Trina Solar Co.,Ltd

ENVIRONMENTAL PRODUCT DECLARATION

PRODUCT NAME :

NEG19RC.20, DEG21C20, NEG21C.20

PLANTS:

No.2 Tian he Road Trina PV Industrial Park

Changzhou, Jiangsu, 213031 CN

in compliance with ISO 14025

Program Operator	UL
Publisher	EPDItaly

Declaration Number	4790852908.101.2
Registration Number	MR-EPDITALY0076

Issue Date Update Date	2023/11 /01 2024 / 01 / 16
Valid to	2028/11/01

Registered under the mutual recognition between EPDItaly and UL.
www.epditaly.it

Environmental Product Declaration

NEG19RC.20, DEG21C20, NEG21C.20

RELIABLE AND SMART SOLAR

Trinasolar

As a global leading provider for PV module and smart energy solution, Trina Solar delivers PV products, applications and services to promote global sustainable development.
Through constant innovation, Trina Solar continue to push the PV industry forward by creating greater grid parity of PV power and popularizing renewable energy. Their mission is to boost global renewable energy development around the world for the benefit of all of humanity.
Trina Solar has delivered more than 56 GW of solar modules worldwide, ranked "Top 500 private enterprises in China". In 2018, Trina Solar first launched the Energy IoT brand, and is now aiming to be the global leader of smart energy.

For more information visit：
https://www.trinasolar.com/cn

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

Environmental Product Declaration

Trinasolar

NEG19RC.20, DEG21C20, NEG21C.20
Photovoltaic Modules

According to ISO 14025, EN 15804, and ISO21930:2017

EPD Program and Program Operator Name, Address, Logo, and Website	UL Solutions 333 Pfingsten Rd, Northbrook, IL 60062 www.ul.com www.spot.ul.com
General Program Instructions and Version Number	Program Operator Rules v 2.7 2022
Manufacturer Name and Address	No.2 Tian he Road Trina PV Industrial Park Changzhou, Jiangsu, 213031CN
Declaration Number	4790852908.101.2
Declared Product & Functional Unit or Declared Unit	NEG19RC.20, DEG21C20, NEG21C.20 1 kWh of electricity generated as output from the solar photovoltaic plant
Reference PCR and Version Number	PCR EPDItaly014: Electricity Produced by Photovoltaic Modules.
Description of product application/use	Trina Solar mono-crystalline silicon PV modules are widely used to generate electricity on rooftop and ground solar farms.
Product RSL Description (if Appl.)	30 years
Markets of Applicability	Global
Date of Issue	November 1, 2023 (Data Update January 2024)
Period of Validity	5 Years
EPD Type	Product-specific
Range of Dataset Variability	N/A
EPD Scope	Cradle-to-grave
Year(s) of reported primary data	May 2022—June 2023
LCA Software & Version Number	SimaPro 9.5
LCI Database(s) & Version Number	Ecoinvent 3.9
LCIA Methodology & Version Number	EN 15804+A2:2019 (version 1.03) & TRACI V2.1

The PCR review was conducted by:	EPDItaly PCR Review Panel info@epditaly.it
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum Cooper McCollum, UL Solutions
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Ecovane Environmental Co,. Ltd
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

LIMITATIONS

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible”. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

Trinasolar

NEG19RC.20, DEG21C20, NEG21C.20
Photovoltaic Modules

According to ISO 14025, EN 15804 and ISO 21930:2017

1. Product Definition and Information

1.1. Description of Company/Organization

Founded in 1997, Trina Solar Co., Ltd. (hereinafter Trina Solar) is mainly engaged in the research and development, production and sales of PV modules; power stations and system products; PV power generation, operation and maintenance services; development and sales of intelligent microgrids and multi-energy systems, as well as the operation of energy cloud platforms, etc., committing to lead the way in smart solar energy solutions for a net-zero future. Through constant innovation, Trina Solar continues to push the PV industry forward by creating greater grid parity of PV power and popularizing renewable energy. 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 the April 11th, 2022, its cumulative shipments of PV modules had exceeded 100GW, which is close to the installed capacity of 4.4 Three Gorges Dam power stations and equivalent to planting 7.4 billion trees worldwide. In addition, Trina's downstream business includes solar PV project development, financing, design, construction, operations and management, and one-stop system integration solutions for customers. Trina Solar has connected over 5.5GW of solar power plants to the grid worldwide.

1.2. Product Description

Product Identification

Trina Solar produces more than a dozen series of mono-crystalline silicon PV modules. Trina Solar Vertex modules taking use of 210mm cells, featuring high power, high efficiency, high reliability, and high energy yield. Trina Solar applied high -quality equipment resources, mature process experience and industrialization advantages, combined the PERC, n-type, MBB module, half-cut module, double-sided double glass module etc. core technologies of cells and modules, advocated the establishment of "600W + product innovation and open ecological alliance" according to the development needs of the photovoltaic industry. It also improved the supply chain ecology of the photovoltaic industry and worked with the whole industry to move towards a new era of 210 high-efficiency modules. The power of high-efficiency module products covers 410W+, 430W+, 510W+, 555W, 580W+, 600W+, 670W and 690W Vertex 210 ultra-high-power modules on the market, applying in all settings from residential rooftops, industrial and commercial rooftops to large-scale power plants.

