www.environdec.com.*

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

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 published 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 first-digit 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 identical scope in terms of included life-cycle stages (unless the excluded life-cycle stage is demonstrated to be insignificant); apply identical impact assessment methods (including the same version of characterisation factors); and be valid at the time of comparison.

For further information about comparability, see EN 15804 and ISO 14025:2006 and ISO 14025:2026.

INFORMATION ABOUT EPD OWNER

The EPD owner and the commissioned LCA practitioner are identified below, with the available contact details and stated organisational responsibilities.

Information about EPD owner
OWNER OF THE EPD **Leapton Solar (Changshu) Co., Ltd.**
ADDRESS No.9, Sunshine Avenue, Changshu City, Jiangsu, China
CONTACT info@leaptonenergy.com +86-512-88800068
ADDRESS AND CONTACT INFORMATION OF THE LCA PRACTITIONER COMMISSIONED BY THE EPD OWNER, IF APPLICABLE Commissioner and EPD owner: Leapton Solar (Changshu) Co., Ltd. External LCA responsible person: Jeff Yang, TÜV NORD (Hangzhou) Co., Ltd., Room 410, Building B, No. 9 Jiuhuan Road, Jianggan District, Hangzhou 310019, China; office phone +86 571 8538 6989. Email: jefyang@tuv-nord.com. The EPD owner commissioned the study; Jeff Yang of TÜV NORD (Hangzhou) Co., Ltd. is the confirmed external LCA responsible person. The practitioner address and office phone are as stated above.
DESCRIPTION OF THE ORGANISATION Leapton Solar (Changshu) Co., Ltd. manufactures crystalline-silicon photovoltaic modules at its Changshu plant in Jiangsu, China. The products covered here are Leapton 210R four-split dual-glass n-type TOPCon photovoltaic modules.
PRODUCT-RELATED OR MANAGEMENT SYSTEM-RELATED CERTIFICATIONS The manufacturer’s 2026 V1 datasheets list IEC 61215 / IEC 61730, CE, ISO 9001 / ISO 14001, JPEA, MCS, PV CYCLE, Clean Energy Council, INMETRO and Solar Stewardship Initiative membership.

PRODUCT INFORMATION

The declaration covers the product identified below. Its composition, dimensions, intended use and documented technical properties define the scope of the reported assessment.

Product name	**Leapton 210R four-split dual-glass n-type TOPCon photovoltaic modules (395–670 W)**

Product identification	The declared group comprises LP182x210-M-42Q-NB (395–425 W), LP182x210-M-45Q-NB (425–455 W), LP182x210-M-48Q-NB (450–485 W), LP182x210-M-51Q-NB (480–515 W), LP182x210-M-54Q-NB (530–545 W), LP182x210-M-57Q-NB (535–575 W), LP182x210-M-60Q-NB (565–610 W), LP182x210-M-63Q-NB (590–640 W) and LP182x210-M-66Q-NB (620–670 W). The ranges are the minimum and maximum ratings listed at standard test conditions (STC). The LCA assesses the highest rated variant in each family. The declared results are the unweighted mean of those nine variants. See Technical annex A. Each family has its own bill of materials; power bins within the same family share that family's physical design. The nine assessed variants do not have identical BOM masses. Result basis: The declared results are the unweighted arithmetic average of the individual results of all nine products in the group, so no product is weighted by its production volume.
VISUAL REPRESENTATION (E.G., AN IMAGE) OF THE PRODUCT	 Leapton 210R four-split dual-glass module, product illustration
UN CPC code	461 — Electric motors, generators and transformers, and parts. The classification follows the applicable photovoltaic-module c-PCR scope.
Other codes for product classification	Not applicable — no additional product classification code is declared.
Product description	Dual-glass monocrystalline photovoltaic module with n-type tunnel-oxide passivated contact cells and four-split cell interconnection. Nine power families are declared together as one product group; each family is anchored at its Pmax power bin, and the declared result is the unweighted arithmetic average of all nine.
Application/intended use	Grid-connected rooftop and ground-mounted photovoltaic power generation for the building, utility and distributed markets.

Technical performance

Property	Value
Assessed STC ratings (Wp)	425 to 670 Wp
Module area	1.75 to 2.70 m²
Module dimensions	1540 to 2382 x 1134 x 30 to 35 mm
Module mass	21 to 32.2 kg
Volumetric mass density	3.87E+02 kg/m³ (nine-family mean, excluding packaging)
Module efficiency	24.3 to 24.8 %
Cell technology	n-type tunnel-oxide passivated contact, four-split
Product standard	IEC 61215 / IEC 61730
Source	Leapton module datasheets

Name and location of production site(s)

Production site	Location
Leapton Solar (Changshu) Co., Ltd.	No.9, Sunshine Avenue, Changshu City, Jiangsu, China

Final process in direct control of trader, if applicable

Not applicable — no trader-controlled final process is declared.

Name of manufacturer(s), if different from EPD owner

Not applicable — the manufacturer is the EPD owner; Manufactured at the EPD owner's own site

References to relevant websites for more information or explanatory materials, if applicable

Reference	URL
Leapton Solar — product information	https://www.leaptonpv.com

EPD shall not include rating, judgements, or direct comparisons with other products or companies.

CONTENT DECLARATION

Product mass: 0.0489 kg per functional unit (1 Wp).

Packaging mass: 0.00159 kg per functional unit (1 Wp), reported separately.

Composition basis: arithmetic mean of all nine family anchors.

Product content	Mass, kg	Post-consumer recycled material, mass-% of product	Biogenic material, mass-% of product	Biogenic material, kg C/product or declared unit	Variation, kg
Aluminium (frame)	3.06E-03	ND	0.00E+00	0.00E+00	2.84E-03 – 3.32E-03
Copper (ribbons and contacts)	5.74E-04	ND	0.00E+00	0.00E+00	5.57E-04 – 5.94E-04
Diode and junction-box metals	2.71E-05	ND	0.00E+00	0.00E+00	2.16E-05 – 3.41E-05
EVA encapsulant	2.91E-03	ND	0.00E+00	0.00E+00	2.86E-03 – 3.04E-03
Glass (front and rear)	4.02E-02	ND	0.00E+00	0.00E+00	3.94E-02 – 4.19E-02
Output cable (whole component)	5.79E-05	ND	0.00E+00	0.00E+00	4.63E-05 – 7.29E-05
Polymer junction-box parts	9.53E-05	ND	0.00E+00	0.00E+00	7.61E-05 – 1.20E-04
Silicon solar cells (finished cells)	1.21E-03	ND	0.00E+00	0.00E+00	1.20E-03 – 1.21E-03
Silicone adhesive and potting	6.50E-04	ND	0.00E+00	0.00E+00	5.99E-04 – 6.93E-04
Solder alloy coatings	1.50E-04	ND	0.00E+00	0.00E+00	1.47E-04 – 1.53E-04
Edge-seal tape	1.94E-05	ND	0.00E+00	0.00E+00	1.90E-05 – 2.03E-05

Product content	Mass, kg	Post-consumer recycled material, mass-% of product	Biogenic material, mass-% of product	Biogenic material, kg C/product or declared unit	Variation, kg
Total	4.89E-02	ND	0.00E+00	0.00E+00	4.78E-02 – 5.12E-02

Packaging materials	Mass, kg	Mass-% (versus the product)	Biogenic material, kg C/product or declared unit	Variation, kg
wood pallet	1.12E-03	2.28E+00	4.74E-04	1.08E-03 – 1.17E-03
corrugated shipping carton	2.69E-04	5.49E-01	1.09E-04	2.45E-04 – 2.94E-04
paper corner protector	9.35E-05	1.91E-01	3.78E-05	7.46E-05 – 1.18E-04
long paper card	2.02E-05	4.14E-02	8.20E-06	1.62E-05 – 2.55E-05
short paper card	1.08E-05	2.21E-02	4.38E-06	8.64E-06 – 1.36E-05
packaging strapping band	6.25E-05	1.28E-01	0.00E+00	5.64E-05 – 7.07E-05
stretch wrap film	1.94E-05	3.96E-02	0.00E+00	1.91E-05 – 2.02E-05
Total packaging	1.59E-03	3.25E+00	6.33E-04	1.50E-03 – 1.70E-03

Finished module (packaging excluded): 0.00E+00 mass-% biogenic material and 0.00E+00 kg C per 1 Wp. Shipping packaging: wood and paper/board contribute 94.9% of packaging mass (1.51E-03 kg per 1 Wp out of 1.59E-03 kg per 1 Wp). Packaging biogenic carbon is 6.33E-04 kg C per 1 Wp. For each family, biogenic carbon equals packaging item mass × dry-matter fraction × dry carbon fraction. The assumed fractions are 0.85 × 0.50 for wood and 0.92 × 0.44 for paper/board, based on adopted assumptions. Masses are divided by each family's Pmax and averaged with equal weight.
1 kg biogenic carbon in the product/packaging is equivalent to the uptake of 44/12 kg of CO_2.

Declaration of hazardous substances

Hazardous substances from the candidate list of SVHC	EC No.	CAS No.	Mass-% per product or declared unit
No SVHC contained			

LCA INFORMATION

Assessment basis, system boundary and modelling context for the declared product.

