Evironmental Product Declaration

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

[*Photovoltaic modules of NEG9R.25, NEG9R.28 and NEG9RC.27*]

from

[*Trina Solar Co. Ltd.*]

Programme:	The International EPD® System, www.environdec.com
Programme operator:	EPD International AB
EPD registration number:	EPD-IES-0015109
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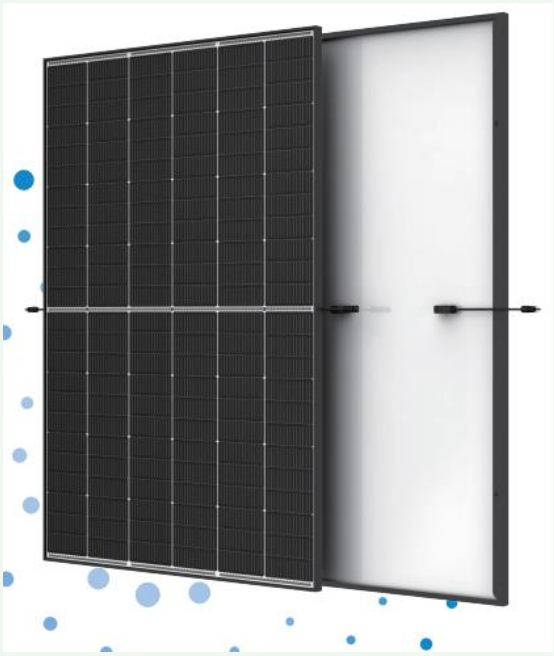
An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

***Statement**: EPD of multiple products, based on a representative product. The products covered are: NEG9R.25, NEG9R.28, and NEG9RC.27.*



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): Product Category Rules (PCR): *PCR 2019:14 PCR Construction products v1.3.3 issue data 2024-03-01 valid until 2024-12-20* *c-PCR-016 Photovoltaic modules and parts thereof (adopted from EPD Norway NPCR 029 Part B Part B for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials, version 1.2, issue data 2022-03-31)*
PCR review was conducted by: <*Technical Committee of the International EPD® System. A full list of members available on www.environdec.com. The review panel may be contacted via info@environdec.com* *Chair of the PCR review: No appointed chair*
Life Cycle Assessment (LCA)
LCA accountability: <*Freddey Land, Independent LCA Practitioner*>
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: <*Jiang Zhu, TÜV Rheinland (China) Ltd.* > Approved by: The International EPD® System
OR
Independent third-party verification of the declaration and data, according to ISO 14025:2006, via: ☐ EPD verification by accredited certification body Third-party verification: <*name, organisation*> is an approved certification body accountable for the third-party verification The certification body is accredited by: <*name of accreditation body & accreditation number, where applicable*>
OR

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

☐ EPD verification by EPD Process Certification*

Internal auditor: *<name, organisation>*

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

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

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

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

☐ Yes ☒ No

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

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

EPDs within the same product category but registered in different EPD programmes, or not compliant with EN 15804, may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison. For further information about comparability, see EN 15804 and ISO 14025.

Company information

Owner of the EPD:
Trina Solar Co. Ltd.
Website: https://www.trinasolar.com/cn

Contact:
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Description of the organisation:

Founded in 1997, Trina Solar Co., Ltd. is mainly engaged in PV products, PV systems and smart energy. PV products include R&D, production and sales of PV modules. PV systems consist of power stations and system products. Smart energy mainly comprises PV power generation and operation & maintenance, smart solutions for energy storage, smart microgrid, and development and sales of multi-energy systems. With the strategic goal of “Creating a new industrial ecosystem led by Trina Solar, and promoting Trina Solar as a leader in smart PV and energy storage solutions ", we are committed to leading the way in smart PV and energy storage solutions and facilitating the transformation of new power systems for a net-zero future.

With innovation-driven development as its most important strategy and core driving force, Trina Solar has put in place a comprehensive and leading science and innovation system. So far, Trina Solar’s SKL has set or broken 25 world records in terms of PV cell conversion efficiency and module output power. By the end of 2023, its cumulative shipments of PV modules had exceeded 190GW.

Going forward, all the employees of Trina Solar will be guided by the Company’s core values: “Focus on the Customers, Persist in Open Innovation, Persevere through Dedication and Hard Work, Strive for Excellence, Share the Responsibility, Create and Share Value together.” By fulfilling its mission of “Solar Energy for All”, Trina Solar aims to bring together the strengths of all the stakeholders with a cooperative and open attitude to lead the development of the industry, and make contributions to global energy conservation, emission reduction and sustainable development

Product-related or management system-related certifications:
Product-related certifications: IEC61215, UL61730, IEC62716
Management system-related certifications: IS09001, IEC62941, ISO14001, IS045001, ISO50001

Name and location of production site(s):
No. 2, TianHe Road, Trina PV Industrial Park, Changzhou City, 213031 Jiangsu, P.R. China