Figure 1: Trina Solar PV modules

Product Specification

Table 1: General information of the products

Series (brand name)	Power output range (W)	Dimensions(mm^3)	Weight(kg)	Module efficiency (%)	Degradation 1st year/rest years(%)
NEG19RC.20	580-605	2384*1134*30	33.7	22.4	1/0.4
DEG21C.20	645-665	2384*1303*33	38.3	21.4	2/0.45
NEG21C.20	670-695	2384*1303*33	38.3	22.4	1/0.4

1.3. Application

Trina Solar PV modules are widely used to generate electricity on rooftop and ground solar farms.

1.4. Declaration of Methodological Framework

The environmental impact results along with the resource consumption and waste generation results of Trina Solar PV modules presented in this report is based on a life cycle assessment (LCA) performed according to ISO 14040/44 standards. In addition, PCR EPDItaly014: Electricity Produced by Photovoltaic Modules has been used for guidance in methodological choices.

The functional unit and declared unit were defined as 1 kWh of electricity generated as output from the solar photovoltaic plant. The system boundary of this study is cradle-to-grave, including manufacturing stage, installation stage, use & maintenance stage, and end-of-life disposal stage.

1.5. Technical Requirements

Table 2: Standards required for Trian Solar PV modules

Products	Standards
NEG19RC.20	IEC61215/IEC61730/IEC61701/IEC62716/UL61730 ISO 9001/ISO 14001/ISO 14064/ISO 45001
DEG21C.20	
NEG21C.20	IEC61215/IEC61730/IEC61701/IEC62716 ISO 9001/ISO 14001/ISO 14064/ISO 45001

1.6. Material Composition

Table 3 listed materials compositions and mass ratio of different module.

Table 3: Materials compositions

MATERIALS	Main substance	CAS number	DEG21C.20	NEG19RC.20	NEG21C.20
Solar cells	Silicon	7440-21-3	2.4%	2.5%	2.1%
EVA	$(C_2H_4)x(C_4H_6O_2)y$	24937-78-8	3.7%	3.9%	3.7%
POE	$(CH_2CHR)n$	308070-21-5	3.5%	3.6%	3.5%
Ribbon	Sn	7440-31-5	0.6%	0.5%	0.7%
Busbar	Cu	7440-50-8	0.2%	0.2%	0.1%
Frame	$AlMg_3$	12604-68-1	7.6%	7.6%	7.2%
Solar glass	$Na_2O \cdot nSiO_2$	1344-09-8	80.8%	80.5%	81.3%
Junction box	Polyamide	7429-90-5	0.3%	0.3%	0.4%
Silicone product	SiO_2	112926-00-8	0.9%	0.9%	1.0%

Table 4 listed biogenic carbon content in the packaging materials.

Table 4: Biogenic carbon content in the packaging materials

Packaging materials	Weight unit	NEG19RC.20	DEG21C.20	NEG21C.20	Biogenic carbon content (kg C/kg)
Wood pallet	kg	1.375	0.848	0.848	4.72E-1
Corrugated Box	kg	0.278	0.485	0.485	4.50E-1
Packaging film	kg	8.00E-06	8.00E-06	8.00E-06	0
Packaging bag	kg	3.30E-03	3.65E-03	3.65E-03	0
Plastic bead	kg	3.87E-04	3.70E-05	3.70E-05	0

1.7. Manufacturing

Step 1 Half-cut: Because the resistance of half-sliced cell modules is smaller than that of uncut cell modules, the cell is cut in half by a spline-machine according to the technical requirements.

Step 2 Welding: Welding machine is used to weld tin-plated belt on the main grid line using multi-point form. Welding heat source is generated from an infrared lamp.

Step 3 Laminated lay: Solar cell string, glass, and Ethylene vinyl acetate (EVA) are laid accordingly for preparation of lamination. A layer of primer is pasted on the glass to strengthen bonding strength. Solar cell string, glass and other materials are properly positioned to prepare for lamination process.

Step 4 Lamination: Solar string is laid into the laminating machine. The air between layers will be extracted out by vacuum process. A heating process is applied to melt EVA, cell string and TPT so that they are bonded together.

Step 5 Framing: Aluminium frame is installed to the laminated piece to enhance the module strength and form a good sealing. The gap between aluminium frame and glass is filled with silicone glue. A horn button is used to connect frames. A junction box is welded on the back of solar module.

Step 6 High-pressure test: High-pressure test is conducted to test the pressure resistance and insulation strength of module. IV test is also conducted to calibrate the power output rate of module.

