OWNER OF THE DECLARATION

ENVIRONMENTAL PRODUCT DECLARATION

TSM-DE15M(II), TSM-DE17M(II)

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in compliance with ISO 14025

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ENVIRONMENTAL PRODUCT DECLARATION

TSM-DE15M(II), TSM-DE17M(II)

RELIABLE AND SMART SOLAR

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

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ENVIRONMENTAL PRODUCT DECLARATION

Trinasolar

TSM-DE15M(II), TSM-DE17M(II)

According to ISO 14025 and EN 15804:2012+A2:2019

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Environment 333 Pfingsten Road Northbrook, IL60611 https://www.ul.com/ https://spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	General Program Instructions v.2.5 March 2020
MANUFACTURER NAME AND ADDRESS	Trina Solar Science & Technology (Thailand) Ltd Moo.6,T.Mabyangporn,A.Pluakdang,Rayong 21140,Thailand Yancheng Trina Solar Guoneng Science & Technology Co., Ltd. No. 101 Wutaishan Road, Yancheng Economic Technological Development Zone, Jiangsu, P.R. China Trina Solar (Suqian) Technology Co., Ltd No. 3 Tianhe Road, Suqian Economic Development Zone, Suqian City. Jiangsu, P.R. China
DECLARATION NUMBER	4789556470.102.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	TSM-DE15M(II), TSM-DE17M(II) 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	Europe, North America, Global
DATE OF ISSUE	2020-October-01
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	January 2020—June 2020
LCA SOFTWARE & VERSION NUMBER	SimaPro 9
LCI DATABASE(S) & VERSION NUMBER	Ecoinvent 3
LCIA METHODOLOGY & VERSION NUMBER	EN 15804+A2:2019 (version 1.00) &TRACI

This PCR review was conducted by:	EPDItaly Program PCR Moderator & Review Committee info@epditaly.it
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	James R. Mellentine James Mellentine, Thrive ESG

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.

1. Product Definition and Information

1.1. Description of Company/Organization

As a global leading provider for photovoltaic (PV) module and smart energy solution, Trina Solar delivers PV products, applications and services to promote global sustainable development. Through constant innovation, we continue to push the PV industry forward by creating greater grid parity of PV power and popularizing renewable energy. Our mission is to boost global renewable energy development around the world for the benefit of all of humanity.

As of Jun. 2020, Trina Solar has delivered more than 50 GW of solar modules worldwide, ranked "Top 500 private enterprises in China". In addition, our downstream business includes solar PV project development, financing, design, construction, operations & management and one-stop system integration solutions for customers. Trina Solar has connected over 3GW of solar power plants to the grid worldwide. In 2018, Trina Solar first launched the Energy IoT brand, and is now aiming to be the global leader of smart energy.

1.2. Product Description

1.2.1 Product Identification

The Trina Solar's PV modules under analysis integrate various technologies like half-cut cells and multi-busbar, with the highest power up to 455W and up to 20.8% module efficiency. Besides, the unique circuit design of half-cut cells can reduce power loss caused by ribbon resistance to 1/4 compared to full cells, which results the decrease of electrical resistance within the ribbon and finally improves the overall module efficiency by more than 2%. Application of this modules can remarkably reduce the number of modules employed in a power station, thus lowering the corresponding cost of supports, cables, construction and land, improving the return on investment.

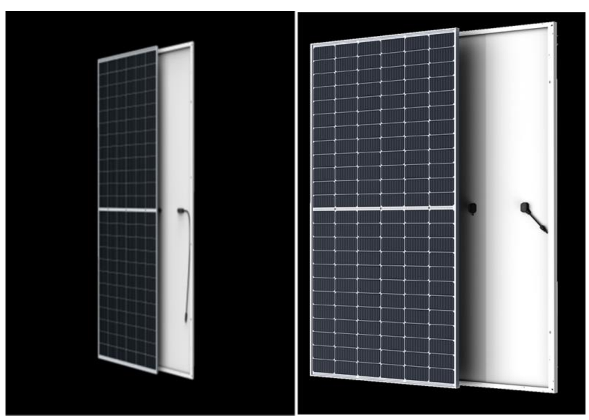

Figure 1 Trina Solar PV Back sheet modules

1.2.2 Product Specification

Trina Solar produces more than a dozen series of mono-crystalline silicon PV modules. Within this project, Trina Solar PV Back sheet modules cover 2 PV modules that are analyzed, including TSM-DE15M(II), TSM-DE17M(II). The full list of the modules under analysis is shown in table 1 below.