Product information

Product name:
NEG9R.25
NEG9R.28
NEG9RC.27

Product identification:

Serious (brand name)	Technology	Minimum Power (W)	Maximum power (W)	**Applied power (W)**	Dimensions (mm^2)	Weight (kg) excluding packaging (kg)	Weight including packaging (kg)	Module efficiency	Cell number	First year degradation	Annual average degradation
NEG9R.25	Mono-crystalline	425	460	**440**	1762*1134	20.688	21.714	22.5%	144	1%	0.4%

Serious (brand name)	Technology	Minimum Power (W)	Maximum power (W)	**Applied power (W)**	Dimensions (mm^2)	Weight (kg) excluding packaging (kg)	Weight including packaging (kg)	Module efficiency	Cell number	First year degradation	Annual average degradation
NEG9R.28	Mono-crystalline	430	460	**445**	1762*1134	20.669	21.713	22.8%	144	1%	0.4%
NEG9RC.27	Mono-crystalline	415	460	**435**	1762*1134	20.670	21.714	22.3%	144	1%	0.4%

The degradation rate is based on the product specification from Trina Solar. No third-party certificate is available currently.

Product description:
These PV modules are dual glass monocrystalline silicon module. The module efficiency can reach as high as 22.3-22.7% thanks to the high density interconnect technology. Modules contain multi-busbar technology for better light trapping, lower series resistance, improved current collection and enhanced reliability. The production volume for the PV modules are:

Modules	Yield over 2023-02-28 to 2024-02-29	Unit	Relative share
NEG9R.25	70	PCS	0.001%
	0.031	KW	
NEG9R.28	2122556	PCS	45.271%
	937.51	KW	
NEG9RC.27	987991	PCS	21.073%
	428.64	KW	

The NEG9R.28 can be justified as the representative product based on its dominant position in terms of the production volume.

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

Geographical scope:
China for A1-A3, and Europe for A4, A5, B2, and C1-C4.

LCA information

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). Since no third-party report is available, a standard reference service life of 25 years for ⩾80% of the labelled power output is applied.

Table 1 The conversion factor to calculate per m^2 impact

PV modules	Cell dimension (m^2)	Applied nominal Watt (Wp)	Value (W/m^2)
NEG9R.25	1.93	440	228.0
NEG9R.28	1.93	445	230.6
NEG9RC.27	1.93	435	225.4

Reference service life:
25 years

Time representativeness:
Data collection period: 2023-02-28 to 2024-02-29
Steps were taken to ensure that the LCI data were reliable and representative. The data type used is clearly stated in the Inventory analysis, measured or calculated from primary sources or whether data are from the LCI databases. In this study, the data quality requirements were as follows:

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

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

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

Description of system boundaries:
The system boundary considered in this LCA study is “cradle to gate with options, modules C1-C4, module D with optional modules (A1-A3 + A4 +A5+ B2 + C + D)”.
A1-A3: Product stage (raw material acquisition, transport to manufacturing site and manufacturing)
A4: Transport to user site
A5: Installation
B2: Maintenance of product
C1-C4: End-of-life stage (deconstruction, transport, waste processing and disposal)
D: Reuse, recovery and/or recycling potentials

A1 Raw materials extraction
Raw materials extraction includes materials needed to produce ingot, wafer, cell and PV module. Ingot, wafer and cell can be regarded as the intermediate products along the PV module production line (See Table 6). The raw materials extraction for the four types Trina PV modules are similar. The PV cells are manufactured by Suqian Trina Solar Co. Ltd. The wafer is sourced from the Ecoinvent datasets “silicon production, single crystal, Czochralski process, photovoltaics RoW”.

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

A3 Module Assembly
For A3 stage, the electricity consumption mix is based on the electricity generation profile for the Jiangsu Province, which is the dedicated location of the manufacturing site of the module assembly. The details of the electricity mix is shown in Figure 1 below. Per the PCR, an grid loss of 3.07% in Jiangsu province is considered to convert the production mix to the consumption[1]. The electricity emission factor of GWP-GHG is 0.921kgCO_{2e}/kWh.