Functional unit	1 Wp of manufactured photovoltaic module, from cradle-to-grave, with activities needed for a study period for a defined reference service life (≥80% of the labelled power output). The reference service life is 25 years. Wp is the nameplate capacity at standard test conditions. A1–A3 results are reported per declared unit; downstream results are reported per functional unit (NPCR 029 v1.2, §6.3.1).
Product mass	0.0489 kg per functional unit (1 Wp), excluding packaging
Volumetric mass density	3.87E+02 kg/m³ (module excluding packaging). Calculated as the arithmetic mean of the nine family densities. See the technical annex for inputs and calculation.
Total mass including packaging	0.0505 kg per functional unit (1 Wp). Equal-weight mean of each family's retained product mass, including retained edge-seal tape, plus packaging mass, divided by that family's Pmax.
Conversion to 1 m²	For each model, multiply the result per Wp by P/A to obtain the result per m², where P is rated power (Wp) and A is module area (m²). Model-specific factors are listed in the technical annex.
Reference period	The manufacturing inventory uses factory data updated to 2025 for electricity, water, annual output and hazardous-waste quantities. The supplied updated BOM is used for all nine assessed models; 2023–2024 refers to the collection-template period. Product specifications are from the manufacturer's datasheets, including the updated PV42Q datasheet. The reference service life is 25 years under the c-PCR; the manufacturer's power warranty is 30 years.
LCA software	openLCA with ecoinvent 3.11.
Background data	ecoinvent 3.11 (cut-off system model), EF 3.1

System boundary

Cradle-to-grave: A1–A5, B1–B7 and C1–C4, with Module D reported separately beyond the product system boundary. B2 covers cleaning water. B1, B3, B4, B5, B6 and B7 have documented no-activity declarations and zero burdens in the defined use scenario. Electricity generation is disclosed separately as information.

Geographical representativeness

A1. Global and Chinese raw-material supply chains (ecoinvent GLO/RoW/RER/CN datasets)

A2. Raw-material transport to the Changshu site

A3. Changshu, China manufacturing site

A4. Changshu to Europe (sea freight plus a conservative European end leg)

A5. Europe installation

B2. Europe maintenance

B6. Declared zero (no operational energy use in the module supply scope)

B7. Declared zero (operational water reported as a zero result)

C1. Europe deconstruction

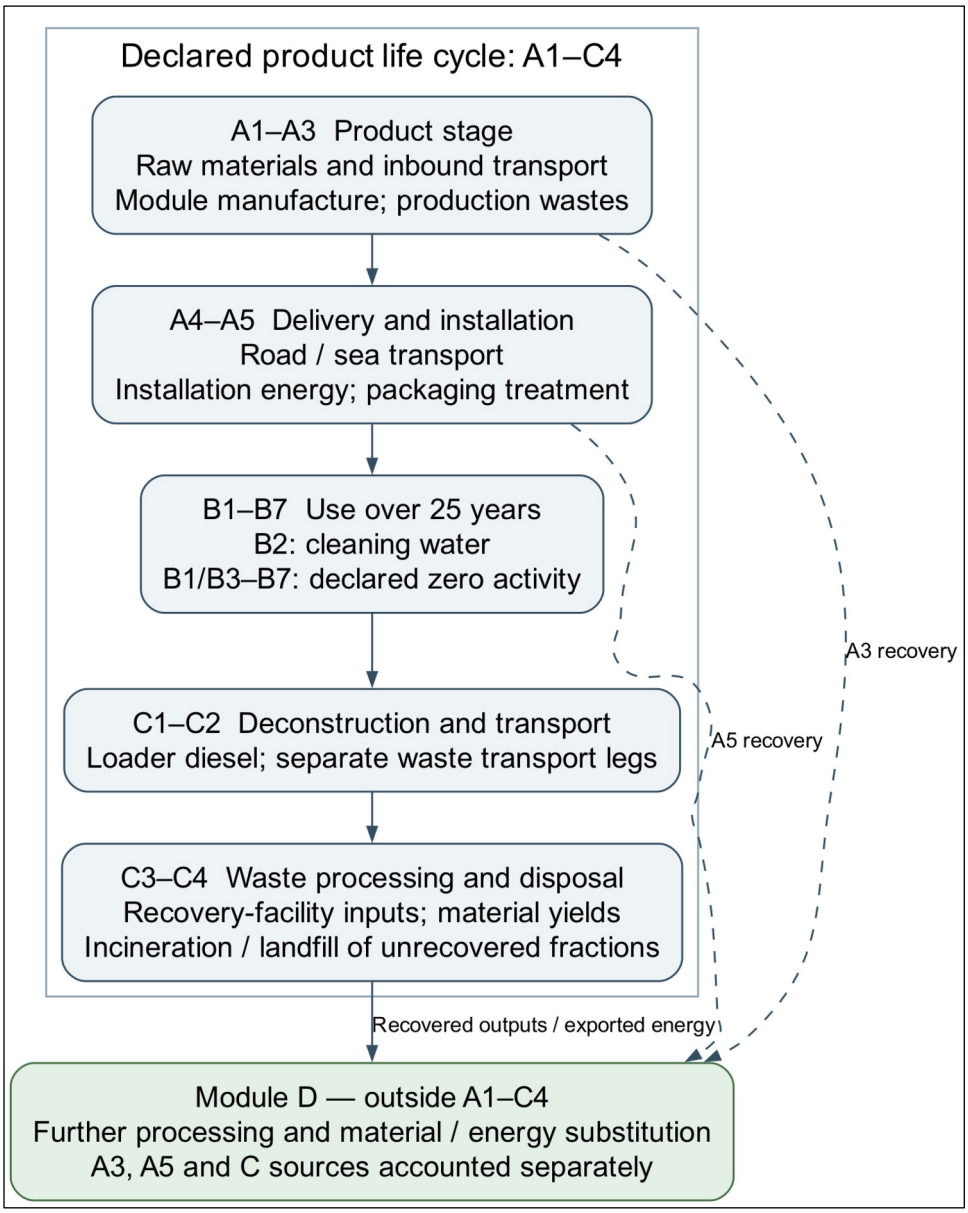
C2. Europe waste transport

C3. Europe waste processing

C4. Europe disposal

D. Material and energy substitution beyond A1–C4; Chinese substitutes for PV42Q A3 waste recovery and European substitutes for installation/end-of-life routes, as identified in the model.

Process flow diagram:



Process flow of the declared module family, from raw-material supply and inbound transport through module manufacturing, distribution, installation and use to end of life and the Module D avoided burden. Module D is drawn outside the product system boundary and is never added to the A1–C4 results.

LIFE-CYCLE MODELLING

A1 Raw-material supply

The BOM identifies net retained materials and packaging. Where a material-specific loss rate is available, modelled gross manufacturing input equals net input divided by (1 − loss rate); these quantities are not purchase invoices or measured process yields. A1 includes the upstream production of purchased materials and components. Where a background dataset expresses a processing service in a different reference quantity from its finished output, the service is scaled to the quantity supplied. The plastic-film extrusion dataset yields 0.976 kg of finished film per 1 kg of reference service, so 1 kg of finished film uses 1/0.976 kg of extrusion service. Supplier-side waste treatment is represented by the existing background inventory. Leapton's manufacturing losses, including the separate 1% encapsulant loss assumption, are accounted for in A3. Material production uses ecoinvent 3.11 background datasets and a custom IEA PVPS-based photovoltaic-cell inventory. No supplier-specific measured production inventory is claimed. Family-specific inventory assumptions are stated in the input annex.

A2 Inbound transport to the manufacturing site

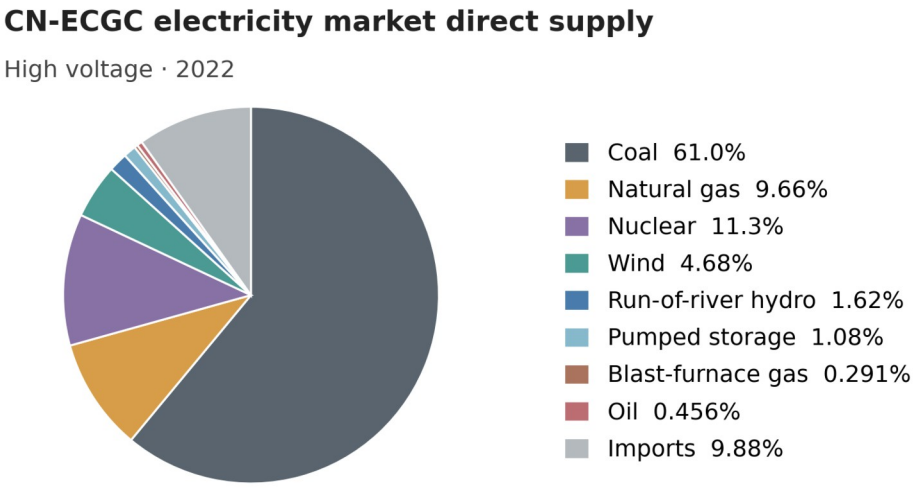
Inbound freight is calculated as material mass multiplied by supplier-to-factory distance and converted to tonne-kilometres. Distances are taken from the supplied BOM, with the adopted packaging-distance estimate stated separately. Road freight uses the 16–32 t diesel EURO 6 lorry dataset. Freight inventories are classified as secondary data.

A3 Module manufacturing

The manufacturing boundary is the Changshu plant, from cell interconnection and lamination to framing, junction-box assembly, testing and packing. The adopted 2025 factory quantities are electricity 21,424,692 kWh, water 26,092 t and output 1,506,151,300 Wp. The five hazardous-waste categories total 7,552 kg. Utilities and hazardous waste are allocated by annual watt-peak output. General manufacturing waste is calculated from material-specific manufacturing losses and the adopted treatment routes.