Table 1 Different PV module products models

Series (brand name)	Power output range (W)	Dimensions(inch[3])	Module efficiency (%)
TSM-DE15M(II)	390-415	79.33×39.21×1.38	20.7
TSM-DE17M(II)	435-455	82.76×40.94×1.38	20.8

Note: TSM: Trina solar common module; DE: Backsheet module; M: half cut; (II): High efficiency module.

1.3. Application

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

1.4. Material Composition

Table 2 contains a list of materials and substances in different modules.

Table 2 Components in different PV modules

Materials	Main substance	CAS No. of main substance	Units	DE15M(II)	DE17M(II)
Solar Cell (mono)	Si	7440-21-3	kg/pcs	0.7632	0.792
EVA	$(C_2H_4)x(C_4H_6O_2)y$	24937-78-8	kg/pcs	2.25	2.47
POE	/	/	kg/pcs	/	/
Tin-plated copper ribbon	Sn	7440-31-5	kg/pcs	0.124	0.13
Bus bar	Cu	7440-50-8	kg/pcs	0.028	0.029
Backsheet	$(C_{10}H_8O_4)n$	25038-59-9	kg/pcs	0.86	0.95
Aluminum Frame	Al	7429-90-5	kg/pcs	2.32	2.43
Coated semi-tempered glass (front side)	$Na_2O \cdot nSiO_2$	1344-09-8;106985-35-7	kg/pcs	15.33	16.94
PV component connector & junction box	Cu	7440-50-8	kg/pcs	0.26	0.25
Silica gel	SiO_2	112926-00-8	kg/pcs	0.33126	0.31226

1.5. Declaration of Methodological Framework

In this project, a full LCA approach was considered with some simplification on data modeling using generic data for most background systems. The EPD analysis uses a cradle-to-grave system boundary. No known flows are deliberately excluded from this EPD.

To calculate the LCA results for the product maintenance stage, a 30-year reference service life (RSL) was assumed for the declared products.

Additional details on assumptions, cut-offs and allocation procedures can be found in section 2.3,2.4,2.8 respectively.

1.6. Technical Requirements

The chart below lists all standards required for Trina solar's PV modules.

Table 2 Standards required for Trina solar's PV modules

PRODUCT	STANDARDS
TSM-DE15M(II)	IEC61215/IEC61730/IEC61701/IEC62716/UL1703
TSM-DE17M(II)	IEC61215/IEC61730/IEC61701/IEC62716

2. Life Cycle Assessment Background Information

2.1. Functional or Declared Unit

The functional unit and declared unit provide a reference by means of which the material flows(input and output data) for each information module of a product are normalized (in mathematical sense) to produce data, expressed on a common basis. It is important that the functional units of these products are equivalent so that the results may be interpreted clearly.

In this report, the functional unit is defined as 1 kWh of electricity generated as output from the solar photovoltaic plant.

2.2. System Boundary

The system boundary considered in this LCA study is from cradle to grave, except use by end consumer. Figure 2 below illustrates the system boundaries for the Trina Solar product, including raw material production and transportation, manufacture, delivery, solar plant installation and waste disposal.