[1] 2023 China Electric Power Yearbook, ISBN 9787523001899

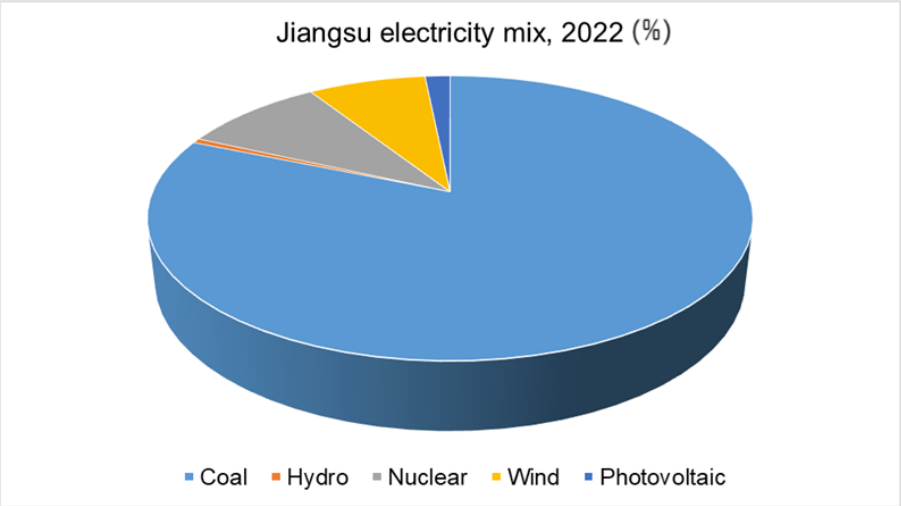


Figure 1 the electricity production mix for Jiangsu province at 2022

Table 2 Energy sources for the product manufacturing processes

	NEG9R.25	NEG9R.28	NEG9RC.27
Manufacturing site location	Changzhou, Jiangsu		
Underlying ecoinvent dataset	Electricity production in Jiangsu Province		
GWP-GHG (kg CO_2 eq. / kWh	0.921		

A4 Product distribution

The distribution scenario(A4) is based on the information provided by the suppliers. The product is firstly transported to the Shanghai Port at a distance of 230km by lorry. Then, the product is transported from Shanghai Port to Rotterdam Port by 19400km through the container ship. After than, the product is unloaded to the storage site by a distance of 300km. Finally, the distance between the storage site to the final consumers is assumed to be 500km for European domestic construction site according to the NPCR 029 Part B version 1.2.

A5 Installation

The packaging materials of the PV modules are mostly wooden pallet and paper, and are assumed to be recycled. The transport distance for the packaging materials to the recycling site is assumed to be 100km. The scaling method is clearly listed in Table 3. Other materials including the mounting system, cables, inverts are not considered based on the requirements listed in the NPCR 029 Part B version 1.2

Table 3 Energy inputs for PV module installation

Construction consumption process (per kWp capacity)		
Electricity	36.033 kWh electricity for 570kWp as in the Ecoinvent dataset (“Photovoltaic plant, 570kWp, multi-Si, on open ground {GLO}| photovoltaic plant construction, 570kWp, multi-Si, on open ground | Cut-off, U”)	0.06 kWh/kWp is applied
Diesel	7673MJ diesel for 570kWp as in the Ecoinvent dataset(“Photovoltaic plant, 570kWp, multi-Si, on open ground {GLO}| photovoltaic plant construction, 570kWp, multi-Si, on open ground | Cut-off, U”)	13.4MJ/kWp is applied

B1-B7 modules

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

B2-maintenance of product The only maintenance for PV panels is cleaning. It is assumed to be cleaned once per month with an application rate of 0.76L water per m2 PV panel.

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

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

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

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

Table 4 Power station information for simulation(Albacete is selected as the reference point)

Item	Value
Location	Albacete, Spain
Peak power of the plant	1MW
Latitude	38.758°N
Longitude:	3.1199°W
Altitude	700m
Nominal solar irradiance	1575 kWh/kWp/year

Energy production in the first year of operation:

$$E1 = S_{rad} * A * PR * y * (1- deg_1) \quad \text{----------} \quad (1)$$

E_1--- Energy produced in the first year of operation, kWh/year

S_{rad}---Site specific annual average solar radiation on module (shadings not included), kWh/kWp/year. The annual radiation must take into consideration the specific inclination (slope, tilt) and orientation.

A --- Area of module, 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).

PR--- Performance ratio, coefficient for losses. 86% in our case considering the default settings in the PVGIS software.

deg_1--- first year degradation rate, in our case 1% according to the product specification

Energy production n year of operation:

$$E_n = E_1 * (1-deg)^{n-1} \quad \text{----------} \quad (2)$$

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

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

Table 5 Total electricity generation over RSL

Serious (brand name)	Maximum power output range(W)	PR ratio	deg-first year	deg-after first year	E_1/kWh	E_{RSL}/kwh
NEG9R.25	440	86%	1%	0.4%	590.02	14063.72
NEG9R.28	445	86%	1%	0.4%	596.72	14223.54
NEG9RC.27	435	86%	1%	0.4%	583.32	13903.91

C1-C4 modules

De-construction (C1) of the PV plant during the disposal stage is assumed mainly consuming electricity, and the electricity consumption is assumed the same as the construction stage (A5), 50km transportation distance from plant site to waste treatment site (C2) is assumed to be 50km according to the NPCR 029 Part B version 1.2. For the C3 phase, Since there is lack of existing data of recycling rate for PV module, this study refers to legal requirements issued by Waste Electrical and Electronic

Equipment (WEEE). In 2012/19/EU-Article 11 & ANNEX V, the required collection rate for waste PV module is 85%. Therefore, 15% of waste PV module end up with waste disposal through landfill. A specific electricity 0.0556kWh/kg and 0.0324MJ/kg diesel consumption is referenced to dissemble and sort the collected PV modules. The final disposal scenario for C4 is based on the following Table 6.