Step 7 Packing: The tested modules will be packed into a carton, and put them on the wooden pallet, so that they are convenient for storage and shipment

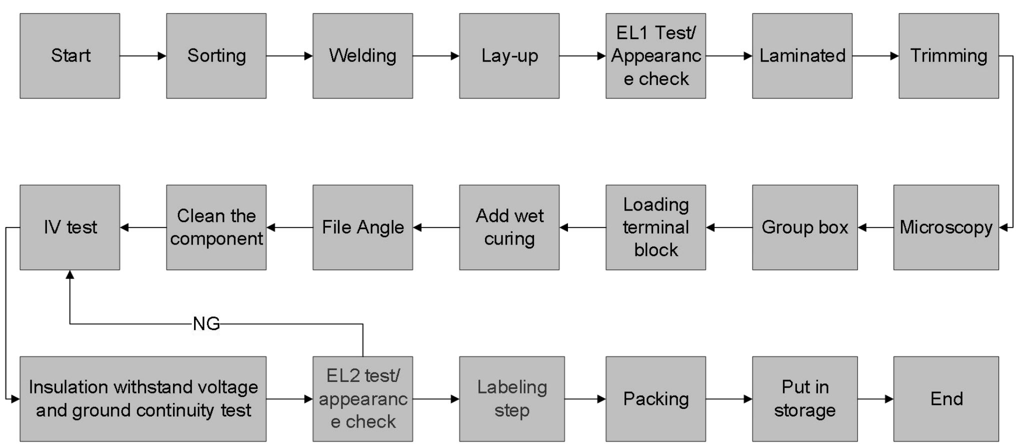

Figure 2: Manufacturing process flowchart for PV modules

1.8. Packaging

There are four main kinds of packaging materials, wood pallet, corrugated box, plastic film and bag, and packaging bead.

1.9. Transportation

All the raw materials used for PV module production are sourced from domestic supplier located in China, the transportation activities are done by truck. As for the transportation of PV module and other PV plant mouting structures and electric equipments, they are transported from China to United Arab Emirates (UAE) through truck for road transportation and container ship for ocean transportation.

1.10. Product Installation

The installation involves PV modules, mounting system, and the electric equipment installation. The PV plant studied in this report is located in Dubai, United Arab Emirates, with a installed capacity of 4.19 MW. Table 5 listed detailed information of the PV plant.

Table 5: PV plant information

Parameters	Value	Unit
Peak power of the plant	4.19	MW
Plant latitude and longitude	25.2631°N, 55.2972°E	°
Plant altitude	16	m
Nominal solar irradiance	1997.1	Wh/m²/year

1.11. Use

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 is used for PV moduel cleaning to maintain its performance. 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). To calculate the expected energy production over the lifetime of the panels, the following formula may be used:

$$E_1 = S_{\mathrm{rad}} * A * y * PR * (1 - \deg)$$

Where:

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 consider 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).

STC: The ratio is given for standard test conditions: irradiance 1000 W/m^2, 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.

Energy production second year of operation:

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

Energy production n year of operation:

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

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

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

1.12. Reference Service Life

30 years.

1.13. Disposal

For end-of-life (EoL) stage, assumptions are made due to a lack of data. De-construction (C1) of the PV plant is assumed to be done with same energy consumption as the construction stage (A5). Transportation distance from the plant site to the waste treatment site (C2) is assumed to be 50km. As for waste processing (C3) stage, the disassembling of PV module is assumed to be mechanically treated to yield the bulk materials with an electricity consumption of 0.277kWh/kg module, based on data from the IEA PVPS Task 12. While the waste processing of electric equipment is modeled using default data from the Ecoinvent database. Modelling of disposal stage (C4) refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under the EU scenario. In 2012/19/EU-Article 11 & ANNEX V, the required recycling rate for waste PV module is 85%. It was assumed that 100% metal components and 85% glass would be recycled. 15% of the waste components (cells, glass, and waste plastics) end up to disposal stage (C4). The plastic components (junction box and back sheet) will be directed to incineration, while the cell and unrecovered glass will be treated as inert materials for landfilling. As for the electric equipment, this study uses a general disposal scenario, with metal mostly being recycled, while the plastic and the oil being incinerated.

2. Life Cycle Assessment Background Information

2.1. Functional or Declared Unit

The functional unit defined in this report is 1 kWh of electricity generated as output from the solar photovoltaic plant, from cradle-to-grave, with activities needed for a reference service of life (RSL) of 30 years.

2.2. System Boundary

The system boundary for this LCA study of Trina Solar's PV modules encompasses the entire life cycle of the product, from cradle to grave, including the product stage, installation stage, use stage, and end-of-life stage, as defined in the PCR. A flow chart is depicted in Figure 3 to illustrate the considered life cycle stages and system boundary.

