Published by EPD Denmark Through MRA
Registration number MD-24018-EN

Environmental Product Declaration

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

Mono Crystalline Silicon Photovoltaic (PV) Modules

WST-XXXNGX-D3

WST-XXXNGXB-D3

from

Win Win Precision Technology Co., Ltd.

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	EPD-IES-0007690
Publication date:	2024-12-18
Valid until:	2029-12-17

An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

EPD of multiple products, based on a representative product

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 v1.3.4 PCR 2019:14-c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)
PCR review was conducted by the Technical Committee of the International EPD® System. A full list of members available on www.environdec.com. Chair of the PCR review: Claudia Peña, DDERE Research & Technology. The review panel may be contacted via info@environdec.com
Life Cycle Assessment (LCA)
LCA accountability:<Hongyu Tian, Junyu Li, TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch>
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: < *Marcel Gómez Ferrer, Marcel Gómez Consultoria Ambiental, Info@marcelgomez.com*> Approved by: The International EPD® System

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.

Company information

Owner of the EPD:

WIN WIN Precision Technology Co., Ltd.

4F., No.180, Sec. 2, Gongdao 5th Rd., East Dist., Hsinchu City 30070, Taiwan

Contact:

Angel Wu, w.angel@winaico.com

Description of the organisation:

WIN WIN Precision Technology Co., Ltd. is a technology enterprise founded in 2003 that specializes in the R&D and production of semiconductor components and solar renewable energy. We have a diverse group of top-tier wafer fab clients, and our goods serve applications in communication, automotive, and aerospace equipment, making us one of the leading producers of materials for semiconductor equipment in the market. Our own solar brand, WINAICO, is proactive in worldwide markets such as Europe, Australia, America, and Asia. Our new energy business group expanded its sphere of influence to include energy storage systems and industrial microgrids in 2022 to establish itself as a one-stop shop for energy integration solutions for energy generation, energy savings, and energy storage.

Product-related or management system-related certifications:

ISO 9001:2015 Quality Management System

Certificate TW20/10259_SGS

ISO 14001:2015 Environment Management System

Certificate TW24/00000151_SGS

ISO 45001:2018 Occupational health and safety management systems

Certificate TW24/00000189_SGS

Name and location of production site(s):

DAS SOLAR CO., LTD.

No.43, South Bailing Road, 324022 Quzhou City, Zhejiang Province, PEOPLE'S REPUBLIC OF CHINA

Product information

Product name:

Mono Crystalline Silicon Photovoltaic (PV) Modules

Product identification:

WST-XXXNGX-D3

WST-XXXNGXB-D3 (reference product)

Product description:

This EPD covers two PV module products, WST-XXXNGXB-D3 and WST-XXXNGX-D3. And the results shown are for the reference product WST-XXXNGXB-D3.

WIN's solar modules are built with a fully automated production line to minimise defects, improve product quality and achieve better product uniformity. Modules can be widely used in rooftop and ground solar farms. The advantages are shown below:

- Half-cell design lowers internal resistance and protects them from long term degradation.
- Combine half-cell, 16 busbars and reflective wires to maximise module efficiency and improve temperature coefficients to perform well even in hot weather.
- Use high-efficiency solar cells designed to perform in any weather. The module efficiency remains high even in low light conditions.
- Up to 15% power increase in yield via bifacial cells active on both sides and the transparent back side.

Series (brand name)	WST-XXXNGXB-D3	WST-XXXNGX-D3
Power output range (W, in step of 5W)	425-430	430-435
Dimensions(mm^3)	1722 * 1134 * 35	1722 * 1134 * 35
Module efficiency (%)	22.02	22.30
Weight per module (kg/pcs)	24	24
First year degradation (%)	1	1
Annual degradation (%)	0.4	0.4
Type of cell/technology	Monocrystalline,TOPCon	Monocrystalline,TOPCon
Area (m^2)	1.95	1.95
Reference service life (year)	30	30
Cell amount (pcs)	108 (6 strings x 18 half-cells)	108 (6 strings x 18 half-cells)