Table 6 Waste treatment scenario for PV modules

PV components	Materials	Recycling	Landfill	Incineration
PV cells	Silicon	80%	20%	0%
	Silver bar line	90%	10%	0%
Solar glass	Glass	85%	15%	0%
PET	PET	0%	0%	100%
Aluminium Frame	Aluminium alloy	94%	6%	0%
Interconnection and busbar string	Copper	63%	37%	0%
	Pb	93%	7%	0%
	Tin	90%	10%	0%
Junction box	Bronze	63%	37%	0%
	Plastics	0%	0%	100%
Chemicals	Adhesive	0%	0%	100%
EVA	EVA	0%	0%	100%

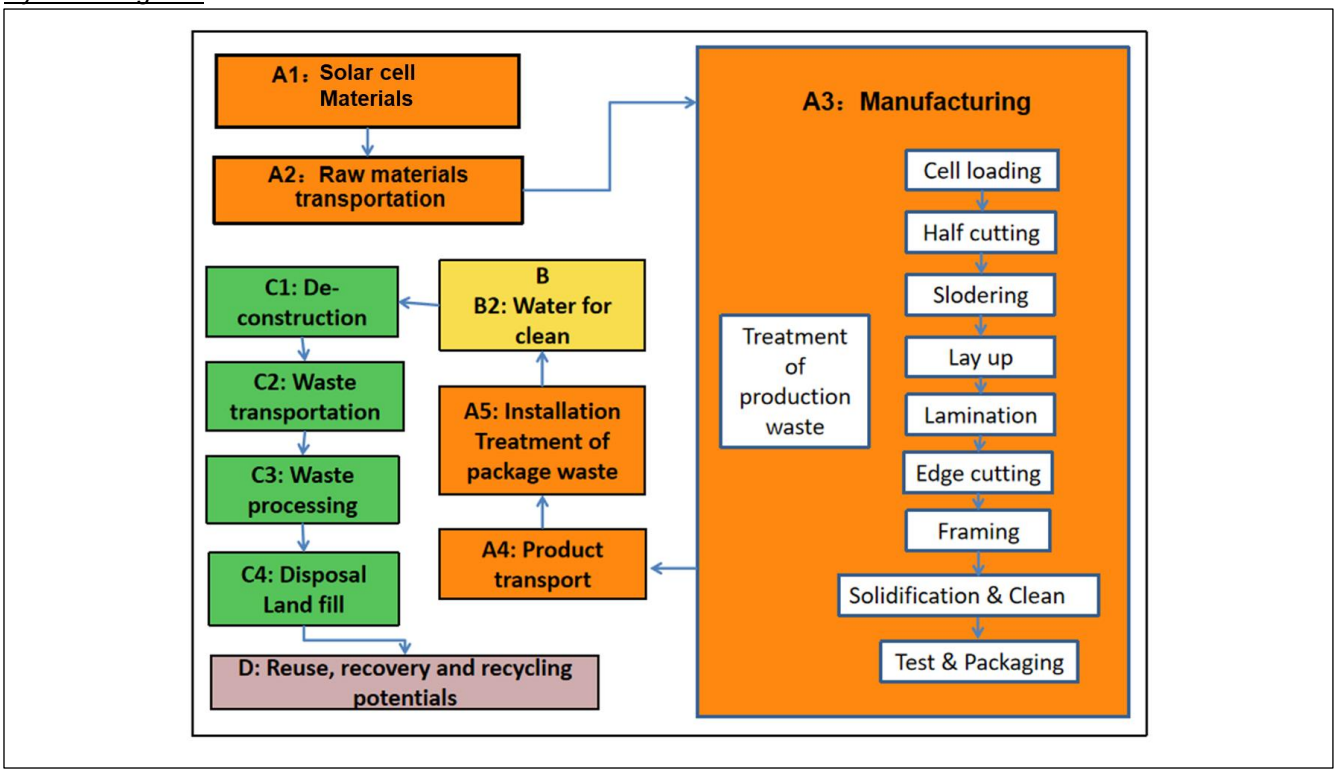
Module D

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

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

In this LCA study, no secondary material was used in the production stage, so the $M_{MR\ in}$ is zero. The Netflow is Aluminium, copper, silver scraps and metallurgical silicon and others recovered from the PV modules. Meanwhile, the incineration considers electricity and heat exports.

System diagram:



More information:

Cut-off criteria

no specific materials have been cut-off in this specific LCA. All materials provided by the manufacturer are properly modelled. However, The following steps/stages are not included in the system boundary for the reason that the elements below are considered irrelevant or can be omitted according to the PCR

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

Allocation

Since the four modules are produced from the same production line. Therefore, a multi-output allocation strategy is applied for the A3 phase to the specific PV modules. In this study, the parameter of “nominal power output” is referred as the allocation reference to partition the environmental impact for the PV modules.

