

Environmental Product Declaration



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

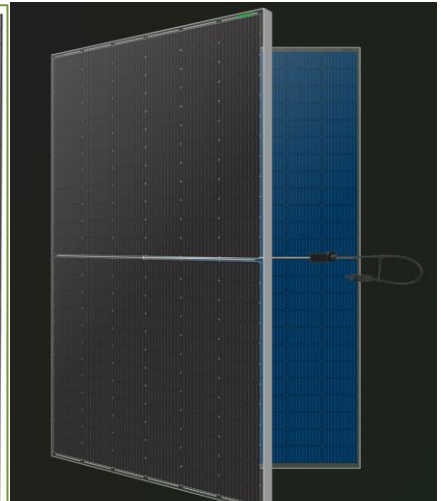
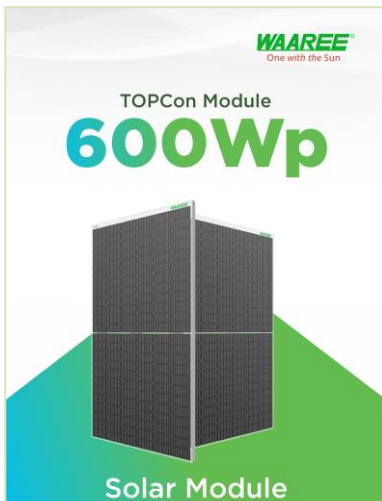
BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module



from
Waaree Energies Limited

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
Licensee:	EPD India
EPD registration number:	EPD-IES-0016932
Version date:	2024-12-09
Validity date:	2029-12-08

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



This EPD follows additional requirements for construction products considered as Electronic or Electric Equipment.

General information

Programme information

Programme:	The International EPD® System	Licensee: EPD India
Address:	EPD International AB Box 210 60 SE-100 31 Stockholm Sweden	EPD India, a licensee of the International EPD® System 422, Midas, Sahar Plaza Mumbai, India- 400059
Website:	www.environdec.com	www.environdecindia.com
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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 2019:14 Construction products, version 1.3.3 NPCR 029 Version 1.2, Photovoltaic modules and parts thereof (adopted from EPD Norway)
PCR review was conducted by: The Technical Committee of the International EPD® System. See https://www.environdec.com/about-us/the-international-epd-system-about-the-system for a list of members.
Life Cycle Assessment (LCA)
LCA accountability: Waaree Energies Limited
LCA and EPD developer: Dr. Rajesh Kumar Singh Thinkstep Sustainability Solutions Pvt. Ltd., a Sphera Company
Third-party verification
Independent third-party verification of the declaration and data, according to ISO 14025:2006, via: <input checked="" type="checkbox"/> EPD verification by individual verifier Third party verifier: Dr. Hüdai Kara, Metsims Sustainability Consulting, 4 Clear Water Place, Oxford OX2 7NL, UK Email: hudai.kara@metsims.com Approved by: The International EPD® System
Procedure for follow-up of data during EPD validity involves third party verifier: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but registered in different EPD programmes, 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 characterization 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: Waaree Energies Limited

Contact: Dr. Amit Paithankar

Description of the organization:

Waaree Energies Limited is a flagship company of Waaree Group.

We have a State-of-the-art 500 MW module manufacture plant at SEZ –Surat and 1.1 GW at Tumb, 1.2 GW at Nandigram, Chikhli- 9.7 GW in the state of Gujarat and 1.2 GW at Noida in the state of Uttar Pradesh, India enabling us to deliver high quality affordable solar products to our customers. Our highly automated production facilities offer mono crystalline, poly crystalline, Bifacial PERC and N type Topcon PV Modules, HJT Modules & Flexible Modules ranging from 3Wp to 715Wp for various on-grid and off-grid applications across India and exported globally, Including highly automated production facilities bifacial Mono PERC cell and bifacial N-Type TOPCON cell.

Product-related or management system-related certifications:

Waaree Energies Limited is ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 certified company. IEC 61215-1:2021, IEC 61215-1-1:2021, IEC 61215-2:2021, IEC 61730-2:2023, IEC 61730-1:2023, UL 61730-1, UL 61730-2, IS 14286 : 2010/ IEC 61215 : 2005, IS/IEC 61730 (PART 1) : 2004 & IS/IEC 61730 (PART 2) : 2004, Sand & Dust - IEC 60068-2-68, Salt Mist- IEC 61701, Ammonia Corrosion- IEC 62716, Transportation- IEC 62759, PAN File- LID- IEC 61853, PID- IEC 62804, LeTID, CEC Testing-IEC 61215, CNL, RoHS, PV life cycle, PVEL RETC.