Note: The technological data is certificated by IEC 61215-1:2016, IEC 61215-2:2016, IEC 61730-1:2016, IEC 61730-2:2016

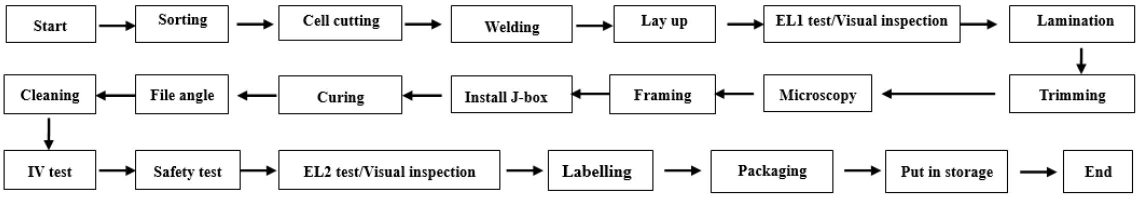
UN CPC code:

461 Electric motors, generators and transformers, and parts thereof

Geographical scope:

Global

Manufacturing process



The descriptions of process steps of PV module are shown below:

Step 1: Sorting

Sort the solar cells which meet the requirements of the order and check whether they conform to the standards.

Step 2: Cell Cutting

The full cell is cut into the appropriate size according to the BOM size.

Step 3: Welding

Solder the positive and negative electrodes of the single solar cell together to form a cell string.

Step 4: Lay up

Connect the soldered cell strings with busbar, and lay up pre-lay glass, EVA film, TPT or glass back plate.

Step 5: EL1 Test & Visual inspection

Inspect the appearance of laid components before lamination and EL test to find the unqualified points.

Step 6: Lamination

The lamination process is to melt EVA and solidify the laminate at a certain temperature.

Step 7: Trimming

Trim the edge of laminate.

Step 8: Microscopy

The laminated components are inspected again.

Step 9: Framing

Assemble the frame and mount the J-box on the back of laminate with silicone adhesive.

Step 10: Install J-box

Solder the welding point of J-box with string connector, then fill the J-box with potting adhesive.

Step 11: Curing

Curing the PV Modules frame glue and junction box glue.

Step 12: File angel

Polish the four corners of the component.

Step 13: Cleaning

Clean the surface of PV modules.

Step 14: IV Test

Test the electrical parameters of PV modules and determine the power rating.

Step 15: Safety test

Insulation test, dielectric withstanding test and grounding continuity test.

Step 16: EL 2 Test/ Visual inspection

Test to find the hidden cracking of cells and determine the EL level.

Step 17: Labelling

Label the PV modules according to the power rating.

Step 18: Packing

Package the products ready for distribution.

Step 19: Put in Storage

Put the packed module into the warehouse procedure.

LCA information

Functional unit:

1 Wp (Watt-peak) of manufactured PV module, from cradle-to-grave, with activities needed for a reference service of life (RSL) of 30 years (≥80% of the labelled power output).

The conversion factor to convert the results to the functional unit of WST-XXXNGXB-D3 and WST-XXXNGX-D3 to 1 m^2 are 220.20 Wp/m^2 and 222.76 Wp/m^2 respectively.

Time representativeness:

From 2023-03-01 to 2024-02-29

Database(s) used:

Secondary data related to the life cycle impacts of the material or energy flows that enter and leave the production system is sourced from Ecoinvent 3.9 "allocation, cut-off by allocation - unit" database. Missing data are completed by data from secondary database, wafer and ingot production is from IEA PVPS Task 12, 2020 report.