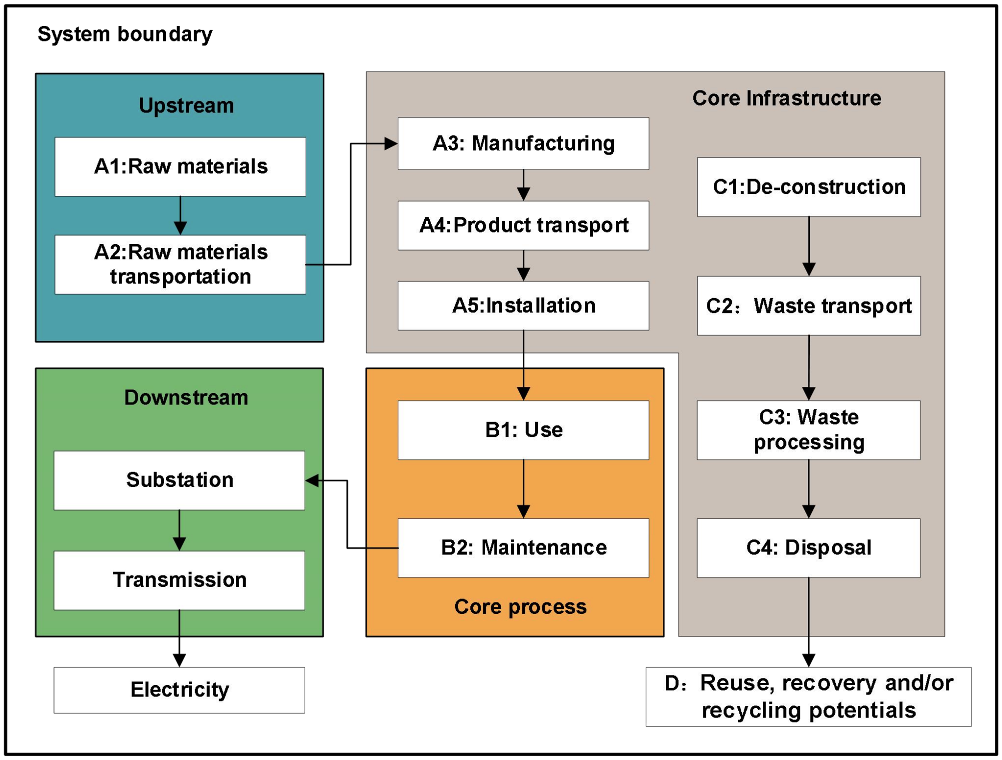

Figure 3: System boundary

2.3. Estimates and Assumptions

A list of asspumtions of different life cycle stages is presented in Table 6.

Table 6: Assumptions

Categories	Items	Assumptions
Manufacturing stage (A1-A3)	Silicon wafer and silicon ingot	Life cycle inventory (LCI) data of silicon ingot and the silicon wafer is difficult to obtain at the stage, thus an average LCI data for China in IEA PVPS Task 12,2020 is used for modelling, the LCI for silicon ingot and silicon wafer are listed in Appendix 2;
Transportation stage (A2 & A4)	Transportation vehicle type	For the vehicle used in raw materials and product transportation, EURO 6 type vehicle with 16-32 ton capacity is assumed for modelling
Installation stage (A5)	PV module	The PV modules employed during the PV plant installation are calculated using PVSYST

Use & Maintenance (B1-B7)	Use (B1)	The use stage requires no energy and materials inputs, and has no emissions.
	B2 Maintenance	Water used for cleaning the PV panels is assumed 0.23L (source: www.polywater.com) per module per time and two times per year,
	Replacement (B4)	No replacement for the module as the module has RSL>30 years
End-of-life (C1-C4)	De-construction (C1)	The de-construction of PV modules is assumed to be done manually, no electricity and materials use in this stage
	Waste transportation (C2)	Waste transportation distance from the de-installation plant to the waste treatment facilities is assumed to be 100 km for simplification purposes.
	Waste processing (C3)	The electricity consumption during this stage is 0.277kWh/kg module based on the data from IEA.
	Disposal (C4)	Disposal scenarios is based on the WEEE

2.4. 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.

2.5. Data Sources

In this LCA study, specific data related to materials or energy flows within the production was calculated and submitted by Trina Solar, generic data for certain processes were sourced from Ecoinvent database 3.9 in SimaPro 9.5.

2.6. Data Quality

Primary data system (such materials or energy flows that enter the production system) is from Trina Solar manufacturing facilities in a reference period of May 2022 to June 2023 (annual average). Generic data related to the life cycle impacts of the material or energy flows that enter the production system is sourced from Ecoinvent 3.9 (2023) "allocation, cut-off by allocation - unit" database. SimaPro is one of the world's most widely used LCA software and the data in it comes predominantly from Ecoinvent, the world's most complete and widely used set of data on industrial processes, material production, packaging production, transport, and so on.

2.7. Allocation

The allocation is made in accordance with the provisions of EN 50693 and Core 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 the inputs and outputs of solar cell and PV module production are allocated by power output ratio. 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.

End-of-life allocation

For end-of-life allocation of background data (energy and materials), the model "allocation cut-off by classification (ISO standard) is used. The underlying philosophy of this approach is that primary (first) production of materials is always allocated to the primary user of a material. If material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials. Consequently, recyclable materials are available burden-free for recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes.