Name and location of production site(s):

Survey No. 1934, Village Degam, Tal. Chikhli, Dist. Navsari 396530, Gujarat, India.



Product information

Product name: BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon (Tunnel oxide passivated contact) Module

Product identification: Framed dual glass bifacial solar PV module N Type TOPCon

Product description: N-type Monocrystalline silicon with TOPCon technology Solar Module containing 144 half-cut cells. These modules can be used in residential, commercial, and industrial buildings for electricity generation for various applications They are also ideal for off-grid applications, utility-scale projects, transportation, public infrastructure, and specialized uses like floating solar also.

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

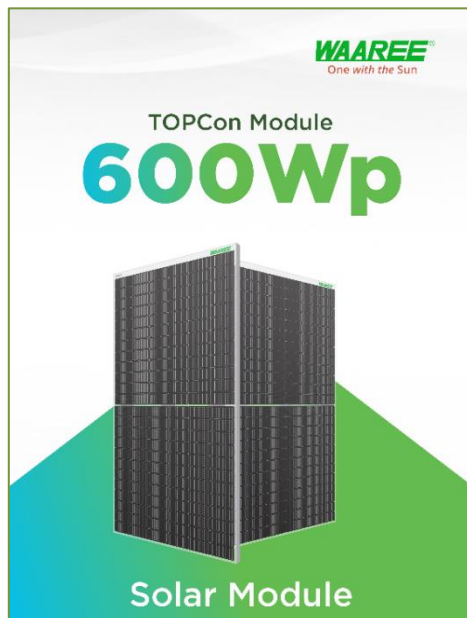
Geographical scope: The product is manufactured in India while the use and end of life of product is global.

The technical specifications of the product are mentioned below:

Features	Description
1. General Information:	
Type	N-type TOPCon Monocrystalline Solar Module
Power Output (P_{max})	600 Wp
Cell Technology	N-type Monocrystalline silicon with TOPCon Technology
Cell Configuration	144 half-cut cells
2. Electrical Characteristics:	
Maximum Power Voltage (V_{mp})	44.61 V
Maximum Power Current (I_{mp})	13.45 A
Open Circuit Voltage (V_{oc})	53.30 V
Short Circuit Current (I_{sc})	14.17 A
Module Efficiency (%)	23.23 %
3. Mechanical Characteristics:	
Dimensions	2278 mm (L) x 1134 mm (W) x 33 mm (T)
Weight	32.5 kgs
Solar Cells per Module (Units) / Arrangement	144 cells / (12x6 12x6)
Solar Cell Type & Size	M10/M10R N-type TOPCon Bifacial
Front (Material / Thickness)	2 mm Low Iron HTAR semi-tempered glass
Back Glass (Material / Thickness)	2 mm Low Iron Printed semi-tempered glass
Encapsulate	PID Free & UV Resistant
Junction Box (Protection degree / Material)	IP68 / Weatherproof PPO
Cable & Connector (Protection degree / Type)	IP68 rated / MC4 compatible
Cable cross - section & length	4 mm ² & 500mm
Frame	Anodized Aluminium Alloy
4. Temperature Characteristics:	
Temperature coefficient of Current (I_{sc}), α (%/°C)	0.046

Temperature coefficient of Voltage (V_{oc}), β (%/°C)	-0.26
Temperature coefficient of Power (P_m), γ (%/°C)	-0.30
NOCT (°C)	43±2
Operating temperature range (°C)	-40 to 85
Bifaciality Factor (%)	80±10

Manufacturing process:



LCA information

Declared unit: 1 Wp of manufactured BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module. The conversion factor to convert the results to the functional unit to 1 m² is 230.6 Wp/m²

Reference service life: 30 Years

During the first year, solar panel will exhibit a power output no less than 98% of the peak power under STC at the end of first year. The measurement shall be in accordance with IEC 60904 & measurement system uncertainty shall be included in all actual power measurements.