The allocation strategy for the EoL process per PCR follows the same strategy listed in the EN15804. Thus, the “cut-off” strategy is applied. This scenario allocates the entire environmental impacts of waste treatment procedures (from deconstruction to the waste processing) to the producer. The recycled materials, on the other hand, are burden-free. An important note is that when materials have reached a so-called “end-of-waste” state, the coverage of the waste processing is thus terminated. Any inputs/flows related to refine gross recycled materials for actual applications are beyond the product system boundary and is accounted in Module D

Key assumptions

Categories	Items	Type	Assumptions
Transportation stage (A2, and A4)	Transportation vehicle type	Assumption	For transport without detailed information, EURO 5 type vehicle with 16-32 ton capacity is used
Installation stage (A5)	PV module and infrastructures	Assumption	No construction waste is considered Packaging materials for PV modules are assumed be transported at a distance 100km Energy consumption for the construction process is sourced from the Ecoinvent dataset “electric installation for 570kWp module, open ground{GLO}|market for photovoltaics, electric installation for 570kWp module, open ground”

Use & Maintenance	Use	Scenario according to NPCR 029 Part B version 1.2	The use stage requires no energy and materials inputs, and has no emissions.
	Cleaning maintenance	Scenario according to NPCR 029 Part B version 1.2	Water used for cleaning the PV panels is assumed 0.76L/m^2 for 12 times per year[2]
	Repair Replacement	Scenario according to Peer reviewed literature	No replacement for the module as the module has RSL>25 years. No operational water and energy are needed for PV module
End-of-life (C1-C4)	Inputs for de-installation	Assumption	The de-construction of PV plant is assumed to be consuming the same energy as the installation stage
	Waste transport distance	Scenario according to the NPCR 029 Part B version 1.2	Waste transportation distance from the de-installation plant to the waste treatment facilities is assumed to be 50 km according to the NPCR 029 Part B version 1.2
	Inputs for disassembly the PV modules	Scenario according to the Peer reviewed Literature	Report IEA-PVPS T12-19:2020 December 2020 [3] is referenced for the energy and diesel consumption to treat and dissemble the PV modules.
	Waste treatment scenarios for dissembled PV modules	Scenario according to the Peer reviewed Literature	The final waste treatment scenarios for different PV components (e.g. silicon cells, busbar, frame and etc.) are sourced from literature[4]
Module D	Exported energy	Assumption	For incineration with the energy recovery, net energy production: 3.93MJ/kg electric energy and 7.66MJ/kg thermal energy.[5]

2 Qing Yang, Tianyue Huang, Fuying Chen, Javier Uche, Yuxuan Wang, Peng Yuan, Yinya Zhang, Jianlan Li, Water saving potential for large-scale photovoltaic power generation in China: Based on life cycle assessment, Renewable and Sustainable Energy Reviews, Volume 167,2022, 112681

3 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.

4 Bošnjaković, M.; Santa, R.; Crnac, Z.; Bošnjaković, T. Environmental Impact of PV Power Systems. Sustainability 2023, 15, 11888. https://doi.org/10.3390/su151511888

5 https://ecoquery.ecoinvent.org/3.9.1/cutoff/dataset/12531/export

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

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
Module	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules declared	x	x	x	x	x	ND	x	ND	ND	ND	ND	ND	x	x	x	x	x
Geography	CN	CN	CN	CN	EUR		EUR						EUR	EUR	EUR	EUR	EUR
Specific data used	>90%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	<10%					-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	0%					-	-	-	-	-	-	-	-	-	-	-	-

Content information

According to the PCR, for EPD with multiple products, three options can be chosen. This EPD follows the approach for “representative product” scenario since the production volume of the four types of PV modules follows the exact same manufacturing process and supplied with a similar production volumes. The NEG9R.28 is used. Per the requirement of the PCR 2019:14 version 1.3.3, the content declaration is based on the weight of one unit of a product as purchased.