Electricity profile in A3

A3 purchased electricity is modelled using ecoinvent 3.11 “market for electricity, medium voltage”, CN-ECGC. This provider supplies 100% of the modelled factory electricity input; no separate on-site generation is declared. The 2025 site record is 21,424,692 kWh, allocated using 1,506,151,300 Wp of annual output, giving 0.0142247940 kWh/Wp. The current provider GWP-GHG intensity is 0.763590466 kg CO_2 eq/kWh, so the supply-weighted intensity is the same (0.764 kg CO_2 eq/kWh displayed to three significant figures). The 2022 CN-ECGC high-voltage market direct-supply shares are coal 61.0%, natural gas 9.66%, nuclear 11.3%, wind 4.68%, run-of-river hydro 1.62%, pumped storage 1.08%, blast-furnace gas 0.291%, oil 0.456% and imports 9.88% (ecoinvent 3.11; Verifier Annex, Table 3).



Source: ecoinvent 3.11, dataset 26881. Shares are rounded.

A4 Distribution to the installation site

The A4 scenario uses 115 km road transport to Shanghai, 26,278 km container shipping to Rotterdam, and 500 km European road transport, including product and packaging mass. The road background inventory uses an average cargo load of 5.79 t including empty journeys and 0.0366 kg diesel/tkm. This average load is not a percentage utilisation: maximum payload has not been documented. The container-ship inventory uses 70% average capacity utilisation including empty trips and 0.00252 kg heavy fuel oil/tkm. These are background dataset averages, not measurements of Leapton shipments; vehicle-km fuel use remains unverified.

A5 Installation

A5 covers installation energy and packaging treatment in Europe. The photovoltaic-installation dataset supplies 1.35E-02 MJ diesel and 6.32E-05 kWh electricity per Wp for all nine families; this installation service includes racking. Wood, paper/board and plastic packaging follow separate recycling, incineration and landfill routes. Treatment burdens and exported energy are reported separately from Module D benefits. The 0% installation-waste assumption is separate from the installation-energy inputs.

The selected plastic-recycling process sorts, cleans and grinds mixed rigid plastic waste into recycled flakes. No oil-recycling or pyrolysis route is modelled. Its use for PET strapping and LDPE film is a disclosed technology proxy.

Use-stage electricity generation — supplementary information

Modules of this type consume no energy in operation, so the operational energy module carries a zero result. The product does generate electricity, and that generation is not a declared result: the energy produced depends on the site radiation, the mounting orientation and the site performance ratio, so it cannot be stated for the product alone. What is declared instead is the information an EPD user needs to calculate generation for an actual installation.

Generation in the first year of operation follows $E_1 = S_{rad} \times A \times y \times PR \times (1 - deg)$ and over a reference service life of RSL years, assuming linear annual degradation, $E_{RSL} = E_1 \times \left(1 + \sum_{n=1}^{RSL-1} (1 - deg)^n\right)$ where S_{rad} is the site-specific annual average solar radiation on the module in kWh per kWp per year, taking the actual inclination and orientation into account; A is the module area in m²; y is the module yield, that is the rated power in kWp divided by the module area in m²; PR is the site performance ratio covering inverter, temperature, cable, shading, dust and snow losses; and deg is the annual degradation rate. Because $A \times y$ is the rated power in kWp, the first-year expression reduces to $E_1 = S_{rad} \times P_{kWp} \times PR \times (1 - deg)$.

The degradation rate applied is 0.35% per year, taken from the linear power warranty on the manufacturer's module datasheet for this product series. That warranty also states a 30-year term whose end-of-term output remains above the threshold the product-category rules use to define the reference service life. This report declares the reference service life as 25 years, the standard value for the module as an energy-producing unit, and discloses the 30-year warranty separately. No third-party validated degradation documentation is claimed for this revision.

The table below gives the module parameters and the first-year and lifetime generation for three annual radiation levels, so a user can interpolate or substitute their own site value. It is disclosed as information and is not part of any declared result.

Table 1 Lifetime electricity generation per functional unit (1 Wp), disclosed as information under NPCR 029 v1.2 6.2.5 and not declared as a result

Code	Rated power (Wp)	Module area (m²)	Annual degradation (%)	Srad (kWh/kWp/y)	E1 first year (kWh)	E over RSL (kWh)	kWh per Wp over RSL
PV42Q	425	1.75	0.35	1200 / 1000 / 1400	407 / 339 / 474	9749 / 8124 / 11373	22.9 / 19.1 / 26.8
PV63Q	640	2.58	0.35	1200 / 1000 / 1400	612 / 510 / 714	14680 / 12234 / 17127	22.9 / 19.1 / 26.8
PV66Q	670	2.70	0.35	1200 / 1000 / 1400	641 / 534 / 748	15368 / 12807 / 17930	22.9 / 19.1 / 26.8
PV45Q	455	1.87	0.35	1200 / 1000 / 1400	435 / 363 / 508	10437 / 8697 / 12176	22.9 / 19.1 / 26.8
PV48Q	485	2.00	0.35	1200 / 1000 / 1400	464 / 387 / 541	11125 / 9271 / 12979	22.9 / 19.1 / 26.8
PV51Q	515	2.10	0.35	1200 / 1000 / 1400	493 / 411 / 575	11813 / 9844 / 13782	22.9 / 19.1 / 26.8
PV54Q	545	2.22	0.35	1200 / 1000 / 1400	521 / 435 / 608	12501 / 10418 / 14585	22.9 / 19.1 / 26.8
PV57Q	575	2.35	0.35	1200 / 1000 / 1400	550 / 458 / 642	13189 / 10991 / 15388	22.9 / 19.1 / 26.8
PV60Q	610	2.46	0.35	1200 / 1000 / 1400	584 / 486 / 681	13992 / 11660 / 16324	22.9 / 19.1 / 26.8

Note — Columns follow the 1200 kWh/kWp/y, 1000 kWh/kWp/y, 1400 kWh/kWp/y annual radiation scenarios in this order. Generation depends on site radiation, orientation and performance ratio, so the EPD user calculates it for the actual installation.

B2 Maintenance

B2 covers maintenance-cleaning water over the 25-year reference service life. No cleaning chemical or replacement component is included. Cleaning water flows to the ground or stormwater system; the calculation includes water supply, with no central wastewater-treatment service and no terminal-return deduction. B6 and B7 have zero operational energy and water inputs for electricity generation; B2 cleaning water is reported separately.

B6 Operational energy

The declared product is an energy-producing module, so no operational energy input is declared and the module's operational energy result is a declared zero rather than a modelled quantity. The

lifetime electricity generation of the module is disclosed as information under NPCR 029 v1.2 section 6.2.5; it is a generation figure derived from the module's rated power, its declared area, its annual degradation and the reference service life, and it does not enter the A1-C4 results of this declaration.

B7 Operational water

No operational water use is declared for the module in service: the module consumes no water to generate electricity, and the cleaning water that the declared maintenance scenario does require is declared in the maintenance module rather than here. The operational water result of this module is therefore a declared zero and not an omitted flow.

C1 Deconstruction

Deconstruction of the declared module is modelled as on-site handling with a four-wheel loader, using the fuel consumption reported for module collection in Europe. The module is removed from its mounting structure as a whole unit and the fuel burned by that handling is charged to this module. Frame, junction-box and cable separation is not performed at the deconstruction site: it takes place at the treatment facility and is charged to the recycling module. The declared result is a small positive burden rather than a zero.

C2 Waste transport

C2 covers transport of retired product and product-treatment residues. Packaging treatment and its associated transport are assigned to A5. NPCR 029 v1.2 §6.3.8.4 (p. 21) permits an assumed standard distance of 50 km and requires deviations to be justified. Collection-to-sorting, direct-landfill and residual-landfill legs remain 50 km. The sorting-to-incineration leg uses 200 km, following Latunussa et al., JRC EUR 27797 EN §3.4.3.6 (printed p. 36), which describes an external incineration facility. This 200 km distance is a literature-based scenario assumption, not a measured Leapton distance. Separate liquid-waste and sludge legs from C3 use an assumed 100 km distance.

C3 — Waste processing

The main product scenario sends 85% of retired module mass to sorting/recovery and 15% directly to landfill. C3 includes facility electricity, diesel, process water, nitric acid and hydrated lime. The JRC/FRELP inventory per tonne of facility input is 114 kWh, 1.14 L diesel, 310 kg water, 7.08 kg 50% nitric acid and 36.5 kg hydrated lime. Recovery yields on routed material are 98% glass, 99% aluminium, 96.5% copper and 95% silicon; other fractions have no material-recycling output. Residues pass to C4. Module D reports further treatment and substitution separately, without counting the same treatment burden twice.

C4 Disposal

The disposal module covers the mass that is not recovered, together with the residues of the recovery routes. The residual fractions are treated by municipal solid waste incineration with energy recovery, by sanitary landfill and by inert landfill, each with its own background treatment dataset. The

exported electricity and heat of the incineration route are declared as exported-energy output flows, and the stored energy that those fractions release is reported against the non-renewable primary energy used as material.

D Module D

Module D reports material and energy substitution separately from A1–C4. For PV42Q, A3, A5 and C-stage recovery sources are identified separately. Copper is represented by a pure-copper treatment proxy. The 96.5% physical recovery yield is applied once; the 1/1.31 provider-reference ratio converts actual scrap input into process demand and does not reduce recovered or displaced copper again. Chinese A3 exported electricity substitutes CN-ECGC electricity and exported heat substitutes industrial natural-gas heat; A5/C-stage substitutes retain their stated European proxy basis. Recovery quality, end-of-waste assumptions and further processing burdens are disclosed in the inventory annex. No A1–C4+D total is declared.