From 2nd to 30th year, the power output will decline annually by no more than 0.55% of the peak power under the STC. So, at the end of 30 (Thirty) years, at least 82.05% of peak power at STC can be achieved from the Warranty Start Date.

Time representativeness: The collection of foreground data refers to April 2024- March 2025.

Database(s) and LCA software used:

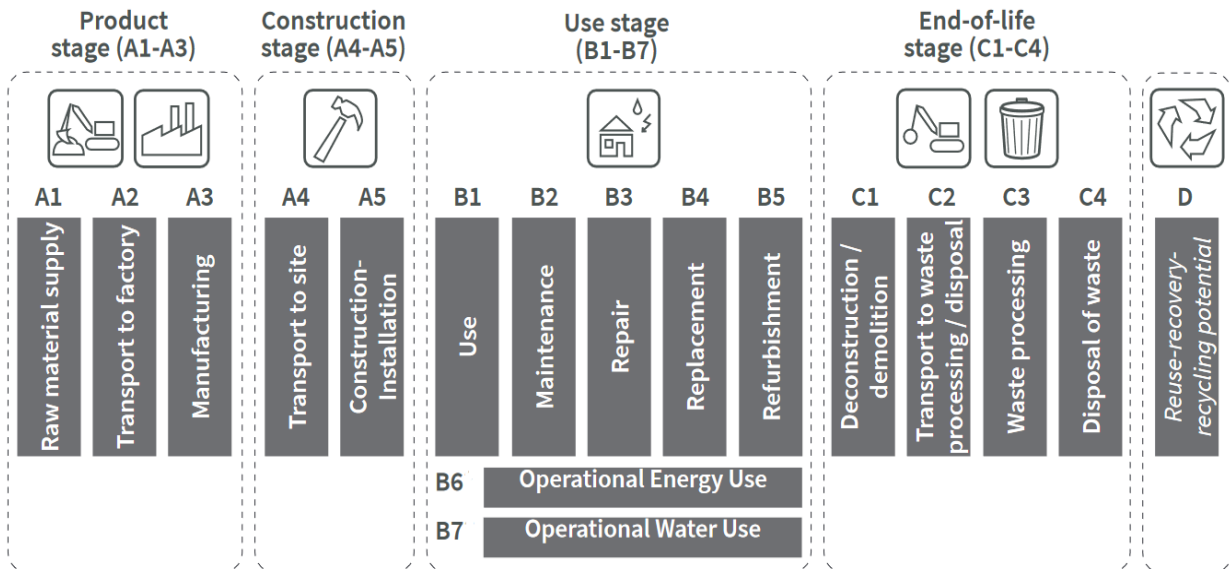
The background data has been taken from the latest available Sphera Managed LCA Content 2024.1

Description of system boundaries:

It includes cradle to grave.

Reference package used:

EN 15804 reference package based on EF 3.1.



- **Module A1 to A3:**

The product stage includes provision of all materials (Solar cell, glass, module ribbon, EVA/EPE, Busbar), product and energy, as well as waste processing up to the end waste stage or disposal of final residues during the product stage. The electricity for the manufacturing process has been sourced from grid. The composition considered in the electricity grid mix data set is lignite - 11.65%, hard coal - 62.18%, natural gas - 4.63%, hydro - 9.25%, wind - 3.33%. The GHG-GWP impact for electricity used for manufacturing is 1.01 kg CO₂ eq./kWh.

- **Module A4:**

The transportation stage includes the distance of transport of the manufactured photovoltaic module to the domestic as well as majorly US market and European market.

Type	Capacity utilization	Type of vehicle	Distance (km)	Fuel energy consumption per tkm (litres)
Truck	70%	IN: Bharat stage IV, 26 - 28t gross weight / 18.4t payload capacity Sphera	58	0.0314
Ship	55%	GLO: Container ship, 5,000 to 200,000 dwt payload capacity, deep sea Sphera	17726	0.00277

- *Module A5:*

The installation stage includes the treatment of packaging and the installation of photovoltaic modules using concrete, water, metal sections, and the use of thermal energy. The plastic packaging is landfilled while the wood, plastic and cardboard are incinerated.

- *Module B1:*

The use phase has no material and energy input or emissions at this stage on the site.