Product components	**Weight, kg**	**Min weight, kg**	**Max weight, kg**	**Post-consumer material, weight**	**Biogenic material, weight- and kg C/product**
Front glass	7.92E+00	7.92E+00	7.92E+00	0%	0
Back glass	7.92E+00	7.92E+00	7.92E+00	0%	0
EVA film	8.92E-01	8.92E-01	8.92E-01	0%	0
POE	8.49E-01	8.49E-01	8.49E-01	0%	0
silica gel	2.60E-01	2.60E-01	2.72E-01	0%	0
welding flux	1.98E-02	1.98E-02	3.67E-02	0%	0
Photovoltaic cell	5.95E-01	5.95E-01	5.95E-01	0%	0
Frame	1.92E+00	1.92E+00	1.92E+00	0%	0
Ribbon interconnection	1.35E-01	1.17E-01	1.35E-01	0%	0
Ribbon String	3.18E-02	3.18E-02	3.32E-02	0%	0
Junction box	1.15E-01	1.15E-01	1.15E-01	0%	0
TOTAL	2.07E+01	2.07E+01	2.07E+01	0%	0
Packaging materials	**Weight, kg**	**Min weight, kg**	**Max weight, kg**	**Weight- (versus the product)**	**Weight biogenic carbon, kg C/product**
Multi-layer plywood	6.82E-01	6.82E-01	6.82E-01	3.30%	3.22E-01
corrugated board	3.13E-01	3.13E-01	3.13E-01	1.51%	1.33E-01
PET	3.65E-02	3.65E-02	3.65E-02	0.18%	0
PP	2.22E-03	2.22E-03	2.22E-03	0.01%	0
PE	1.03E-02	1.03E-02	1.03E-02	0.05%	0
TOTAL	9.10E-01	9.10E-01	9.10E-01	5.05%	4.55E-01

No dangerous substances from the candidate list of SVHC for Authorisation

Results of the environmental performance indicators

Mandatory impact category indicators according to EN 15804

Results per functional unit										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	kg CO2 eq.	3.58E-01	1.57E-02	1.75E-03	1.20E-03	1.36E-03	4.38E-04	8.96E-04	1.33E-02	-3.55E-02
GWP-fossil	kg CO2 eq.	3.56E-01	1.57E-02	1.52E-03	1.20E-03	1.36E-03	4.37E-04	8.64E-04	1.33E-02	-3.42E-02
GWP-biogenic	kg CO2 eq.	1.56E-03	1.82E-06	2.31E-04	1.97E-06	1.17E-06	3.95E-07	2.99E-05	3.26E-06	-7.38E-04
GWP-luluc	kg CO2 eq.	4.87E-04	1.04E-05	2.08E-07	1.59E-06	2.07E-07	2.12E-07	1.98E-06	1.34E-07	-5.85E-04
ODP	kg CFC11 eq.	3.37E-07	2.65E-10	2.19E-11	2.34E-10	2.16E-11	9.52E-12	1.56E-11	1.11E-11	-9.65E-10
AP	mol H^+ eq.	2.23E-03	3.07E-04	1.25E-05	6.35E-06	1.25E-05	1.43E-06	4.69E-06	4.09E-06	-3.23E-04
EP-freshwater	kg P eq.	1.56E-04	7.76E-07	6.21E-08	4.34E-07	6.15E-08	3.06E-08	7.16E-07	3.69E-07	-2.38E-05
EP-marine	kg N eq.	4.13E-04	7.87E-05	5.92E-06	1.29E-06	5.75E-06	4.90E-07	1.17E-06	3.39E-05	-3.52E-05
EP-terrestial	mol N eq.	4.45E-03	8.67E-04	6.28E-05	1.32E-05	6.25E-05	5.18E-06	1.13E-05	2.05E-05	-3.56E-04
POCP	kg NMVOC eq.	1.31E-03	2.45E-04	1.86E-05	4.25E-06	1.85E-05	2.13E-06	3.52E-06	5.57E-06	-1.43E-04
ADP-minerals& metals	kg Sb eq.	1.73E-05	2.68E-08	5.24E-10	5.46E-09	5.10E-10	1.40E-09	1.56E-09	6.66E-10	-2.60E-06
ADP-fossil	MJ	4.32E+00	2.06E-01	1.80E-02	1.44E-02	1.80E-02	6.20E-03	1.86E-02	4.72E-03	-5.04E-01
WDP	m^3	2.59E-01	6.76E-04	4.40E-05	3.96E-02	4.28E-05	2.53E-05	1.82E-04	1.73E-04	-5.60E-03
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 of these results are high or as there is limited experience with the indicator.*

Additional mandatory and voluntary impact category indicators

Results per functional unit										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-GHG[6]	kg CO_2 eq.	3.68E-01	1.58E-02	1.75E-03	1.22E-03	1.36E-03	4.40E-04	9.44E-04	1.33E-02	-3.71E-02

Resource use indicators

[6] 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.

Results per functional unit										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	MJ	6.85E-01	2.07E-03	2.06E-04	1.37E-03	2.01E-04	9.62E-05	3.53E-03	1.28E-04	-2.15E-01
PERM	MJ	9.05E-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
PERT	MJ	6.94E-01	2.07E-03	2.06E-04	1.37E-03	2.01E-04	9.62E-05	3.53E-03	1.28E-04	-2.15E-01
PENRE	MJ	4.20E+00	2.06E-01	1.80E-02	1.44E-02	1.80E-02	6.20E-03	1.85E-02	4.72E-03	-5.04E-01
PENRM	MJ	1.16E-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	4.32E+00	2.06E-01	1.80E-02	1.44E-02	1.80E-02	6.20E-03	1.85E-02	4.72E-03	-5.04E-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
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	9.65E-03	2.28E-05	2.01E-06	9.24E-04	1.78E-06	8.83E-07	1.43E-05	9.70E-06	-1.43E-03