For end-of-life stage of the inverter products, the polluter pays principle (PPP) is followed in this report. This means that the waste transportation to the treatment site and the waste processing (mainly shredding) is considered in this report, while the benefit, the load from waste treatment for recycling purposes such as de-pollution and crushing, etc., is allocated to the next life cycle of substituted products, but not the primary producers, hence no burden or benefit will be allocated to the primary producer of the electric products (cut-off approach).

2.8. Comparability

No comparisons or benchmarking are included in this EPD. LCA results across EPDs can be calculated with different background databases, modeling assumptions, geographic scope and time periods, all of which are valid and acceptable according to the Product Category Rules (PCR) and ISO standards. The user of the EPD should take care when comparing EPDs from different companies. Assumptions, data sources, and assessment tools may all impact the uncertainty of the final results and make comparisons misleading.

3. Life Cycle Assessment Scenarios

Table 7. Transport to the building site (A4)

NAME	VALUE	UNIT
Fuel type	Diesel/Heavy oil	
Liters of fuel	31.1	l/100km
Vehicle type	Truck/Ship	
Transport distance	800/10500	km
Capacity utilization (including empty runs, mass based	36.7/70	%
Gross density of products transported	N/A	kg/m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	1	-

4. Life Cycle Assessment Results

Table 1. Description of the system boundary modules

	PRODUCT STAGE			CONSTRUCT-ION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
	Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Building Operational Energy Use During Product Use	Building Operational Water Use During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential
EPD Type	X	X	X	X	X	X	X	MND	MND	MND	MND	MND	X	X	X	X	MND

4.1. Life Cycle Impact Assessment Results

Table 2. North American Impact Assessment Results-NEG19RC.20

TRACI v2.1	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
Ozone depletion	kg CFC-11 eq	1.40E-10	8.37E-11	6.17E-14	4.77E-11	2.71E-10
Global warming	kg CO2 eq	6.16E-03	3.69E-03	3.15E-07	2.52E-03	1.24E-02
Smog	kg O3 eq	4.54E-04	3.23E-04	1.96E-08	2.76E-04	1.05E-03
Acidification	kg SO2 eq	3.45E-05	2.91E-05	1.46E-09	2.11E-05	8.47E-05
Eutrophication	kg N eq	1.72E-05	1.96E-05	1.15E-09	1.18E-05	4.86E-05
Carcinogenics	CTUh	5.61E-10	4.64E-09	2.19E-13	1.28E-09	6.48E-09
Non carcinogenics	CTUh	2.61E-09	4.63E-09	1.42E-13	2.85E-09	1.01E-08
Respiratory effects	kg PM2.5 eq	6.23E-06	5.57E-06	4.18E-10	3.50E-06	1.53E-05
Ecotoxicity	CTUe	2.50E-01	4.49E-01	5.76E-06	7.93E-01	1.49E+00
Fossil fuel depletion	MJ surplus	5.70E-03	3.72E-03	2.46E-07	2.46E-03	1.19E-02

Table 3. North American Impact Assessment Results-DEG21C.20

TRACI v2.1	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
Ozone depletion	kg CFC-11 eq	1.63E-10	8.94E-11	5.85E-14	4.97E-11	3.02E-10
Global warming	kg CO2 eq	6.66E-03	3.93E-03	2.99E-07	2.63E-03	1.32E-02
Smog	kg O3 eq	4.83E-04	3.42E-04	1.86E-08	2.88E-04	1.11E-03
Acidification	kg SO2 eq	3.62E-05	3.03E-05	1.38E-09	2.20E-05	8.85E-05
Eutrophication	kg N eq	1.80E-05	2.04E-05	1.09E-09	1.23E-05	5.07E-05
Carcinogenics	CTUh	6.06E-10	4.97E-09	2.07E-13	1.34E-09	6.92E-09
Non carcinogenics	CTUh	2.45E-09	4.71E-09	1.35E-13	2.98E-09	1.01E-08
Respiratory effects	kg PM2.5 eq	6.82E-06	5.89E-06	3.96E-10	3.65E-06	1.64E-05
Ecotoxicity	CTUe	2.38E-01	4.56E-01	5.46E-06	8.28E-01	1.52E+00
Fossil fuel depletion	MJ surplus	6.52E-03	3.96E-03	2.34E-07	2.57E-03	1.31E-02