- *Module B2:*

The module B2 includes the maintenance of product by the use of 3.28E-11 kg lubricating oil and 3.28E-11 kg water for per kWh

- *Module B3:*

The repair of the PV module during the operation phase is not required under normal circumstances.

- *Module B4:*

The replacement of the PV module in its described RSL is not required under normal circumstances.

- *Module B5:*

The PV module does not require refurbishment during its operational phase

- *Module B6:*

The operational energy consumed is considered to be zero.

- *Module B7:*

The operational water use is not required for PV module.

Calculation for energy production

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 total produced electricity must be calculated based on site specific details.

Energy production in the first year of operation:

$$E1 = Srad * A * y * PR * (1 - deg)$$

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

Srad = 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), m² (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).

STC: The ratio is given for standard test conditions: irradiance 1000 W/m², cell temperature 25 °C, wind speed 1 m/s, AM1.5.

PR = Performance ratio, coefficient for losses. Site specific performance ratio can be modelled with PV simulation software tools, such as PVSyst or similar.

- Inverter losses
- Temperature losses
- DC cables losses
- AC cables losses
- Shadings
- Losses at weak radiation
- Losses due to dust, snow
- Other Losses

deg = yearly degradation rate (stated in the EPD).

Degradation

If no data is available, a default linear degradation rate of 0.007 (0.7 %) per year shall be applied. Product specific degradation rate may be used if based on evidence (third-party validated report like DNV or other similar third-party validated documentation/certificates).

The nameplate capacity of the PV module, as printed in the data sheet, shall be used as the starting point of the degradation curve. If uncertainties on performance measurements are factored in the performance tolerance provided on the data sheet, e.g. +2.5 % / -0 %, the nameplate capacity without calculating uncertainties shall be used.

Energy production second year of operation:

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

Energy production n year of operation:

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

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

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

RSL = Reference service life for energy-producing unit, from functional unit (FU), stated in the EPD
n = year of operation

- *Module C1 to C4:*

Within this EPD, the modules C1-C4 are included. These modules consider the transportation of the dismantled components to their End of Life (EoL) destination (C2), the waste processing for recovery or recycling (C3) as well as the disposal (C4). The EoL of the entire product is done considering the nature of raw materials (recycling of metal and glass).

- *Module D:*

Module D includes all the declared benefits and loads from net flows leaving the product system that hasnot been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

The credits from packaging (incineration of cardboard and wooden pallets) have been considered in module D. Also, all the benefits from metal recycling (material credits) and energy and thermal benefits from particle board incineration have been added to module D.

Data quality assessment and declaration:

Process	Source type	Source	Reference year	Data category	Share of primary data, of GWP-GHG results for A1-A3
Manufacturing of Product	Collected data	EPD owner	2024-2025	Primary data	0.004%
Generation of electricity used in manufacturing	Database	Sphera MLC 2024.1	2023	Primary data	1.67%
Transport of raw materials to the manufacturing site	Database	Sphera MLC 2024.1	2022	Primary data	1.54%
Total share of primary data, of GWP-GHG results for A1-A3					3.22%

Note: The share of primary data is calculated based on GWP-GHG results. It is a simplified indicator for data quality that does not capture all relevant aspects of data quality. The indicator is not comparable across product categories

Cut-off criteria:

The environmental impact of the product studied has been assessed by considering all significant processes, materials, and emissions. Excluded flows are assumed to have a negligible impact, contributing less than 5% to the cumulative impact assessment categories. The production of capital equipment, facilities, and infrastructure required for manufacture has not been considered.

Data quality and sources:

Data quality is compliant with ISO 14025:2006. All primary data were collected for the year 2024-25. All background data come from the Sphera Managed LCA Content 2024.1 databases

Allocation:

This study employs economic allocation to address the production of the main product and its co-products. This method assigns environmental impacts based on the relative market value of the main product (Waaree Energies Limited) and its co-products. The flow of materials and energy and the associated release of substances and energy into the environment is related exclusively to the Waaree model produced. Any allocation performed in the background processes is according to the PCR.

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

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage	
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential	
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	
Modules declared	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Geography	IN			GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	GLO	
Specific data used	3.22%			-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Variation – products	0%			-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Variation – sites	0%			-	-	-	-	-	-	-	-	-	-	-	-	-	-	

NR- Not reported. MNR- Module not declared.