Allocation and cut-off

Factory utilities and waste quantities use the adopted 2025 data and are allocated by rated watt-peak output. The nine-family EPD result is an unweighted mean of the independently converted family results. No quantified BOM reference flow is omitted under the applied mass or energy cut-off criteria. The product inventory covers the photovoltaic module and packaging. Packaging inbound transport uses an estimated 100 km lorry distance: retained packaging is assigned to A2 and factory-loss packaging to A3. Source-derived wastewater in the cell inventory is treated once using the selected average-treatment dataset. Fuel and electricity inventories include their combustion emissions.

Data quality assessment

The following tables identify the data sources and their contribution to the A1–A3 GWP-GHG result.

Assessment topic	Declaration
Assessment summary	The data-quality assessment follows EN 15804 Annex E.2 and distinguishes manufacturer data, literature inventories and background datasets. Manufacturing quantities use the updated 2025 factory data. Each family has 179 classified A1–A3 contributions: 2 primary and 177 secondary.
Data collection period	Factory electricity, water, annual output and hazardous-waste data: 2025. BOM: current data supplied by Leapton Solar (Changshu) Co., Ltd.
Sites covered	No. 9 Sunshine Avenue, Changshu, China (module manufacturing site)

Assessment topic	Declaration
Geographical representativeness	Manufacturing is in Changshu, China; Europe is the representative installation market. The A4 China road leg uses the RoW lorry dataset, the ocean leg uses the GLO container-ship dataset, and the European road leg uses the RER lorry dataset. Scenario geography and database geography are reported separately; EUR identifies the European scenario, whereas RER identifies the regional coverage of the selected background dataset.
Technological representativeness	Dual-glass monocrystalline n-type TOPCon photovoltaic module with four-split cell interconnection; glass-glass lamination and aluminium frame assembly.
Production coverage	The manufacturing allocation uses the site output for the 2025 calendar year (1.51 GW). No per-family production volume is available, so no per-family volume coverage can be stated.
Background database	ecoinvent 3.11 (cut-off system model), EF 3.1
External EPD sources	No external environmental declaration is used as a foreground data source.
Assessment method	EN 15804:2012+A2:2019 Annex E data-quality criteria, with the PCR 2019:14 v2.0.1 section 4.6.5 reporting requirements.
Assessment coverage	The table identifies 179 classified A1–A3 contributions per family: 2 primary and 177 secondary. Specific-data shares are calculated from their GWP-GHG contributions.
Specific data share — A1–A3 GWP-GHG	2.78% primary (A1–A3 GWP-GHG)

Process contributions to A1–A3 GWP-GHG

The photovoltaic-cell input uses the IEA PVPS-based crystalline-silicon cell inventory, connected to ecoinvent background activities. The detailed inputs are provided in the Calculation Support workbook, sheet “IEA cell LCI”.

Key assumption

The assumptions distinguish installation packaging from product end of life. The main product scenario sends 85% of retired mass to sorting/recovery and 15% directly to landfill, followed by the stated material-specific yields and residue routes. A3 uses the updated 2025 factory data, material-specific manufacturing-loss quantities and the adopted 50 km waste-treatment transport distance. Packaging inbound transport is estimated at 100 km.

Life-cycle stage	Scenario description
A4 transport	115 km road + 26,278 km sea + 500 km road; product and packaging transported.

Life-cycle stage	Scenario description
A5 installation	installation diesel 0.0135 MJ/Wp and electricity 6.32E-05 kWh/Wp; proxy boundary disclosed.
A5 packaging	recovery R = 37.7% wood, 87.0% paper/board, 41.7% plastic. Remaining mass: 55% incineration, 45% landfill.

A5 packaging mass by treatment route (kg/Wp; nine-family equal-weight mean)

Material	Total	Recycling	Incineration	Landfill
Wood	1.12E-03	4.21E-04	3.82E-04	3.13E-04
Paper/board	3.93E-04	3.42E-04	2.81E-05	2.30E-05
PET	6.25E-05	2.61E-05	2.00E-05	1.64E-05
LDPE	1.94E-05	8.08E-06	6.22E-06	5.09E-06

The adopted recovery rates are 37.7% for wood, 87.0% for paper/board and 41.7% for plastics; the remainder is split 55% incineration and 45% landfill.

Life-cycle stage	Scenario description
C1 dismantling	loader diesel 0.0648 MJ/kg retired product.
C2 transport	NPCR 029 v1.2 §6.3.8.4 (p. 21) permits an assumed standard 50 km distance and requires deviations to be justified. Collection, direct-landfill and residual-landfill legs remain 50 km; sorting-to-incineration uses 200 km following Latunussa et al., JRC EUR 27797 EN §3.4.3.6 (printed p. 36; external incineration facility). This is a literature-based scenario, not a measured Leapton distance. Separate liquid-waste and sludge legs from C3 use an assumed 100 km distance.
C3 sorting	85% of retired product sent to sorting/recovery; 15% sent directly to landfill.
C3 processing inputs	Per tonne of facility input: electricity 114 kWh; diesel 1.14 L; water 310 kg; 50% HNO_3 7.08 kg; $Ca(OH)_2$ 36.5 kg.
C3 recovery yields	glass 98%, aluminium 99%, copper 96.5%, silicon 95%; other fractions have no recycled-material output.
C4 disposal	residual combustible fractions to incineration with energy recovery; unrecovered inert/direct-landfill fractions to landfill.
Module D	material/energy substitution and further processing outside A1–C4; A3, A5 and C-stage sources remain identifiable. Rows at successive treatment stages must not be summed as independent waste inputs.
Copper recovery	apply physical recovery yield once; actual scrap input divided by provider reference ratio determines process demand, not a second output loss.
Plastic recovery	sorting, cleaning and grinding of mixed rigid waste plastic; proxy for PET strapping/LDPE film. No oil cycle.

Life-cycle stage	Scenario description
PV42Q mass	For PV42Q, 20.909 kg is the raw BOM material subtotal and excludes 0.00825 kg of retained edge-seal tape already modeled in A1; the derived retained-product total is 20.917 kg, matching the C-stage tracked mass. The BOM retained mass is the modeling basis; the 21 kg datasheet mass is disclosed separately and is not used for the LCA.
Product scenarios	The main product end-of-life scenario sends 85% of product mass to recovery and 15% directly to landfill. C4 energy recovery applies to downstream C3 residues. The 100% recovery (RC100) and 100% landfill (LF100) scenarios are calculated separately for all nine families and expressed per 1 Wp. Their declared results are the respective equal-weight means.

Selected recoverable material fractions in product end of life (kg/Wp; nine-family equal-weight mean)

Material	Sent to C3 recovery	Recovered output MFR	C3 residual to C4	Direct landfill
Aluminium frame	2.60E-03	2.58E-03	2.60E-05	4.59E-04
Copper	4.92E-04	4.74E-04	1.72E-05	8.68E-05
Glass	3.41E-02	3.35E-02	6.83E-04	6.02E-03
Solar-cell fraction	1.03E-03	9.77E-04	5.14E-05	1.81E-04

This summary covers selected recoverable material fractions only; it is not a complete product-mass closure. Sent, recovered and residual quantities at successive treatment stages must not be summed as independent waste inputs. Module D uses avoided copper of 4.74E-04 kg/Wp; 3.75E-04 kgref/Wp is treatment-provider demand and must not be deducted again from avoided copper. Glass D represents virgin batch inputs and energy, not an equal mass of finished glass.

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

The matrix identifies declared modules and their geographical scope. ND denotes a module outside the declaration; it is distinct from a calculated zero. Primary-data share and variation use the stated GWP-GHG basis.

	Product stage			Distribution/ installation stage		Use stage							End-of-life stage				Beyond product life cycle
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
Module	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules declared	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Geography	CN	CN	CN	CN/EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR
Share of primary data	2.78%																
Variation – products	-2.27%/2.63%																
Variation – sites	N.A.																

Data sources and primary-data share

The A1–A3 GWP-GHG primary-data share is 2.78% for the nine-family result and 2.73% for PV42Q. Each family has 179 assessed contributions: 2 primary and 177 secondary. The primary contributions are site electricity and water. Production and freight inventories remain secondary when their activity quantities or distances come from the owner. The nine-family share is the mean primary contribution per Wp divided by the mean A1–A3 GWP-GHG result per Wp. Module D is excluded.