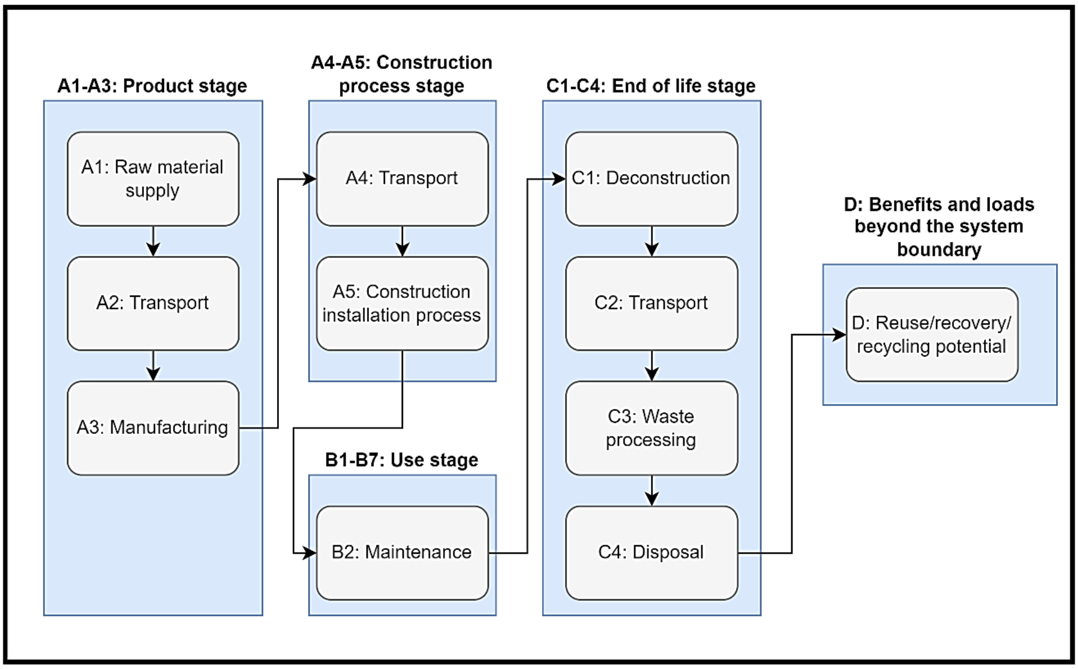
LCA software used:

SimaPro version 9.5.0.0

Description of system boundaries:

The system boundary for this LCA study of WIN's PV modules encompasses the life cycle stages of the product, from cradle to gate with options (A4-A5-B2)+C+D, including raw materials acquisition, transportation, manufacturing, delivery, installation, maintenance, waste disposal for end-of-life and benefits and loads after end-of-life, as defined in the PCR.

System diagram:



	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
Module	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules declared	X	X	X	X	X	ND	X	ND	ND	ND	ND	ND	X	X	X	X	X
Geography	CN			GLO		-	EU	-	-	-	-	-	EU				EU
Specific data used	47%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	<10%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	0%					-	-	-	-	-	-	-	-	-	-	-	-

<u>Excluded processes:</u>

- Impacts related to the production, transportation, and installation of capital goods (buildings, infrastructure, machinery, internal transport packaging) and general operations (staff travel, marketing, and communication actions) that cannot be directly allocated to products are excluded from the LCA study.

- The packaging for silicon wafer and solar cells is reused internally and its impact was excluded from the system.
- Emissions during the PV module installation and operation due to no obvious emission observable.
- Storage phases and sales of PV products due to no observable impact. Product losses due to abnormal damage such as natural disasters or fire accidents would occur at a rather low frequency.
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.
- Research and development activities.
- Long-term emissions.