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

Results per functional unit										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste disposed	kg	2.90E-04	3.89E-06	2.56E-06	7.96E-07	1.69E-07	1.53E-07	5.79E-07	2.42E-04	-1.22E-05
Non-hazardous waste disposed	kg	4.68E-02	6.90E-03	1.08E-04	1.67E-04	2.64E-05	3.03E-04	4.91E-05	1.23E-02	-8.49E-03
Radioactive waste disposed	kg	6.79E-06	3.69E-08	5.58E-09	2.54E-08	5.50E-09	2.01E-09	1.25E-07	2.02E-09	-2.12E-06

Output flow indicators

Results per functional unit										
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	6.12E-04	0.00E+00	0.00E+00	0.00E+00	3.04E-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
Exported energy, electricity	MJ	0.00E+00	0.00E+00	1.84E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-02	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	3.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E-02	0.00E+00

Other environmental performance indicators

Results per functional unit										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PM	Disease incidence	2.44E-08	8.56E-10	3.46E-10	8.07E-11	3.45E-10	3.48E-11	4.56E-11	3.30E-11	-2.35E-09
IRP	kBq U235 eq.	2.76E-02	1.56E-04	2.25E-05	1.05E-04	2.22E-05	8.29E-06	4.84E-04	8.35E-06	-8.06E-03
ETP-fw	CTUe	3.75E+00	1.03E-01	9.10E-03	5.26E-03	8.42E-03	3.06E-03	2.98E-03	1.03E-01	-2.52E-01
ETP-c	CTUh	1.84E-10	6.85E-12	4.34E-13	2.84E-12	4.16E-13	1.99E-13	2.75E-13	1.02E-12	-1.17E-10
HTP-nc	CTUh	6.62E-09	9.74E-11	3.75E-12	4.01E-11	3.03E-12	4.37E-12	6.68E-12	1.70E-10	-2.61E-09
SQP	Dimensionless	1.08E+00	8.62E-02	1.31E-03	2.99E-03	1.26E-03	3.69E-03	2.83E-03	7.42E-03	-1.56E-01

Additional environmental information

Trina Solar Co. Ltd. and its PV module products obtain the following comprehensive products and organization certification.

For products:

IEC61215: Terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC61730: Photovoltaic (PV) module safety qualification
UL61730: Photovoltaic (PV) module safety qualification
IEC62716: Photovoltaic (PV) modules - Ammonia corrosion testing

For the organization management:

ISO 9001: Quality Management System
IEC 62941: Terrestrial photovoltaic (PV) modules - Quality system for PV module manufacturing

For EHS and energy management:

ISO14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System
ISO50001: Energy Management

Mandatory impact category indicators according to EN 15804 expressed by m^2

Results per m^2										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	kg CO2 eq.	8.25E+01	3.62E+00	4.03E-01	2.77E-01	3.14E-01	1.01E-01	2.07E-01	3.07E+00	-8.19E+00
GWP-fossil	kg CO2 eq.	8.21E+01	3.62E+00	3.50E-01	2.77E-01	3.14E-01	1.01E-01	1.99E-01	3.07E+00	-7.89E+00
GWP-biogenic	kg CO2 eq.	3.60E-01	4.20E-04	5.33E-02	4.54E-04	2.70E-04	9.11E-05	6.89E-03	7.52E-04	-1.70E-01
GWP-luluc	kg CO2 eq.	1.12E-01	2.40E-03	4.80E-05	3.67E-04	4.77E-05	4.89E-05	4.57E-04	3.09E-05	-1.35E-01
ODP	kg CFC11 eq.	7.77E-05	6.11E-08	5.05E-09	5.40E-08	4.98E-09	2.20E-09	3.60E-09	2.56E-09	-2.23E-07
AP	mol H^+ eq.	5.14E-01	7.08E-02	2.88E-03	1.46E-03	2.88E-03	3.30E-04	1.08E-03	9.43E-04	-7.45E-02
EP-freshwater	kg P eq.	3.60E-02	1.79E-04	1.43E-05	1.00E-04	1.42E-05	7.06E-06	1.65E-04	8.51E-05	-5.49E-03
EP-marine	kg N eq.	9.52E-02	1.81E-02	1.36E-03	2.97E-04	1.33E-03	1.13E-04	2.70E-04	7.82E-03	-8.12E-03
EP-terrestial	mol N eq.	1.03E+00	2.00E-01	1.45E-02	3.04E-03	1.44E-02	1.19E-03	2.61E-03	4.73E-03	-8.21E-02
POCP	kg NMVOC eq.	3.02E-01	5.65E-02	4.29E-03	9.80E-04	4.27E-03	4.91E-04	8.12E-04	1.28E-03	-3.30E-02
ADP-minerals&metals	kg Sb eq.	3.99E-03	6.18E-06	1.21E-07	1.26E-06	1.18E-07	3.23E-07	3.60E-07	1.54E-07	-5.99E-04
ADP-fossil	MJ	9.96E+02	4.75E+01	4.15E+00	3.32E+00	4.15E+00	1.43E+00	4.29E+00	1.09E+00	-1.16E+02
WDP	m^3	5.97E+01	1.56E-01	1.01E-02	9.13E+00	9.87E-03	5.83E-03	4.20E-02	3.99E-02	-1.29E+00
Acronyms		GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption								