Process	Source type	Source	Reference year	Data category	Share of primary data, of GWP-GHG results for A1-A3
Solar cells	Custom inventory	IEA PVPS-derived cell inventory with ecoinvent 3.11 links	IEA PVPS crystalline-silicon cell inventory, published 2020; ecoinvent background activities.	Secondary data	0%
Aluminium frame	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Solar glass panes	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Junction box, cable and connectors	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Encapsulant (EVA)	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Ribbons, solder and flux	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Silicone adhesives and potting	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%

Process	Source type	Source	Reference year	Data category	Share of primary data, of GWP-GHG results for A1-A3
Packaging materials	Database	ecoinvent 3.11 (cut-off system model)	Dataset-specific; see provider register. Database: ecoinvent 3.11.	Secondary data	0%
Inbound transport of materials	Collected data	Leapton Solar (Changshu) Co., Ltd.: supplied BOM quantities and distances; ecoinvent 3.11: background freight inventory.	Updated BOM; template dates only	Secondary data	0%
Module assembly: electricity and water	Collected data	Leapton Solar (Changshu) Co., Ltd. plant records	2025-01-01/2025-12-31 (collection)	Primary data	2.78%
Manufacturing waste treatment	Database	ecoinvent 3.11 (cut-off system model)	2025 factory activity data; ecoinvent 3.11 background treatment	Secondary data	0%
Total share of primary data, of GWP-GHG results for A1-A3					2.78%

ENVIRONMENTAL PERFORMANCE

LCA results of the product(s) - main environmental performance results

Mandatory impact category indicators according to EN 15804

All declared information modules are presented: A1–A5, B1–B7 and C1–C4, with Module D reported separately. B1, B3, B4, B5, B6 and B7 have zero results under the stated no-activity assumptions; B2 includes cleaning.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	kg CO2 eq.	3.89E-01	1.94E-02	4.00E-03	0.00E+00	1.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-04	8.59E-04	3.71E-03	8.41E-03	-8.08E-02
GWP-fossil	kg CO2 eq.	3.89E-01	1.94E-02	1.54E-03	0.00E+00	1.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-04	8.58E-04	3.70E-03	8.40E-03	-8.04E-02
GWP-biogenic	kg CO2 eq.	-5.92E-04	3.59E-06	2.45E-03	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E-08	1.83E-07	4.47E-06	1.30E-06	-2.42E-04
GWP-luluc	kg CO2 eq.	2.97E-04	9.41E-06	3.31E-07	0.00E+00	1.45E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E-08	2.89E-07	4.75E-06	3.24E-07	-1.07E-04
ODP	kg CFC 11 eq.	5.20E-08	3.10E-10	2.17E-11	0.00E+00	2.14E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.74E-12	1.87E-11	4.17E-11	7.98E-12	-7.48E-10
AP	mol H+ eq.	2.75E-03	4.12E-04	1.27E-05	0.00E+00	5.96E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-06	1.84E-06	7.52E-05	4.83E-06	-6.96E-04
EP-freshwater	kg P eq.	2.64E-05	1.02E-07	8.93E-09	0.00E+00	4.61E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-09	6.38E-09	1.62E-07	1.24E-08	-3.50E-06
EP-marine	kg N eq.	6.18E-04	1.02E-04	5.85E-06	0.00E+00	1.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-06	4.33E-07	3.47E-05	1.83E-06	-1.11E-04
EP-terrestrial	mol N eq.	5.34E-03	1.14E-03	6.36E-05	0.00E+00	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-05	4.79E-06	3.89E-04	1.96E-05	-1.05E-03
POCP	kg NMVOC eq.	1.58E-03	3.19E-04	1.91E-05	0.00E+00	3.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06	2.92E-06	9.20E-05	5.50E-06	-3.14E-04
ADP-minerals&metals*	kg Sb eq.	1.67E-05	3.42E-08	9.02E-10	0.00E+00	5.43E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-10	3.02E-09	6.83E-09	3.78E-09	-2.96E-06
ADP-fossil*	MJ	4.47E+00	2.49E-01	1.93E-02	0.00E+00	1.39E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-03	1.22E-02	4.75E-02	7.78E-03	-8.64E-01
WDP*	m^3 world eq. deprived	1.58E-01	9.19E-04	9.34E-05	0.00E+00	2.89E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-05	6.47E-05	1.23E-03	6.70E-04	-2.17E-02

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
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															

** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.*

The estimated impact results are relative statements and do not indicate endpoint categories, threshold exceedance, safety margins or risks.

The results of modules C1–C4 should be considered together with the results of modules A1–A3.

Biogenic carbon and recovered energy: packaging biogenic-carbon uptake is assigned to A1 and its release to A5. Biogenic CO_2 already included in the background inventories is treated separately from these packaging-carbon quantities. Recovered energy is reported as exported electricity or thermal energy where applicable.

Additional mandatory and voluntary impact category indicators

The additional environmental impact indicators are listed below.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-GHG[1]	kg CO2 eq.	3.91E-01	1.94E-02	1.67E-03	0.00E+00	1.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-04	8.59E-04	3.71E-03	8.41E-03	-8.06E-02
PM	disease incidence	3.16E-08	8.34E-10	3.53E-10	0.00E+00	7.76E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.14E-11	6.40E-11	2.26E-10	5.19E-11	-6.34E-09
IRP	kBq U-235 eq	5.64E-03	6.26E-05	9.64E-06	0.00E+00	3.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.91E-07	5.33E-06	3.32E-04	3.97E-06	-1.02E-03
ETP-fw	CTUe	2.80E+00	2.37E-02	1.75E-03	0.00E+00	3.91E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-04	1.64E-03	5.21E-03	1.85E-02	-5.47E-01
HTP-c	CTUh	1.60E-10	3.85E-12	2.03E-13	0.00E+00	9.05E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-14	1.44E-13	3.65E-13	9.58E-13	-5.22E-11
HTP-nc	CTUh	6.99E-09	9.24E-11	5.91E-12	0.00E+00	3.41E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.13E-13	7.69E-12	1.52E-11	3.16E-11	-2.68E-09

[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.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
SQP	dimensionless (pt)	1.37E+00	6.17E-02	1.96E-03	0.00E+00	2.81E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04	7.32E-03	8.38E-03	8.77E-03	-3.35E-01

Resource use indicators

The resource-use indicators are listed below.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	MJ	4.19E-01	2.60E-03	9.93E-03	0.00E+00	1.44E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-05	2.01E-04	9.14E-03	2.69E-04	-9.99E-02
PERM	MJ	2.37E-02	0.00E+00	-2.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	4.43E-01	2.60E-03	-1.38E-02	0.00E+00	1.44E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-05	2.01E-04	9.14E-03	2.69E-04	-9.99E-02
PENRE	MJ	4.34E+00	2.49E-01	2.05E-02	0.00E+00	1.39E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-03	1.22E-02	4.75E-02	1.04E-01	-8.64E-01
PENRM	MJ	1.35E-01	0.00E+00	-2.33E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.33E-01	0.00E+00
PENRT	MJ	4.47E+00	2.49E-01	1.82E-02	0.00E+00	1.39E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-03	1.22E-02	4.75E-02	-2.90E-02	-8.64E-01
SM	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	3.71E-03	2.13E-05	6.47E-07	0.00E+00	9.25E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-07	1.49E-06	4.23E-05	1.03E-05	-4.87E-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 indicators

The waste-disposal indicators are listed below.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste disposed	kg	3.31E-02	2.74E-04	2.21E-05	0.00E+00	8.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.71E-06	1.26E-05	4.65E-05	4.26E-03	-1.12E-02
Non-hazardous waste disposed	kg	8.36E+00	2.15E-03	1.51E-03	0.00E+00	1.89E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.73E-05	1.34E-04	7.93E-04	4.96E-03	-1.77E-02
Radioactive waste disposed	kg	3.99E-06	4.06E-08	7.20E-09	0.00E+00	2.31E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-10	3.63E-09	2.68E-07	2.51E-09	-7.00E-07

Output flow indicators

The output-flow indicators are listed below.

A1–A3 per 1 Wp declared unit; A4–D per 1 Wp functional unit																
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Material for recycling	kg	8.61E-06	0.00E+00	7.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E-02	0.00E+00	0.00E+00
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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	1.54E-04	0.00E+00	8.30E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	0.00E+00
Exported energy, thermal	MJ	3.01E-04	0.00E+00	1.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02	0.00E+00

Product variation (A-C)

Product variation per functional unit (A1–C4)	Unit	Min (%)	Max (%)
GWP-fossil	kg CO2 eq.	-2.30E+00	2.79E+00
GWP-biogenic	kg CO2 eq.	-2.43E+00	2.80E+00
GWP-luluc	kg CO2 eq.	-3.89E+00	4.31E+00
GWP-total	kg CO2 eq.	-2.30E+00	2.79E+00
ODP	kg CFC 11 eq.	-7.36E+00	6.49E+00
AP	mol H+ eq.	-2.58E+00	3.24E+00
EP-freshwater	kg P eq.	-1.82E+00	1.76E+00
EP- marine	kg N eq.	-1.88E+00	2.49E+00
EP-terrestrial	mol N eq.	-2.25E+00	3.06E+00
POCP	kg NMVOC eq.	-2.27E+00	3.08E+00
ADP-minerals&metals*	kg Sb eq.	-2.06E+00	2.24E+00
ADP-fossil*	MJ	-2.23E+00	2.73E+00
WDP*	m³ world eq. deprived	-1.74E+00	1.87E+00

Packaging and product end-of-life scenarios

Results are the equal-weight mean of the nine families per functional unit (1 Wp), for all 38 indicators. Packaging results report A5 and D (packaging); product end-of-life results report C1–C4 and D (product C).