Assumptions：

- Since the lorries for transportation are unspecified, it is assumed that the lorries are EURO6, 16-32 metric ton for LCA modelling for all the road transportation (for A2, A4, A5, &C2). And the ship for transportation to oversea market is assumed as container ship (for A4).
- The electricity consumption during PV plant installation stage (A5) is scaled up based on the data from Ecoinvent database value (36.03 kWh/570kWp) according to the power capacity.
- The diesel consumption during PV plant installation stage (A5) is scaled up based on the data from Ecoinvent database value (7673 MJ/570kWp) according to the power capacity.
- For waste disposal, recycling during the installation stage (A5), the transportation distance from PV plant to waste disposal site is assumed as 200 km.
- The use stage (B1) requires no energy and materials inputs and has no emissions.
- During the maintenance stage (B2), water used for cleaning is assumed 0.23L per module per time and cleaning frequency is two time per year. And it assumed small manual systems with handheld that spray water onto panels are used, no electricity consumption during the cleaning process.
- Replacement (B4) is assumed no replacement for the module as the module has RSL>30 years.
- De-construction (C1) is assumed mainly energy use for onsite dismantling and the energy use is assumed the same as the construction stage (A5).
- Waste transportation (C2) distance from the de-installation plant to the waste treatment facilities is assumed to be 50 km for simplification purposes.
- Waste processing (C3): The electricity consumption for demolition of PV modules and sorting of waste is assumed the same as the manufacture stage (A3) of PV modules.

- For end-of-life stages (C3 &C4), the scenario of waste treatment refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under the EU scenario.

Allocation：

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

Multi-input allocation: For data sets in this study, the allocation of electricity during the manufacturing stage of PV module is allocated by power output ratio. The electricity consumption value per piece of PV module is equal to electricity consumption value per functional unit multiplied by the highest power rating of this PV module. The transportation of raw materials is allocated by mass ratio.

Multi-output allocation: No other by-products are produced from the production, hence there is no production of by-products that need to be used to allocate the situation. The allocation of emissions during the manufacturing stage of PV module is allocated by power output ratio. Emissions per piece is equal to emissions per functional unit multiplied by the highest power rating of this PV module.

End-of-life allocation: For end-of-life stage of the PV modules, polluter-pays-principle (PPP) is followed. As for the load and benefit of reuse, recycling, and recovery processes (Module D), it is reported separately following the PCR's recommendation.

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

Cut-off criteria:

For the processes within the system boundary, all available energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts. LCI data shall according to EN 15804 include a minimum of 95% of total inflows (mass and energy) per module and 99% of the total life cycle.

Electricity mix:

In this LCA study, it is important to note that different electricity grid mixes are used for different stages of the life cycle. Specifically, the production of solar cells and PV modules takes place in Zhejiang Province, China, where the Eastern China grid electricity mix is used. For the installation stage and end-of-life stage, Netherland’s market is chosen for representative. Because 97% of PV modules exports to Netherland. For electricity markets without trade of Guarantees of Origin (or similar), the residual mix will, however, be identical to the consumption mix.

Electricity grid	Unit	GWP-GHG
Electricity, medium voltage {CN-ECGC}| market for electricity, medium voltage| Cut-off, U	kg CO_2 eq / kWh	0.857
Electricity, low voltage {CN-ZJ}| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | Cut-off, U	kg CO_2 eq / kWh	0.0943
Electricity, low voltage {NL}| market group for | Cut-off, U	kg CO_2 eq / kWh	0.496
Electricity, medium voltage {NL}| market group for | Cut-off, U	kg CO_2 eq / kWh	0.510

Content information

	WST-XXXNGXB-D3	WST-XXXNGX-D3	WST-XXXNGXB-D3	WST-XXXNGX-D3	WST-XXXNGXB-D3	WST-XXXNGX-D3
Product components	**Weight, %**		**Post-consumer material, weight-%**		**Biogenic material, weight-% and kg C/kg**	
Frame	8.13	8.13	0	0	0	0
Glass	72.12	72.12	0	0	0	0
Cell	1.93	1.93	0	0	0	0
Solder	0.67	0.67	0	0	0	0
POE	11.15	11.15	0	0	0	0
Junction box	0.83	0.83	0	0	0	0
Tape	0.00	0.00	0	0	0	0
Silicone	1.14	1.14	0	0	0	0
Flux	0.06	0.06	0	0	0	0
Nameplate	0.00	0.00	0	0	0	0
Sticker	0.00	0.00	0	0	0	0
Total, kg/FU	6.00E-02	5.93E-02	0	0	0	0
Packaging materials	**Weight, %**		**Weight-% (versus the product)**		**Weight biogenic carbon, kg C/kg**	
Packing film	1.73	1.73	0.07	0.07	0	0
Packing belt	1.94	1.94	0.08	0.08	0	0
Pallet	71.70	71.70	2.94	2.94	4.72E-01	4.72E-01
Packing bag	0.62	0.62	0.03	0.03	0	0
Packing protector	1.15	1.15	0.05	0.05	4.17E-01	4.17E-01
Box	23.30	23.30	0.96	0.96	4.50E-01	4.50E-01
Total, kg/FU	2.47E-03	2.44E-03	4.13	4.13	3.12E-03	3.08E-03