Table 4. North American Impact Assessment Results-NEG21C.20

TRACI v2.1	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
Ozone depletion	kg CFC-11 eq	1.58E-10	8.30E-11	5.38E-14	4.78E-11	2.89E-10
Global warming	kg CO2 eq	6.90E-03	3.63E-03	2.75E-07	2.53E-03	1.31E-02
Smog	kg O3 eq	5.16E-04	3.17E-04	1.71E-08	2.77E-04	1.11E-03
Acidification	kg SO2 eq	3.80E-05	2.80E-05	1.27E-09	2.12E-05	8.72E-05
Eutrophication	kg N eq	2.08E-05	1.88E-05	1.00E-09	1.18E-05	5.15E-05
Carcinogenics	CTUh	6.25E-10	4.61E-09	1.91E-13	1.29E-09	6.52E-09
Non carcinogenics	CTUh	3.36E-09	4.37E-09	1.24E-13	2.86E-09	1.06E-08
Respiratory effects	kg PM2.5 eq	7.02E-06	5.45E-06	3.65E-10	3.51E-06	1.60E-05
Ecotoxicity	CTUe	3.12E-01	4.22E-01	5.02E-06	7.96E-01	1.53E+00
Fossil fuel depletion	MJ surplus	6.42E-03	3.67E-03	2.15E-07	2.47E-03	1.26E-02

Table 5. EU Impact Assessment Results- NEG19RC.20

EN15804	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-total	kg CO2 eq	6.22E-03	3.74E-03	3.22E-07	2.56E-03	1.25E-02
GWP-fossil	kg CO2 eq	6.24E-03	3.74E-03	3.19E-07	2.55E-03	1.25E-02
GWP-biogenic	kg CO2 eq	-3.25E-05	2.83E-06	1.76E-09	7.31E-07	-2.89E-05
GWP-luluc	kg CO2 eq	6.53E-06	3.28E-06	5.12E-10	4.86E-06	1.47E-05
ODP	kg CFC11 eq	1.05E-10	6.48E-11	4.96E-14	3.68E-11	2.07E-10
AP	mol H+ eq	4.06E-05	3.55E-05	1.71E-09	2.53E-05	1.01E-04
EP-Freshwater	kg P eq	2.02E-06	2.43E-06	1.40E-10	1.47E-06	5.93E-06
EP-Marine	kg N eq	7.69E-06	5.47E-06	3.45E-10	4.57E-06	1.77E-05
EP-Terrestrial	mol N eq	8.26E-05	6.03E-05	3.48E-09	5.04E-05	1.93E-04

POCP	kg NMVOC eq	2.42E-05	2.12E-05	1.14E-09	1.67E-05	6.20E-05
ADP- M&M*	kg Sb eq	2.49E-07	2.17E-07	1.49E-12	1.48E-07	6.14E-07
ADP-fossil*	MJ	7.41E-02	4.46E-02	4.09E-06	2.84E-02	1.47E-01
WDP	m3 depriv.	7.11E-03	3.63E-04	1.49E-05	5.01E-04	7.98E-03

Table 6. EU Impact Assessment Results- DEG21C.20

EN15804	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-total	kg CO2 eq	6.75E-03	3.99E-03	3.05E-07	2.67E-03	1.34E-02
GWP-fossil	kg CO2 eq	6.75E-03	3.98E-03	3.03E-07	2.66E-03	1.34E-02
GWP-biogenic	kg CO2 eq	-5.25E-06	3.14E-06	1.67E-09	7.62E-07	-1.35E-06
GWP-luluc	kg CO2 eq	7.44E-06	3.49E-06	4.85E-10	5.07E-06	1.60E-05
ODP	kg CFC11 eq	1.27E-10	6.92E-11	4.71E-14	3.83E-11	2.34E-10
AP	mol H+ eq	4.26E-05	3.69E-05	1.62E-09	2.64E-05	1.06E-04
EP-Freshwater	kg P eq	2.08E-06	2.52E-06	1.33E-10	1.54E-06	6.14E-06
EP-Marine	kg N eq	8.17E-06	5.80E-06	3.27E-10	4.77E-06	1.87E-05
EP-Terrestrial	mol N eq	8.96E-05	6.38E-05	3.30E-09	5.26E-05	2.06E-04
POCP	kg NMVOC eq	2.59E-05	2.25E-05	1.08E-09	1.74E-05	6.58E-05
ADP- M&M*	kg Sb eq	2.05E-07	2.18E-07	1.41E-12	1.54E-07	5.77E-07
ADP-fossil*	MJ	8.08E-02	4.76E-02	3.88E-06	2.96E-02	1.58E-01
WDP	m3 depriv.	8.61E-03	3.63E-04	1.42E-05	5.23E-04	9.51E-03

Table 7. EU Impact Assessment Results- NEG21C.20

EN15804	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-total	kg CO2 eq	7.00E-03	3.69E-03	2.81E-07	2.57E-03	1.33E-02
GWP-fossil	kg CO2 eq	7.00E-03	3.68E-03	2.79E-07	2.56E-03	1.32E-02
GWP-biogenic	kg CO2 eq	-5.69E-06	2.84E-06	1.54E-09	7.33E-07	-2.12E-06
GWP-luluc	kg CO2 eq	7.45E-06	3.23E-06	4.47E-10	4.88E-06	1.56E-05
ODP	kg CFC11 eq	1.20E-10	6.43E-11	4.33E-14	3.69E-11	2.21E-10
AP	mol H+ eq	4.46E-05	3.42E-05	1.49E-09	2.54E-05	1.04E-04
EP-Freshwater	kg P eq	2.47E-06	2.33E-06	1.22E-10	1.48E-06	6.28E-06
EP-Marine	kg N eq	8.73E-06	5.37E-06	3.01E-10	4.58E-06	1.87E-05
EP-Terrestrial	mol N eq	9.41E-05	5.91E-05	3.04E-09	5.06E-05	2.04E-04
POCP	kg NMVOC eq	2.74E-05	2.08E-05	9.91E-10	1.67E-05	6.49E-05
ADP- M&M*	kg Sb eq	4.37E-07	2.02E-07	1.30E-12	1.48E-07	7.87E-07
ADP-fossil*	MJ	8.33E-02	4.40E-02	3.57E-06	2.85E-02	1.56E-01
WDP	m3 depriv.	8.18E-03	3.40E-04	1.30E-05	5.02E-04	9.04E-03