Packaging scenario definitions

Scenario	Route allocation	Processing and residues	Reported modules
Declared mix	Paper/board: 87.0% recycling, 7.2% incineration, 5.8% landfill. PET and LDPE: 41.7%, 32.1%, 26.2%. Wood: 37.7%, 34.3%, 28.0%, respectively.	Material-specific treatment inventories, recovered outputs and residue routes.	A5; D (packaging)
100% recycling	All packaging is sent to recycling.	Recycling treatment with the stated recovery outputs and residue routes.	A5; D (packaging)
100% incineration	All packaging is sent to incineration.	Incineration with energy recovery.	A5; D (packaging)
100% landfill	All packaging is sent to landfill.	Landfill treatment.	A5; D (packaging)

Product end-of-life scenario definitions

Scenario	Route allocation	Processing and residues	Reported modules
Declared mix	85% sent to sorting/recovery; 15% sent directly to landfill.	Recovery yields: glass 98%, aluminium 99%, copper 96.5%, silicon 95%. Unrecovered fractions follow the stated C4 routes.	C1–C4; D (product C)
100% direct landfill	All retired product is sent directly to landfill.	Landfill treatment after the stated dismantling and transport activities.	C1–C4; D (product C)
100% sorting/recovery	All retired product is sent to sorting/recovery.	The stated material recovery yields and residue routes are retained.	C1–C4; D (product C)

Packaging — Declared mix; nine-family equal-weight mean per 1 Wp

Indicator	Unit	A5	D (packaging)
Environmental impacts			
GWP-total	kg CO_2 eq	4.00E-03	-1.35E-04
GWP-fossil	kg CO_2 eq	1.54E-03	-1.63E-04
GWP-biogenic	kg CO_2 eq	2.45E-03	2.78E-05
GWP-luluc	kg CO_2 eq	3.31E-07	1.79E-07
GWP-GHG	kg CO_2 eq	1.67E-03	-1.35E-04
ODP	kg CFC-11 eq	2.17E-11	-2.32E-10
AP	mol H^+ eq	1.27E-05	-7.09E-07
EP-freshwater	kg P eq	8.93E-09	1.40E-09
EP-marine	kg N eq	5.85E-06	2.77E-08
EP-terrestrial	mol N eq	6.36E-05	-1.38E-06
POCP	kg NMVOC eq	1.91E-05	-7.13E-07
ADP-minerals&metals	kg Sb eq	9.02E-10	-6.27E-10
ADP-fossil	MJ	1.93E-02	-3.71E-03
WDP	m^3 world eq. deprived	9.34E-05	-1.47E-05
PM	disease incidence	3.53E-10	-5.38E-12
IRP	kBq U-235 eq	9.64E-06	-1.65E-05
ETP-freshwater	CTUe	1.75E-03	2.24E-04
HTP-c	CTUh	2.03E-13	-1.91E-14
HTP-nc	CTUh	5.91E-12	-6.03E-13
SQP	dimensionless (pt)	1.96E-03	-2.40E-02
Resource use			
PERE	MJ	9.93E-03	-4.61E-03
PERM	MJ	-2.37E-02	0.00E+00
PERT	MJ	-1.38E-02	-4.61E-03
PENRE	MJ	2.05E-02	-3.71E-03
PENRM	MJ	-2.33E-03	0.00E+00
PENRT	MJ	1.82E-02	-3.71E-03
SM	kg	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00
FW	m^3	6.47E-07	-4.18E-07
Waste disposed			
HWD	kg	2.21E-05	-3.28E-06
NHWD	kg	1.51E-03	9.11E-04
RWD	kg	7.20E-09	-1.33E-08
Output flows			
CRU	kg	0.00E+00	0.00E+00
MFR	kg	7.22E-04	0.00E+00
MER	kg	0.00E+00	0.00E+00
EEE	MJ	8.30E-04	0.00E+00
EET	MJ	1.65E-03	0.00E+00

Packaging — 100% recycling; nine-family equal-weight mean per 1 Wp

Indicator	Unit	A5	D (packaging)
Environmental impacts			
GWP-total	kg CO_2 eq	3.87E-03	-6.28E-05
GWP-fossil	kg CO_2 eq	1.54E-03	-1.01E-04
GWP-biogenic	kg CO_2 eq	2.33E-03	3.77E-05
GWP-luluc	kg CO_2 eq	4.49E-07	3.74E-07
GWP-GHG	kg CO_2 eq	1.55E-03	-6.28E-05
ODP	kg CFC-11 eq	2.20E-11	-5.51E-10
AP	mol H^+ eq	1.28E-05	-6.26E-07
EP-freshwater	kg P eq	1.05E-08	1.04E-08
EP-marine	kg N eq	5.83E-06	8.00E-08
EP-terrestrial	mol N eq	6.38E-05	-1.29E-06
POCP	kg NMVOC eq	1.92E-05	-7.78E-07
ADP-minerals&metals	kg Sb eq	1.11E-09	-1.02E-09
ADP-fossil	MJ	1.98E-02	-2.74E-03
WDP	m^3 world eq. deprived	8.36E-05	2.28E-05
PM	disease incidence	3.55E-10	-7.13E-12
IRP	kBq U-235 eq	1.25E-05	-1.59E-06
ETP-freshwater	CTUe	1.43E-03	4.13E-04
HTP-c	CTUh	1.92E-13	3.44E-15
HTP-nc	CTUh	4.09E-12	-3.20E-13
SQP	dimensionless (pt)	2.04E-03	-4.18E-02
Resource use			
PERE	MJ	4.78E-04	-7.29E-03
PERM	MJ	-2.37E-02	0.00E+00
PERT	MJ	-2.32E-02	-7.29E-03
PENRE	MJ	2.02E-02	-2.73E-03
PENRM	MJ	-2.33E-03	0.00E+00
PENRT	MJ	1.79E-02	-2.73E-03
SM	kg	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00
FW	m^3	1.99E-06	4.90E-07
Waste disposed			
HWD	kg	2.01E-05	-3.62E-06
NHWD	kg	2.07E-04	2.13E-03
RWD	kg	9.48E-09	-9.36E-10
Output flows			
CRU	kg	0.00E+00	0.00E+00
MFR	kg	1.40E-03	0.00E+00
MER	kg	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00

Packaging — 100% incineration; nine-family equal-weight mean per 1 Wp

Indicator	Unit	A5	D (packaging)
Environmental impacts			
GWP-total	kg CO_2 eq	3.94E-03	-5.15E-04
GWP-fossil	kg CO_2 eq	1.62E-03	-5.14E-04
GWP-biogenic	kg CO_2 eq	2.32E-03	-6.60E-07
GWP-luluc	kg CO_2 eq	2.16E-07	-8.43E-07
GWP-GHG	kg CO_2 eq	1.62E-03	-5.15E-04
ODP	kg CFC-11 eq	2.12E-11	-8.50E-12
AP	mol H^+ eq	1.26E-05	-1.60E-06
EP-freshwater	kg P eq	7.33E-09	-2.76E-08
EP-marine	kg N eq	5.80E-06	-2.65E-07
EP-terrestrial	mol N eq	6.36E-05	-2.96E-06
POCP	kg NMVOC eq	1.90E-05	-1.27E-06
ADP-minerals&metals	kg Sb eq	6.81E-10	-7.56E-10
ADP-fossil	MJ	1.86E-02	-1.02E-02
WDP	m^3 world eq. deprived	1.39E-04	-1.87E-04
PM	disease incidence	3.50E-10	-5.06E-12
IRP	kBq U-235 eq	7.51E-06	-5.82E-05
ETP-freshwater	CTUe	2.21E-03	-7.45E-04
HTP-c	CTUh	2.25E-13	-6.07E-14
HTP-nc	CTUh	6.51E-12	-2.44E-12
SQP	dimensionless (pt)	1.45E-03	-1.00E-03
Resource use			
PERE	MJ	1.57E-02	-1.48E-03
PERM	MJ	-2.37E-02	0.00E+00
PERT	MJ	-7.96E-03	-1.48E-03
PENRE	MJ	2.00E-02	-1.02E-02
PENRM	MJ	-2.33E-03	0.00E+00
PENRT	MJ	1.77E-02	-1.02E-02
SM	kg	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00
FW	m^3	2.35E-06	-4.35E-06
Waste disposed			
HWD	kg	3.21E-05	-7.96E-06
NHWD	kg	1.75E-03	-5.65E-05
RWD	kg	5.54E-09	-4.73E-08
Output flows			
CRU	kg	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00
EEE	MJ	3.05E-03	0.00E+00
EET	MJ	6.10E-03	0.00E+00

Packaging — 100% landfill; nine-family equal-weight mean per 1 Wp

Indicator	Unit	A5	D (packaging)
Environmental impacts			
GWP-total	kg CO_2 eq	5.56E-03	-2.19E-06
GWP-fossil	kg CO_2 eq	1.41E-03	-2.18E-06
GWP-biogenic	kg CO_2 eq	4.15E-03	-4.18E-09
GWP-luluc	kg CO_2 eq	2.13E-07	-5.39E-09
GWP-GHG	kg CO_2 eq	3.24E-03	-2.19E-06
ODP	kg CFC-11 eq	2.11E-11	-3.63E-14
AP	mol H^+ eq	1.24E-05	-9.29E-09
EP-freshwater	kg P eq	1.02E-08	-1.77E-10
EP-marine	kg N eq	6.33E-06	-1.33E-09
EP-terrestrial	mol N eq	6.24E-05	-1.50E-08
POCP	kg NMVOC eq	1.93E-05	-5.31E-09
ADP-minerals&metals	kg Sb eq	6.22E-10	-4.21E-12
ADP-fossil	MJ	1.87E-02	-4.82E-05
WDP	m^3 world eq. deprived	7.23E-05	-1.14E-06
PM	disease incidence	3.50E-10	-2.76E-14
IRP	kBq U-235 eq	7.45E-06	-3.76E-07
ETP-freshwater	CTUe	4.41E-03	-4.20E-06
HTP-c	CTUh	3.09E-13	-3.23E-16
HTP-nc	CTUh	2.49E-11	-1.42E-14
SQP	dimensionless (pt)	2.26E-03	-6.12E-06
Resource use			
PERE	MJ	2.39E-02	-9.53E-06
PERM	MJ	-2.37E-02	0.00E+00
PERT	MJ	2.01E-04	-9.53E-06
PENRE	MJ	2.10E-02	-4.82E-05
PENRM	MJ	-2.33E-03	0.00E+00
PENRT	MJ	1.87E-02	-4.82E-05
SM	kg	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00
FW	m^3	-2.98E-06	-2.65E-08
Waste disposed			
HWD	kg	1.68E-05	-4.27E-08
NHWD	kg	3.67E-03	-2.93E-07
RWD	kg	5.49E-09	-3.06E-10
Output flows			
CRU	kg	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00
EEE	MJ	1.98E-05	0.00E+00
EET	MJ	9.90E-06	0.00E+00