Content information (1 PV Module; 230.6 Wp/m²)

Product components	Weight, kg	Post-consumer material, weight-%	Biogenic material, weight-%	Biogenic material, kg C/kg
Solar cell	0.8	0	0	0
Front Glass	12.8	0	0	0
Back Glass	12.7	0	0	0
EVA/EPE	2.7	0	0	0
Ribbon	0.14	0	0	0
Busbar	0.056	0	0	0
RTV	0.36	0	0	0
Potting	0.029	0	0	0
Aluminium Frame	2.8	0	0	0
Junction box	0.15	0	0	0
TOTAL	32.53	0	0	0

Packaging materials	Weight, kg	Weight-% (versus the product)	Weight biogenic carbon, kg C/kg
Plastic	0.175	0.54%	0
Corrugated board	0.548	1.68%	0.236
Wooden pallets	1.129	3.47%	0.485
Paper	0.008	0.02%	0.003
TOTAL	1.85	5.69%	0.725

Products do not contain any substances that can be included in “Candidate List of Substances of Very High Concern for Authorization” and raw materials used are not part of the EU REACH regulation.

Results of the environmental performance indicators

The environmental performance of the functional unit of 1 Wp reported below using the parameters and units as specified in PCR 2019:14 v1.3.3.

The estimated impact results are only relative statements, which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins and/or risks. The scenarios included are currently in use and are representative of one of the most probable alternatives.

Mandatory impact category indicators according to EN 15804+A2:2019

Environmental Impacts for 1 Wp of BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module																
Impact indicators	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP-fossil	kg CO ₂ eq.	3.72E-01	6.34E-03	9.17E-02	0.00E+00	2.53E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-02	0.00E+00	2.54E-03	-9.22E-02
GWP-biogenic	kg CO ₂ eq.	-4.38E-03	0.00E+00	4.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GWP-luluc	kg CO ₂ eq.	3.09E-04	1.40E-07	3.70E-06	0.00E+00	1.34E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E-07	0.00E+00	1.52E-05	-2.43E-05
GWP-total	kg CO ₂ eq.	3.68E-01	6.34E-03	9.61E-02	0.00E+00	2.53E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-02	0.00E+00	2.56E-03	-9.23E-02
ODP	kg CFC-11 eq.	1.33E-12	1.21E-16	2.51E-14	0.00E+00	1.76E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-16	0.00E+00	6.86E-15	-2.32E-13
AP	Mole of H ⁺ eq.	2.65E-03	1.13E-04	6.97E-04	0.00E+00	6.43E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-04	0.00E+00	1.80E-05	-5.09E-04
EP-freshwater	kg P eq.	1.24E-06	6.48E-10	8.71E-09	0.00E+00	4.51E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-09	0.00E+00	5.78E-09	-7.10E-08
EP-marine	kg N eq.	3.96E-04	4.79E-05	3.50E-04	0.00E+00	1.02E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.09E-05	0.00E+00	4.64E-06	-9.35E-05
EP-terrestrial	Mole of N eq.	4.36E-03	5.25E-04	3.83E-03	0.00E+00	1.14E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.86E-04	0.00E+00	5.11E-05	-1.09E-03
POCP	kg NMVOC eq.	1.21E-03	1.31E-04	9.50E-04	0.00E+00	5.49E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-04	0.00E+00	1.42E-05	-2.53E-04
ADP-minerals & metals*	kg Sb eq.	4.36E-06	7.19E-11	-7.00E-08	0.00E+00	5.69E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-10	0.00E+00	1.66E-10	-1.23E-06
ADP-fossil*	MJ	4.47E+00	7.98E-02	2.99E-01	0.00E+00	6.25E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-01	0.00E+00	3.36E-02	-9.84E-01

WDP	m³ world equiv.	7.07E-02	6.90E-06	7.11E-03	0.00E+00	5.67E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-05	0.00E+00	2.90E-04	-9.19E-03
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-land use = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption															

Additional mandatory and voluntary impact category indicators

Indicator	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP-GHG	kg CO ₂ eq.	3.72E-01	6.30E-03	9.20E-02	0.00E+00	2.50E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02	0.00E+00	2.54E-03	-9.20E-02

*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. We discourage the use of the results of modules A1-A3 without considering the results of module C.