ADP- M&M* and ADP-fossil*: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high as there is limited experience with the indicator

Caption

1E+01 is equal to 1 x 10^1

GWP-total: Global Warming Potential; **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 and compartment; See “additional Norwegian requirements” for indicator given as PO4 eq. **EP-Marine**: Eutrophication potential, fraction of nutrients reaching freshwater end compartment; **EP-Terrestrial**: Eutrophication potential, Accumulated Exceedance; **POCP**: Formation potential of tropospheric ozone; **ADP-M&M**: Abiotic depletion potential for non-fossil resources (minerals and metals); **ADP-fossil**: Abiotic depletion potential for fossil resources; **WDP**: Water deprivation potential, deprivation weighted water consumption

4.2. Life Cycle Inventory Results

Table 8. Resource Use- NEG19RC.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
PERE	MJ	1.36E-02	3.61E-03	4.36E-07	2.42E-03	1.97E-02
PERM	MJ	5.19E-04	0.00E+00	0.00E+00	0.00E+00	5.19E-04
PERT	MJ	1.41E-02	3.61E-03	4.36E-07	2.42E-03	2.02E-02
PENRE	MJ	7.40E-02	4.46E-02	4.09E-06	2.84E-02	1.47E-01
PENRM	MJ	9.71E-05	0.00E+00	0.00E+00	0.00E+00	9.71E-05
PENRT	MJ	7.41E-02	4.46E-02	4.09E-06	2.84E-02	1.47E-01
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	1.85E-04	1.66E-05	3.59E-07	2.05E-05	2.22E-04

Table 9. Resource Use- DEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
PERE	MJ	2.30E-02	3.82E-03	4.13E-07	2.53E-03	2.93E-02
PERM	MJ	3.04E-04	0.00E+00	0.00E+00	0.00E+00	3.04E-04
PERT	MJ	2.33E-02	3.82E-03	4.13E-07	2.53E-03	2.96E-02
PENRE	MJ	8.07E-02	4.76E-02	3.88E-06	2.96E-02	1.58E-01
PENRM	MJ	9.21E-05	0.00E+00	0.00E+00	0.00E+00	9.21E-05

PENRT	MJ	8.08E-02	4.76E-02	3.88E-06	2.96E-02	1.58E-01
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	2.25E-04	1.71E-05	3.41E-07	2.14E-05	2.64E-04

Table 10. Resource Use- NEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
PERE	MJ	1.55E-02	3.54E-03	3.81E-07	2.43E-03	2.15E-02
PERM	MJ	2.79E-04	0.00E+00	0.00E+00	0.00E+00	2.79E-04
PERT	MJ	1.58E-02	3.54E-03	3.81E-07	2.43E-03	2.17E-02
PENRE	MJ	8.32E-02	4.40E-02	3.57E-06	2.85E-02	1.56E-01
PENRM	MJ	8.47E-05	0.00E+00	0.00E+00	0.00E+00	8.47E-05
PENRT	MJ	8.33E-02	4.40E-02	3.57E-06	2.85E-02	1.56E-01
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	2.13E-04	1.59E-05	3.14E-07	2.06E-05	2.50E-04

Table 11. Output Flows and Waste Categories- NEG19RC.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
HWD	kg	5.40E-06	6.34E-07	1.15E-11	2.52E-07	6.28E-06
NHWD	kg	6.93E-04	1.43E-03	4.74E-08	9.71E-03	1.18E-02
RWD	kg	9.24E-08	4.57E-08	9.99E-12	1.60E-08	1.54E-07
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	1.73E+00	0.00E+00	0.00E+00	1.73E+00
MER	kg	0.00E+00	4.05E-02	0.00E+00	0.00E+00	4.05E-02
ETE	MJ	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

Table 12. Output Flows and Waste Categories- DEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
HWD	kg	7.05E-06	6.48E-07	1.09E-11	2.63E-07	7.96E-06
NHWD	kg	6.93E-04	1.54E-03	4.49E-08	1.01E-02	1.24E-02
RWD	kg	9.22E-08	4.82E-08	9.47E-12	1.67E-08	1.57E-07
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	1.85E+00	0.00E+00	0.00E+00	1.85E+00