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

LCA Scenarios

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

A4 Transport

All activity data in A4 are based on practical data.

It is assumed that the lorries are EURO6, 16-32 metric ton for LCA modelling for all the road transportation. And the ship for transportation to oversea market is assumed as container ship.

Vehicles	Capacity Utilization (incl. return) %	Type of vehicle	Distance (km)	Fuel/energy consumption per tkm (kg/tkm)	Fuel/energy consumption per km (kg/km)
Truck	36.7	EURO6 16-32 ton	409.4	Diesel: 0.0366	8.78E-4
Boat	70	Container ship	18906.11	Heavy oil: 0.0025	6.00E-5

A5 Installation

The waste generated from the product packaging, mainly consisting of waste wood pallets, is accounted for in this stage, transportation of waste is assumed as 200km. The treatment of the waste wood pallets is modeled as 75% recycling and 25% incineration. Other packaging materials, including paper and plastic film, are modeled as 100% incineration.

Input and Output	Unit	WST-XXXNGX-D3		WST-XXXNGXB-D3	
		Value	Weight-% (versus the product)	Value	Weight-% (versus the product)
Waste plastic (incineration)	kg	1.05E-04	0.17	1.06E-04	0.17
Wastepaper box (incineration)	kg	5.95E-04	0.96	6.02E-04	0.96
Waste pallet (incineration)	kg	4.37E-04	0.71	4.42E-04	0.71
Waste pallet (recycled)	kg	1.31E-03	2.12	1.33E-03	2.12
Waste transportation	tkm	4.89E-04	/	4.95E-04	/
Diesel	MJ	1.35E-02	/	1.36E-02	/
Electricity	kWh	6.32E-05	/	6.40E-05	/

B Use Stage

For the use stage (B1) of the PV products, no energy and materials inputs, or emissions are involved. As for the maintenance stage (B2), water used for cleaning to maintain the performance is considered, 0.23L water used per module each time, and 2 times in a year are assumed as mentioned in the assumption section. During the operation of PV module, no repair (B3), replacement (B4), and refurbishment (B5) is required. There is no operational electricity (B6) or water consumption (B7).

WIN WIN's modules generate energy during the use stage. The site specific total produced electricity for the declared module can be calculated based on the module specifications and formulas provided by the c-PCR and described below.

The energy produced by a PV module depends on the installed power peak [Wp], degradation factor, geographic location, and direction/placement of the installation. The calculation formula of energy production are as follows:

- S_{rad}= Site specific annual average solar radiation on module (shadings not included), kWh/kWp/year. The annual radiation must take into consideration the specific inclination (slope, tilt) and orientation.
- A = Area of module, from functional unit (FU), m^2 (stated in the EPD).
- y = Module yield: electrical power, kWp for standard test conditions (STC) of the module divided by the area of the module (stated in the EPD).
- deg = yearly degradation rate (stated in the EPD).
- RSL = Reference service life for energy-producing unit, from functional unit (FU), stated in the EPD.
- PR = Performance ratio, coefficient for losses. Site specific performance ratio can be modelled with PV simulation software tools, such as PVSyst or similar.