Resource use indicators according to EN 15804+A2:2019

Resource Use for 1 Wp of BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module																
Impact indicators	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PERE	MJ	1.02E+00	9.86E-05	6.31E-02	0.00E+00	1.30E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-04	0.00E+00	5.85E-03	-3.56E-01
PERM	MJ	5.05E-02	0.00E+00	-5.05E-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	1.07E+00	9.86E-05	1.25E-02	0.00E+00	1.30E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-04	0.00E+00	5.85E-03	-3.56E-01
PENRE	MJ	4.45E+00	7.98E-02	3.10E-01	0.00E+00	6.25E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-01	0.00E+00	3.36E-02	-9.84E-01
PENRM	MJ	1.16E-02	0.00E+00	-1.16E-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
PENRT	MJ	4.47E+00	7.98E-02	2.99E-01	0.00E+00	6.25E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-01	0.00E+00	3.36E-02	-9.84E-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	2.07E-03	2.19E-07	1.85E-04	0.00E+00	1.80E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E-07	0.00E+00	8.87E-06	-3.40E-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															

Output flows & Waste Indicators according to EN 15804+A2:2019

Waste Flow for 1 Wp of BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module																
Impact indicators	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	kg	2.82E-09	1.02E-12	-1.00E-09	0.00E+00	8.79E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-12	0.00E+00	8.37E-12	-2.27E-10
NHWD	kg	3.11E-02	1.23E-06	1.29E-02	0.00E+00	1.41E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-06	0.00E+00	1.70E-01	-2.58E-02
RWD	kg	8.38E-05	1.02E-08	8.16E-09	0.00E+00	1.08E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-08	0.00E+00	3.53E-07	-3.54E-05
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	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
MER	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Acronyms	HWD = Hazardous waste disposed, NHWD = Non-hazardous waste disposed, RWD = Radioactive waste disposed, CRU = Components for re-use, MFR = Materials for Recycling, MER = Materials Energy for Recovery, EEE = Exported electrical energy, EET = Exported thermal energy.															

Additional environmental performance indicators according to EN 15804+A2:2019

Additional Environmental Impacts for 1 Wp BiN-08-(565-600 Wp) Glass to Glass Bifacial TOPCon Module																
Impact indicators	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Particulate matter	Disease incidences	3.66E-08	2.97E-09	7.67E-09	0.00E+00	5.99E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.03E-09	0.00E+00	2.26E-10	-5.88E-09
Ionising radiation, human health	kBq U235 eq.	8.92E-03	9.22E-07	3.77E-04	0.00E+00	9.80E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-06	0.00E+00	4.08E-05	-4.63E-03
Ecotoxicity, freshwater	CTUe	2.68E+00	3.59E-02	4.79E-02	0.00E+00	2.96E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	0.00E+00	1.93E-02	1.21E+00
Human toxicity, cancer	CTUh	7.70E-10	5.64E-13	3.30E-11	0.00E+00	5.01E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.43E-13	0.00E+00	4.56E-13	-6.31E-11
Human toxicity, non-cancer	CTUh	5.15E-08	1.20E-11	1.89E-10	0.00E+00	1.15E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.01E-11	0.00E+00	1.76E-11	-7.77E-10
Land Use	Pt	1.65E+00	9.79E-05	1.43E-02	0.00E+00	1.17E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-04	0.00E+00	9.20E-03	-3.95E-01

References

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- PCR 2019:14. Construction Products, Version 1.3.3 (Valid until: 2024-12-20)
- NPCR 029 Version 1.2, Photovoltaic modules and parts thereof (adopted from EPD Norway)
- Sustainability of construction works - Environmental product declarations - Methodology for selection and use of generic data; CEN/TR 15941:2010
- EN 15804: EN 15804:2012+A2:2019: Sustainability of construction works -EnvironmentalProduct Declarations - Core rules for the product category of construction products.
- EN ISO 14025: EN ISO 14025:2011-10 Environmental labels and declarations - Type III environmental declarations - Principles and procedures
- EN ISO 14040: EN ISO 14040:2009-11 Environmental management - Life cycle assessment - Principles and framework
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- LCA FE: LCA FE Software System and Database for Life Cycle Engineering, Sphera Solution Inc, 2024. (<https://sphera.com/solutions/product-stewardship/life-cycle-assessment-software-and-data/managed-lca-content/>)