Product end-of-life — Declared mix; nine-family equal-weight mean per 1 Wp

Indicator	Unit	C1	C2	C3	C4	D (product C)
Environmental impacts						
GWP-total	kg CO_2 eq	3.19E-04	8.59E-04	3.71E-03	8.41E-03	-8.05E-02
GWP-fossil	kg CO_2 eq	3.19E-04	8.58E-04	3.70E-03	8.40E-03	-8.01E-02
GWP-biogenic	kg CO_2 eq	3.54E-08	1.83E-07	4.47E-06	1.30E-06	-2.70E-04
GWP-luluc	kg CO_2 eq	3.26E-08	2.89E-07	4.75E-06	3.24E-07	-1.07E-04
GWP-GHG	kg CO_2 eq	3.19E-04	8.59E-04	3.71E-03	8.41E-03	-8.03E-02
ODP	kg CFC-11 eq	4.74E-12	1.87E-11	4.17E-11	7.98E-12	-5.16E-10
AP	mol H^+ eq	2.85E-06	1.84E-06	7.52E-05	4.83E-06	-6.92E-04
EP-freshwater	kg P eq	1.12E-09	6.38E-09	1.62E-07	1.24E-08	-3.49E-06
EP-marine	kg N eq	1.33E-06	4.33E-07	3.47E-05	1.83E-06	-1.10E-04
EP-terrestrial	mol N eq	1.45E-05	4.79E-06	3.89E-04	1.96E-05	-1.05E-03
POCP	kg NMVOC eq	4.35E-06	2.92E-06	9.20E-05	5.50E-06	-3.13E-04
ADP-minerals&metals	kg Sb eq	1.17E-10	3.02E-09	6.83E-09	3.78E-09	-2.93E-06
ADP-fossil	MJ	4.16E-03	1.22E-02	4.75E-02	7.78E-03	-8.59E-01
WDP	m^3 world eq. deprived	1.07E-05	6.47E-05	1.23E-03	6.70E-04	-2.16E-02
PM	disease incidence	8.14E-11	6.40E-11	2.26E-10	5.19E-11	-6.32E-09
IRP	kBq U-235 eq	6.91E-07	5.33E-06	3.32E-04	3.97E-06	-1.00E-03
ETP-freshwater	CTUe	2.25E-04	1.64E-03	5.21E-03	1.85E-02	-5.44E-01
HTP-c	CTUh	3.25E-14	1.44E-13	3.65E-13	9.58E-13	-5.19E-11
HTP-nc	CTUh	5.13E-13	7.69E-12	1.52E-11	3.16E-11	-2.65E-09
SQP	dimensionless (pt)	2.76E-04	7.32E-03	8.38E-03	8.77E-03	-3.10E-01
Resource use						
PERE	MJ	2.61E-05	2.01E-04	9.14E-03	2.69E-04	-9.52E-02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.61E-05	2.01E-04	9.14E-03	2.69E-04	-9.52E-02
PENRE	MJ	4.16E-03	1.22E-02	4.75E-02	1.04E-01	-8.59E-01
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	-1.33E-01	0.00E+00
PENRT	MJ	4.16E-03	1.22E-02	4.75E-02	-2.90E-02	-8.59E-01
SM	kg	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
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.66E-07	1.49E-06	4.23E-05	1.03E-05	-4.86E-04
Waste disposed						
HWD	kg	3.71E-06	1.26E-05	4.65E-05	4.26E-03	-1.11E-02
NHWD	kg	2.73E-05	1.34E-04	7.93E-04	4.96E-03	-1.86E-02
RWD	kg	4.35E-10	3.63E-09	2.68E-07	2.51E-09	-6.85E-07
Output flows						
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	3.75E-02	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	1.25E-02	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	2.43E-02	0.00E+00

Product end-of-life — 100% direct landfill; nine-family equal-weight mean per 1 Wp

Indicator	Unit	C1	C2	C3	C4	D (product C)
Environmental impacts						
GWP-total	kg CO_2 eq	3.19E-04	4.57E-04	0.00E+00	4.75E-04	-7.16E-06
GWP-fossil	kg CO_2 eq	3.19E-04	4.57E-04	0.00E+00	4.75E-04	-7.13E-06
GWP-biogenic	kg CO_2 eq	3.54E-08	9.75E-08	0.00E+00	1.35E-07	-1.37E-08
GWP-luluc	kg CO_2 eq	3.26E-08	1.54E-07	0.00E+00	3.93E-08	-1.76E-08
GWP-GHG	kg CO_2 eq	3.19E-04	4.57E-04	0.00E+00	4.75E-04	-7.16E-06
ODP	kg CFC-11 eq	4.74E-12	9.95E-12	0.00E+00	2.87E-12	-1.19E-13
AP	mol H^+ eq	2.85E-06	9.80E-07	0.00E+00	1.44E-06	-3.04E-08
EP-freshwater	kg P eq	1.12E-09	3.40E-09	0.00E+00	1.20E-09	-5.78E-10
EP-marine	kg N eq	1.33E-06	2.30E-07	0.00E+00	7.52E-07	-4.34E-09
EP-terrestrial	mol N eq	1.45E-05	2.55E-06	0.00E+00	6.84E-06	-4.89E-08
POCP	kg NMVOC eq	4.35E-06	1.56E-06	0.00E+00	2.21E-06	-1.74E-08
ADP-minerals&metals	kg Sb eq	1.17E-10	1.60E-09	0.00E+00	1.28E-10	-1.38E-11
ADP-fossil	MJ	4.16E-03	6.49E-03	0.00E+00	2.58E-03	-1.57E-04
WDP	m^3 world eq. deprived	1.07E-05	3.44E-05	0.00E+00	4.44E-05	-3.72E-06
PM	disease incidence	8.14E-11	3.41E-11	0.00E+00	3.86E-11	-9.01E-14
IRP	kBq U-235 eq	6.91E-07	2.84E-06	0.00E+00	5.94E-07	-1.23E-06
ETP-freshwater	CTUe	2.25E-04	8.71E-04	0.00E+00	1.26E-02	-1.37E-05
HTP-c	CTUh	3.25E-14	7.67E-14	0.00E+00	3.80E-14	-1.05E-15
HTP-nc	CTUh	5.13E-13	4.09E-12	0.00E+00	4.26E-12	-4.62E-14
SQP	dimensionless (pt)	2.76E-04	3.89E-03	0.00E+00	4.12E-03	-2.00E-05
Resource use						
PERE	MJ	2.61E-05	1.07E-04	0.00E+00	2.74E-05	-3.11E-05
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.61E-05	1.07E-04	0.00E+00	2.74E-05	-3.11E-05
PENRE	MJ	4.16E-03	6.49E-03	0.00E+00	1.35E-01	-1.57E-04
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	-1.33E-01	0.00E+00
PENRT	MJ	4.16E-03	6.49E-03	0.00E+00	2.48E-03	-1.57E-04
SM	kg	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
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.66E-07	7.94E-07	0.00E+00	-1.37E-05	-8.65E-08
Waste disposed						
HWD	kg	3.71E-06	6.68E-06	0.00E+00	2.76E-06	-1.39E-07
NHWD	kg	2.73E-05	7.14E-05	0.00E+00	9.86E-03	-9.56E-07
RWD	kg	4.35E-10	1.93E-09	0.00E+00	3.76E-10	-1.00E-09
Output flows						
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	6.46E-05	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	3.24E-05	0.00E+00

Product end-of-life — 100% sorting/recovery; nine-family equal-weight mean per 1 Wp