Energy production in the first year of operation:

$E1=S_{rad}*A*y*PR*(1-deg)$

Energy production over reference service life of module:

$E_{RSL}=E1*(1+\sum_{n=1}^{RSL-1}(1-\mathrm{deg})^n)$

End-of-life Stage

For end-of-life (EoL) stage, assumptions are made due to a lack of data. Decommissioning stage (C1) of PV modules is assumed to be taken with same energy and fuel consumption as for installation stage. Transportation distance from the plant site to the waste treatment site (C2) is assumed to be 50km. The electricity consumption for demolition of PV modules and sorting of waste (C3) is assumed the same as the manufacture stage (A3) of PV modules. The scenario of waste treatment refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under the EU scenario. The required recycling rate for waste PV modules is 85% according to 2012/19/EU-Article 11 & ANNEX V. According to the IEA report, the recycling rate of PV modules is above 85% in the main EU countries. Therefore, it is safe to use 85% as a recycling rate for waste PV modules. 15% of the waste components (cells, glass, and waste plastics) end up to disposal stage (C4).

Input and Output	WST-XXXNGX-D3	WST-XXXNGXB-D3

	Weight, kg/FU	Weight-% (versus the product)	Weight, kg/FU	Weight-% (versus the product)
Waste glass 15%	6.67E-03	0.11	6.74E-03	0.11
Waste silicon cell 100%	1.19E-03	0.02	1.20E-03	0.02
Waste plastic	8.09E-03	0.13	8.19E-03	0.13
Other solid waste	4.11E-04	0.01	4.16E-04	0.01

Results of the environmental performance indicators

The functional unit (per Wp) results of WST-XXXNGXB-D3 are selected as representative results because it has a more significant impact on environment. The highest power output of WST-XXXNGXB-D3 is 430W.

Please note that the results are relative expressions and do not predict impacts on endpoint categories, exceedance of certain levels, safety margins or risks.

This LCA used EN 15804+A2:2019 (version 1.03) for impact assessment.

Mandatory impact category indicators according to EN 15804

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
GWP-total	kg CO_2 eq.	4.21E-01	1.68E-02	6.12E-03	9.87E-06	1.38E-03	5.55E-04	2.70E-02	-2.57E-03	-7.23E-02
GWP-Fossil	kg CO_2 eq.	4.24E-01	1.68E-02	2.07E-03	9.86E-06	1.38E-03	5.54E-04	2.70E-02	-2.57E-03	-7.14E-02
GWP-Biogenic	kg CO_2 eq.	-4.05E-03	0.00E+00	4.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GWP-LULUC	kg CO_2 eq.	4.88E-04	1.18E-05	2.22E-07	1.72E-08	1.64E-07	2.74E-07	2.68E-06	-1.11E-07	-9.43E-04
ODP	kg CFC11 eq.	8.57E-09	2.60E-10	2.62E-11	2.79E-13	2.25E-11	1.21E-11	2.50E-10	-1.06E-10	-7.69E-10
AP	mol H^+ eq.	2.50E-03	3.69E-04	1.31E-05	5.39E-08	1.26E-05	1.21E-06	1.73E-05	-3.19E-06	-6.27E-04
EP-freshwater	kg P eq.	6.96E-05	9.25E-08	7.57E-09	7.11E-10	6.19E-09	4.50E-09	3.00E-07	-2.76E-09	-1.55E-06
EP-marine	kg N eq.	6.06E-04	9.19E-05	6.02E-06	8.93E-09	5.82E-06	2.98E-07	5.49E-06	-1.35E-06	-9.02E-05
EP-terrestrial	mol N eq.	5.49E-03	1.02E-03	6.54E-05	1.01E-07	6.33E-05	3.11E-06	6.15E-05	-1.61E-05	-1.06E-03
POCP	kg NMVOC eq.	1.60E-03	2.82E-04	1.95E-05	3.69E-08	1.88E-05	1.88E-06	1.75E-05	-6.66E-06	-3.13E-04
ADP-M&M*	kg Sb eq.	1.95E-05	2.72E-08	1.13E-09	5.18E-11	7.56E-10	1.81E-09	1.09E-08	-6.82E-10	2.58E-07
ADP-fossils*	MJ	5.18E+00	2.15E-01	1.98E-02	1.77E-04	1.82E-02	7.87E-03	1.12E-01	-3.24E-02	-4.70E-01
WDP*	m^3	-6.07E-01	6.30E-04	1.24E-04	1.35E-03	4.25E-05	3.25E-05	1.77E-03	5.34E-05	-1.56E-02
PM	disease inc.	3.10E-08	7.07E-10	3.60E-10	5.37E-13	3.50E-10	4.11E-11	7.60E-11	4.05E-13	-8.16E-09
IRP	kBq U-235 eq	9.00E-03	5.57E-05	5.65E-06	1.20E-06	4.66E-06	3.99E-06	2.51E-04	-1.80E-06	-1.85E-03
ETP-fw	CTUe	5.93E+00	1.09E-01	1.16E-02	4.52E-05	8.54E-03	3.89E-03	5.03E-02	-5.88E-04	-3.69E-01