MER	kg	0.00E+00	3.70E-02	0.00E+00	0.00E+00	3.70E-02
ETE	MJ	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

Table 13. Output Flows and Waste Categories- NEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
HWD	kg	6.35E-06	6.00E-07	1.00E-11	2.53E-07	7.21E-06
NHWD	kg	8.03E-04	1.42E-03	4.13E-08	9.74E-03	1.20E-02
RWD	kg	1.05E-07	4.47E-08	8.71E-12	1.61E-08	1.65E-07
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	1.71E+00	0.00E+00	0.00E+00	1.71E+00
MER	kg	0.00E+00	3.48E-02	0.00E+00	0.00E+00	3.48E-02
ETE	MJ	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

Table 14. Biogenic CO_2 removals and emissions associated within bio-based packaging- NEG19RC.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-biogenic	kg CO2 eq	-7.66E-05	7.66E-05	0.00E+00	0.00E+00	0.00E+00

Table 15. Biogenic CO_2 removals and emissions associated within bio-based packaging- DEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-biogenic	kg CO2 eq	-5.58E-05	5.58E-05	0.00E+00	0.00E+00	0.00E+00

Table 16. Biogenic CO_2 removals and emissions associated within bio-based packaging- NEG21C.20

Parameters	Unit	Upstream	Core infrastructure	Core process	Downstream	Total
GWP-biogenic	kg CO2 eq	-5.55E-05	5.55E-05	0.00E+00	0.00E+00	0.00E+00

5. LCA Interpretation

The contribution analysis on various impact categories reveals that the raw materials extraction stage and installation stage are responsible for most impacts. The three key materials that contribute the most to the environmental impacts in PV module production are solar cells, glass, and frame. These three materials have the largest share of environmental impacts and must be closely monitored in order to reduce the overall impact of PV module production on the environment. While for the installation, cable and brackets are the two key components with large contribution of environmental impacts.

Sensitivity analysis shows that the changes in assumptions such as waste transportation distance only led to minor fluctuation of the final LCA results. Therefore, the assumptions used in modeling are safe to use.

6. Additional Environmental Information

6.1. Environmental Activities and Certifications

Clean Solar Energy

Trina Solar is committed to continuously exploring and applying technologies that increase PV product efficiency and help reduce CO2 emission. We strive to use the clean solar energy to promote energy transformation. We are committed to systematically addressing the issues of economic development, environmental protection and energy security and providing the clean solar energy to the public. We not only conduct our operation in a responsible manner, but also contribute to meet the rising demand for clean energy by establishing Product Stewardship Policy, technological innovations, efficiency improvement, so as to actively respond to global climate change.

Sustainable Use of Water Resource

Trina Solar regards protecting water resource as one of its important tasks, and strives to reduce the consumption of water resource per MW module production through sustainable use of water resource. Solar module production consumes a lot of water. To carry out water conservation management, we setup water saving goals for each workshops and implemented various of water saving projects, such as reuse of RO (Reverse Osmosis) rejected water, treat and reuse of wastewater, collection of condensated water from air conditioning system etc. We setup a strict maintenance scheme to clean RO membrane to increase DI(De-ionized) water yield. With business expanding, total amount of water consumption is in increasing trend. But as we continue to develop and implement water conservation projects, our water use efficiency continues to increase.

Biological Diversity Management

To protect ecological environment, Trina Solar build PV projects without changing the original use of the land, such as PV plus agriculture, PV plus fishery etc. while providing clean energy to local communities:

• Trina Solar built a solar farm in Dorset, London. We set up bird houses and bat nests near the farm and planted local

wildflowers while keeping the solar panels high without affecting the farm's continued grazing.

• Trina Solar built a 120MW 'PV plus fishery' project in Xiangshui, Jiangsu Province. The lower layer remains as aquaculture while the upper layer is PV panels, thus achieving sustainable economic, ecological and social benefits.

• Trina Solar successfully built a 5MW 'PV plus agriculture' project in Menghe, Changzhou. A shed is constructed for

ecological agriculture, where the roof is made of double-glass PV modules for clean power generation. The double-glass PV modules have strong permeability, thus keep the required illumination for the growth of crops.

• Trina Solar built a 51MW 'PV plus agriculture' project in the tea garden in Xishuangbanna, Yunnan. The transparent double-glass PV modules were used above the tea tree for efficient use of the space. The project generates about 80 million kWh/year clean solar energy, which reduces carbon emissions by 60,000 tons.

Certifications

Plants of Trina Solar comply with the following standards:

- ISO 9001-Quality Management System

- ISO 14001- Environmental Management System

- ISO 50001- Energy Management System

- ISO14064 - Organization Level for Quantification and Reporting of Greenhouse Gas Emission and Removals
- ISO 45001: Occupational Health and Safety Management System

7. Supporting Documentation

Additional information about Trina Solar's products can be found on the website: https://www.trinasolar.com/cn. LCA reports and other cerftificates can be provided upon request.

8. References

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[6] ISO 21930:2017, Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.

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