Indicator	Unit	C1	C2	C3	C4	D (product C)
Environmental impacts						
GWP-total	kg CO_2 eq	3.19E-04	9.29E-04	4.36E-03	9.80E-03	-9.47E-02
GWP-fossil	kg CO_2 eq	3.19E-04	9.29E-04	4.35E-03	9.80E-03	-9.42E-02
GWP-biogenic	kg CO_2 eq	3.54E-08	1.98E-07	5.26E-06	1.51E-06	-3.18E-04
GWP-luluc	kg CO_2 eq	3.26E-08	3.13E-07	5.59E-06	3.75E-07	-1.26E-04
GWP-GHG	kg CO_2 eq	3.19E-04	9.29E-04	4.36E-03	9.80E-03	-9.45E-02
ODP	kg CFC-11 eq	4.74E-12	2.02E-11	4.91E-11	8.88E-12	-6.07E-10
AP	mol H^+ eq	2.85E-06	1.99E-06	8.85E-05	5.42E-06	-8.14E-04
EP-freshwater	kg P eq	1.12E-09	6.91E-09	1.91E-07	1.44E-08	-4.10E-06
EP-marine	kg N eq	1.33E-06	4.69E-07	4.08E-05	2.02E-06	-1.30E-04
EP-terrestrial	mol N eq	1.45E-05	5.19E-06	4.57E-04	2.18E-05	-1.23E-03
POCP	kg NMVOC eq	4.35E-06	3.16E-06	1.08E-04	6.08E-06	-3.68E-04
ADP-minerals&metals	kg Sb eq	1.17E-10	3.26E-09	8.04E-09	4.43E-09	-3.44E-06
ADP-fossil	MJ	4.16E-03	1.32E-02	5.59E-02	8.70E-03	-1.01E+00
WDP	m^3 world eq. deprived	1.07E-05	7.00E-05	1.45E-03	7.80E-04	-2.54E-02
PM	disease incidence	8.14E-11	6.93E-11	2.66E-10	5.42E-11	-7.43E-09
IRP	kBq U-235 eq	6.91E-07	5.77E-06	3.91E-04	4.57E-06	-1.18E-03
ETP-freshwater	CTUe	2.25E-04	1.77E-03	6.13E-03	1.95E-02	-6.40E-01
HTP-c	CTUh	3.25E-14	1.56E-13	4.29E-13	1.12E-12	-6.10E-11
HTP-nc	CTUh	5.13E-13	8.33E-12	1.79E-11	3.64E-11	-3.12E-09
SQP	dimensionless (pt)	2.76E-04	7.92E-03	9.86E-03	9.59E-03	-3.64E-01
Resource use						
PERE	MJ	2.61E-05	2.18E-04	1.08E-02	3.12E-04	-1.12E-01
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.61E-05	2.18E-04	1.08E-02	3.12E-04	-1.12E-01
PENRE	MJ	4.16E-03	1.32E-02	5.59E-02	9.81E-02	-1.01E+00
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	-1.33E-01	0.00E+00
PENRT	MJ	4.16E-03	1.32E-02	5.59E-02	-3.46E-02	-1.01E+00
SM	kg	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
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.66E-07	1.61E-06	4.97E-05	1.45E-05	-5.71E-04
Waste disposed						
HWD	kg	3.71E-06	1.36E-05	5.47E-05	5.01E-03	-1.31E-02
NHWD	kg	2.73E-05	1.45E-04	9.34E-04	4.10E-03	-2.19E-02
RWD	kg	4.35E-10	3.93E-09	3.16E-07	2.89E-09	-8.05E-07
Output flows						
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	4.41E-02	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	1.47E-02	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	2.86E-02	0.00E+00

ABBREVIATIONS

The following abbreviations are used for lifecycle stages, environmental indicators and technical terms in this declaration.

Abbreviation	Definition
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
DU	Declared unit
PCR	Product category rules
EPD	Environmental product declaration
GWP	Global warming potential
ODP	Ozone depletion potential
POCP	Photochemical ozone formation potential
AP	Acidification potential
EP	Eutrophication potential
ADPE	Abiotic depletion potential for non-fossil resources
ADPF	Abiotic depletion potential for fossil resources
PERE	Use of renewable primary energy excluding renewable primary energy resources used as raw materials
PENRE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials
EN	European Norm
EF	Environmental Footprint characterisation method
GPI	General Programme Instructions of the International EPD System
ISO	International Organization for Standardization
CEN	European Committee for Standardization
CLC	CEN-CENELEC
CPC	Central Product Classification (UN)
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
SVHC	Substances of Very High Concern (REACH candidate list)
ND	Not declared / no data
FU	Functional unit

REFERENCES

Numbered citations in the text refer to the standards, programme documents and evidence sources listed below.

No.	Reference
1	EN 15804:2012+A2:2019/AC:2021, Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products (2019/2021). CEN.
2	ISO 14040:2006, Environmental management — Life cycle assessment — Principles and framework (2006). ISO.
3	ISO 14044:2006, Environmental management — Life cycle assessment — Requirements and guidelines (2006). ISO.
4	PCR 2019:14 Construction products (EN 15804+A2), v2.0.1 (2025). EPD International (programme operator).

No.	Reference
5	c-PCR-016 / NPCR 029 Photovoltaic modules, v1.2 (2022). EPD International (programme operator).
6	ecoinvent database, version 3.11, cut-off system model (2024). ecoinvent Association.
7	Environmental Footprint method EN 15804 + A2 (EF 3.1), characterisation factors (2023). European Commission Joint Research Centre.
8	Leapton LEAP series module datasheets (LP182x210-M-42Q-NB to -66Q-NB), including the updated PV42Q datasheet supplied on 12 November 2026, linear power warranty 0.35 %/year over 30 years (2026). Leapton Energy Co., Ltd.
9	EPD International (2025). General Programme Instructions for the International EPD System, version 5.0.1, 27 February 2025. https://www.environdec.com/resources/general-programme-instructions
10	ISO (2006). ISO 14025:2006, Environmental labels and declarations — Type III environmental declarations — Principles and procedures. Referenced alongside ISO 14025:2026 for conformance with EN 15804. https://www.iso.org/standard/38131.html
11	ISO (2026). ISO 14025:2026, Environmental statements and programmes for products — Environmental product declarations (EPDs). 2nd ed., June 2026. https://www.iso.org/standard/87610.html
12	Leapton Solar (Changshu) Co., Ltd. (2026). Leapton 210R four-split dual-glass n-type TOPCon photovoltaic modules LCA Background Report. Report No. LEAPTON-LCA-2026-001, R2, 12 November 2026.
13	EPD International (2026). General Programme Instructions for the International EPD System, v5.1.0 (10 November 2026). The 10 November 2026 EPD International transition notice requires references to ISO 14025:2006 and ISO 14025:2026 for EPDs under PCR 2019:14 v2 and later, to maintain conformance with EN 15804:2012+A2:2019. https://www.environdec.com/news/gpi-510-to-align-with-iso-14025

VERSION HISTORY

Document version history.

Version	Date	Change
1.0	2026-11-12	First issue of the environmental product declaration for the 210R four-split module family.

TECHNICAL ANNEX

A. Datasheet ratings and dimensions

STC power ranges are taken from the manufacturer's datasheets. The assessed rating is the highest listed rating of each family. EPD group results use the unweighted mean of the nine assessed variants.

Family	STC range (W)	Assessed (Wp)	Datasheet mass (kg)	Dimensions (mm)	Efficiency (%)
42Q	395–425	425	21	1540 × 1134 × 30	24.31
45Q	425–455	455	23.0	1650 × 1134 × 35	24.31
48Q	450–485	485	24.0	1762 × 1134 × 30	24.27
51Q	480–515	515	25.7	1856 × 1134 × 35	24.47
54Q	530–545	545	26.6	1961 × 1134 × 30	24.51
57Q	535–575	575	28.1	2068 × 1134 × 30	24.52
60Q	565–610	610	29.4	2172 × 1134 × 30	24.77
63Q	590–640	640	30.2	2278 × 1134 × 30	24.77
66Q	620–670	670	32.2	2382 × 1134 × 30	24.80

Source: Leapton module datasheets. Masses exclude packaging, and efficiency is given at the assessed rating.

B. Conversion from Wp to module area

For each family, A is module length × width in metres and P is the assessed rating in Wp. One Wp corresponds to A/P m². Multiply a result per Wp by P/A to express it per m² for that family. Quarter-cell pieces per Wp equal the number of pieces per module divided by P.

Family	Area (m²)	Area per Wp (m²/Wp)	Power per area (Wp/m²)	Quarter-cell pieces/module	Quarter-cell pieces/Wp
42Q	1.746	4.11E-03	243.4	168	0.395
45Q	1.871	4.11E-03	243.2	180	0.396
48Q	1.998	4.12E-03	242.7	192	0.396
51Q	2.105	4.09E-03	244.7	204	0.396
54Q	2.224	4.08E-03	245.1	216	0.396
57Q	2.345	4.08E-03	245.2	228	0.397
60Q	2.463	4.04E-03	247.7	240	0.393
63Q	2.583	4.04E-03	247.7	252	0.394
66Q	2.701	4.03E-03	248.0	264	0.394

C. Mass and volumetric density

The retained BOM mass includes edge-seal tape and is used for the module end-of-life inventory. The raw material subtotal excludes this tape. Process-consumed flux and shipping packaging are excluded from the retained product mass.

Family	Raw BOM subtotal (kg/module)	Retained BOM mass (kg/module)	Packaging mass (kg/module)
42Q	20.909	20.917	0.706
45Q	23.272	23.281	0.772
48Q	23.834	23.844	0.787
51Q	25.716	25.726	0.839
54Q	26.469	26.480	0.858
57Q	27.882	27.893	0.900
60Q	29.256	29.268	0.938
63Q	30.639	30.651	0.976
66Q	32.008	32.020	1.006

Volumetric density uses datasheet mass divided by module length × width × frame thickness, all in metres. For PV42Q, 21.0 kg ÷ (1.540 m × 1.134 m × 0.030 m) = 4.01E+02 kg/m³. The unweighted mean of the nine family densities is 3.87E+02 kg/m³ (range 3.49E+02 to 4.01E+02 kg/m³).

Other datasheet specifications include temperature coefficients are Voc −0.24%/°C, Pmax −0.26%/°C and Isc +0.046%/°C; operating temperature is −40 to +70°C; NMOT is 41±3°C; maximum system voltage is 1500 V; bifaciality is 85±5%; the product warranty is 25 years and the power warranty is 30 years.

D. Manufacturing electricity supply

The table shows the direct high-voltage supply shares for CN-ECGC in 2022. Imports and pumped storage are shown separately at the point of supply. Source: ecoinvent 3.11, ecoQuery dataset 26881. The medium-voltage consumption market is dataset 26804.

Direct high-voltage supply or source	Share (%)
Coal	61
Natural gas	9.66
Nuclear	11.3
Wind	4.68
Run-of-river hydro	1.62
Pumped storage	1.08
Blast-furnace gas	0.291
Oil	0.456
Imports: CN-NECG	0.198
Imports: CN-NWG	2.31
Imports: CN-SWG	5.49
Imports: CN-NCGC	1.88