HTP-c	CTUh	1.81E-09	7.37E-12	6.30E-13	4.35E-14	4.25E-13	2.53E-13	3.28E-12	-2.20E-13	-1.32E-10
HTP-nc	CTUh	1.29E-07	9.13E-11	9.95E-12	5.70E-13	3.26E-12	5.59E-12	9.39E-11	-2.59E-12	-1.04E-09
SQP	Pt	1.72E+00	5.19E-02	2.29E-03	3.86E-05	1.29E-03	4.76E-03	2.29E-02	4.48E-03	-1.30E-01
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; PM= Potential incidence of disease due to PM emissions; IRP=Potential Human exposure efficiency relative to U235; ETP-fw[=Potential Comparative Toxic Unit for ecosystems; HTP-c=Potential Comparative Toxic Unit for humans; HTP-nc=Potential Comparative Toxic Unit for humans; SQP: Potential Soil quality index.									

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

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.	4.25E-01	1.68E-02	2.07E-03	9.87E-06	1.38E-03	5.55E-04	2.70E-02	-2.57E-03	-7.23E-02

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

Resource use indicators

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
PERE	MJ	9.50E-01	1.91E-03	2.13E-04	2.81E-05	1.80E-04	1.22E-04	1.42E-02	1.82E-04	-8.55E-02
PERM	MJ	3.22E-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
PERT	MJ	9.83E-01	1.91E-03	2.13E-04	2.81E-05	1.80E-04	1.22E-04	1.42E-02	1.82E-04	-8.55E-02
PENRE	MJ	4.88E+00	2.12E-01	1.96E-02	1.90E-04	1.80E-02	7.78E-03	1.09E-01	5.65E-03	-1.52E-01
PENRM	MJ	3.07E-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
PENRT	MJ	5.19E+00	2.12E-01	1.96E-02	1.90E-04	1.80E-02	7.78E-03	1.09E-01	5.65E-03	-1.52E-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
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

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
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	-1.19E-02	2.13E-05	3.08E-06	3.39E-05	1.61E-06	1.12E-06	5.19E-05	2.98E-05	-2.18E-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

Indicator	Unit	A1-A3	A4	A5	B2	C1	C2	C3	C4	D
Hazardous waste disposed	kg	3.90E-04	1.17E-06	1.31E-07	5.59E-10	1.21E-07	5.01E-08	2.70E-07	3.23E-08	-4.29E-07
Non-hazardous waste disposed	kg	4.12E-02	3.72E-03	1.56E-04	2.23E-06	2.70E-05	3.91E-04	2.37E-04	8.75E-03	-5.45E-03
Radioactive waste disposed	kg	6.01E-06	3.07E-08	3.51E-09	1.04E-09	2.85E-09	2.59E-09	2.20E-07	2.50E-09	-2.67E-07

Output flow indicators

Indicator	Unit	A1-A3	A4	A5	B2	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
Material for recycling	kg	0.00E+00	0.00E+00	1.33E-03	0.00E+00	0.00E+00	0.00E+00	4.33E-02	0.00E+00	0.00E+00

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	8.19E-03	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-02	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	0.00E+00	2.33E-02	0.00E+00

Information related to EPD of multiple products

Results of WST-XXXNGXB-D3 in this report are presented by its A1-A3 stage results (per Wp) and variation against WST-XXXNGX-D3 results. The highest power output of WST-XXXNGX-D3 is 435W.