Additional mandatory and voluntary impact category indicators expressed by m^2

Results per m^2										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-GHG[7]	kg CO_2 eq.	8.48E+01	3.64E+00	4.03E-01	2.81E-01	3.14E-01	1.01E-01	2.18E-01	3.07E+00	-8.55E+00

Resource use indicators

Results per m2										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PENRT	MJ	9.96E+02	4.75E+01	4.15E+00	3.32E+00	4.15E+00	1.43E+00	4.27E+00	1.09E+00	-1.16E+02
PENRE	MJ	9.68E+02	4.75E+01	4.15E+00	3.32E+00	4.15E+00	1.43E+00	4.27E+00	1.09E+00	-1.16E+02
PENRM	MJ	2.67E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.60E+02	4.77E-01	4.75E-02	3.16E-01	4.63E-02	2.22E-02	8.14E-01	2.95E-02	-4.96E+01
PERE	MJ	1.58E+02	4.77E-01	4.75E-02	3.16E-01	4.63E-02	2.22E-02	8.14E-01	2.95E-02	-4.96E+01
PERM	MJ	2.09E+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
SM	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.23E+00	5.26E-03	4.63E-04	2.13E-01	4.10E-04	2.04E-04	3.30E-03	2.24E-03	-3.30E-01

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

Results per m2										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste disposed	kg	6.69E-02	8.97E-04	5.90E-04	1.84E-04	3.90E-05	3.53E-05	1.34E-04	5.58E-02	-2.81E-03
Non-hazardous waste disposed	kg	1.08E+01	1.59E+00	2.49E-02	3.85E-02	6.09E-03	6.99E-02	1.13E-02	2.84E+00	-1.96E+00
Radioactive waste disposed	kg	1.57E-03	8.51E-06	1.29E-06	5.86E-06	1.27E-06	4.63E-07	2.88E-05	4.66E-07	-4.89E-04

Output flow indicators

Results per m2										
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	1.41E-01	0.00E+00	0.00E+00	0.00E+00	7.01E+00	0.00E+00	0.00E+00

[7] 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.

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
Exported energy, electricity	MJ	0.00E+00	0.00E+00	4.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	8.42E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E+00	0.00E+00

Other environmental performance indicators

Results per m2										
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PM	Disease incidence	5.63E-06	1.97E-07	7.98E-08	1.86E-08	7.95E-08	8.02E-09	1.05E-08	7.61E-09	-5.42E-07
IRP	kBq U235 eq.	6.36E+00	3.60E-02	5.19E-03	2.42E-02	5.12E-03	1.91E-03	1.12E-01	1.93E-03	-1.86E+00
ETP-fw	CTUe	8.65E+02	2.37E+01	2.10E+00	1.21E+00	1.94E+00	7.06E-01	6.87E-01	2.37E+01	-5.81E+01
ETP-c	CTUh	4.24E-08	1.58E-09	1.00E-10	6.55E-10	9.59E-11	4.59E-11	6.34E-11	2.35E-10	-2.70E-08
HTP-nc	CTUh	1.53E-06	2.25E-08	8.65E-10	9.25E-09	6.99E-10	1.01E-09	1.54E-09	3.92E-08	-6.02E-07
SQP	Dimensionless	2.49E+02	1.99E+01	3.02E-01	6.89E-01	2.91E-01	8.51E-01	6.53E-01	1.71E+00	-3.60E+01

Since the representative product NEG9R.28 have a range of output power in 430W to 460W. Thus, a correction factors are reported if the actual product is deviated from the baseline 490W applied.The correction factor is defined as the following formular. Since

$$impacts\ for\ other\ output\ power\ levels = correction\ factor * impacts\ values\ reported\ in\ the\ EPD$$

Output power	**430W**	**435W**	**440W**	**445W**	**450W**	**455W**	**460W**
Correction factor	103.49%	102.30%	101.14%	100.00%	98.89%	97.80%	96.74%

Additional social and economic information

None

Information related to Sector EPD

This EPD is not sectorial

Differences versus previous versions

This EPD is a new submission

References

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IEC 62716:2013 Photovoltaic (PV) modules - Ammonia corrosion testing

IEC 62941:2019 Terrestrial photovoltaic (PV) modules - Quality system for PV module manufacturing

ISO 9001:2015 Quality Management System

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