Indicator	Unit	WST-XXXNGX-D3 Variation
GWP-total	kg CO_2 eq.	-1.15%
GWP-Fossil	kg CO_2 eq.	-1.15%
GWP-Biogenic	kg CO_2 eq.	-1.15%
CWP-LULUC	kg CO_2 eq.	-1.15%
ODP	kg CFC11 eq.	-1.17%
AP	mol H^+ eq.	-1.13%
EP-freshwater	kg P eq.	-1.15%
EP-marine	kg N eq.	-1.14%
EP-terrestrial	mol N eq.	-1.14%
POCP	kg NMVOC eq.	-1.15%
ADP-M&M*	kg Sb eq.	-1.15%
ADP-fossils*	MJ	-1.16%
WDP*	m^3	-1.15%
PM	disease inc.	-1.15%
IRP	kBq U-235 eq	-1.11%
ETP-fw	CTUe	-1.16%
HTP-c	CTUh	-1.15%
HTP-nc	CTUh	-1.15%
SQP	Pt	-1.20%

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

Indicator	Unit	WST-XXXNGX-D3 Variation
GWP-GHG[1]	kg CO_2 eq.	-1.15%

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

Indicator	Unit	WST-XXXNGX-D3 Variation
RPEE	MJ	-1.15%
RPEM	MJ	-1.16%

Indicator	Unit	WST-XXXNGX-D3 Variation
TPE	MJ	-1.15%
NRPE	MJ	-1.17%
NRPM	MJ	-1.16%
TRPE	MJ	-1.17%
SM	kg	0.00%
RSF	MJ	0.00%
NRSF	MJ	0.00%
W	m^3	-1.16%

Indicator	Unit	WST-XXXNGX-D3 Variation
HW	kg	-1.17%
NHW	kg	-1.36%
RW	kg	-1.11%
CR	kg	0.00%
MR	kg	0.00%
MER	kg	0.00%
EEE	MJ	0.00%
ETE	MJ	0.00%

Hazardous substances

The declaration is based upon reference to threshold values and/or test results and/or material safety data sheets provided to EPD verifiers. Documentation available upon request to EPD owner.

Information related to Sector EPD

This EPD is not sectorial.

Differences versus previous versions

This EPD is the first version.

References

1. General Programme Instructions of the International EPD® System. Version 4.0.
2. General Programme Instructions of the International EPD® System. Version 5.0.0.
3. PCR 2019:14 Construction Products, Version 1.3.4
4. c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway 2022-04-27)
5. EN 15804:2012+A2:2019/AC:2021 Sustainability of construction works - Environmental product declarations Core rules for the product category of construction products
6. LCA report of Photovoltaic Modules for Environmental Product Declaration_WIN WIN (Version 3.0)
7. ISO 14020:2022 Environmental statements and programmes for products: Principles and general requirements
8. ISO 14025:2011 Environmental labels and declarations - Type III environmental declarations - Principles and procedures
9. ISO 14040: 2006/Amd 1:2020 Environmental management - Life cycle assessment - Principles and framework Amendment 1 (ISO 2020)
10. ISO 14044: 2006/Amd 2:2020 Environmental management - Life cycle assessment - Requirements and guidelines Amendment 2 (ISO 2020)
11. WEEE Directive 2012/19/EU Article 4,11&15
12. 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.
13. SimaPro 9.5, LCA software
14. Ecoinvent Database 3.9
15. Glass Recycling – Life Cycle Carbon Dioxide Emissions, Final Report, February 2004