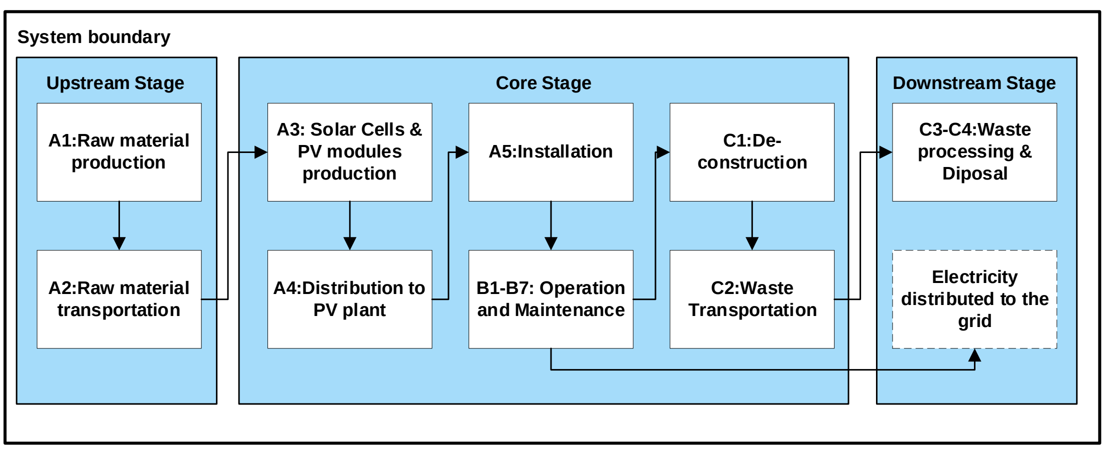

Figure 2 System boundaries

According to the PCR, the life cycle stage must refer to segmentation in the following three processes:

Upstream Stage for module: which includes extraction and processing of raw materials (A1), transportation of the raw material to the factory (A2);

Core Stage for module: which includes all the relevant processes managed by the Organization proposing the EPD. The core stage in this study includes manufacturing of solar cells and PV modules (A3) with the supply of the energy and water input, and gaseous emissions, wastewater and solid wastes; distribution of PV modules to solar PV plant (A4); construction of the solar plant (A5), the use (B1), maintenance (B2), repair (B3), replacement (B4), refurbishment (B5) and the operational energy use (B6) and water use (B7) during the RSL (30 years) period; de-construction and demolition of the solar plant (C1), transport to waste processing (C2). According to the PCR, the benefit and avoided loads beyond the product system boundary are not reported in module D separately within this study, neither will the benefit and loads be reported in other stages by following a cut off allocation approach. However, considering that the installation and operation is beyond the control of Trina Solar, for simplification purpose, assumption is made on the life cycle inventory (LCI) data during the modeling of core stage;

Downstream Stage for module: which includes waste processing (C3) and disposal (C4), dissipation related to voltage drop operations before feeding electricity into the grid, and environmental impacts of using booster station.which includes dissipation related to voltage drop operations before feeding electricity into the grid; and environmental impacts of using booster station.

2.3. Estimates and Assumptions

The key assumptions of this LCA study are as follows：

• For missing background data, substitution of missing data using similar background data approach was taken to shorten the gap;

• Data of electricity consumption for silicon ingot processing and wafer slicing was adapted with reference to China’s Technical specification for green-design product assessment photovoltaic silicon wafer (T/CESA 1074—2020 T/CPIA 0021—2020);

• Electricity consumption during 166 mm solar cells production is assumed same to 158.75mm solar cells;

• The number of PV module employed in PV plant construction (A5) was calculated by dividing the total power capacity of the PV plant (30MW) by the peak power output of each PV module;

• The electricity consumption during PV plant construction stage is scaled up based on the data from Ecoinvent database value (36.03 kWh/570kWp) according to the power capacity;

• Electricity used during the PV plant operation is assumed to be powered by the plant itself, 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 of inverter is assumed 1 inverter/ 2 years during RSL;

• The electricity consumption during deconstruction of PV plant (C1) is assumed same to the electricity consumption of construction stage (A5), and electricity consumption for PV module demolition at waste processing stage (C3) is assumed same to the electricity consumption of PV module assembling;

• During the end of life stage, the transportation of the waste PV modules and other equipment from the solar PV plant to treatment facilities including recycling, landfill or incineration center is assumed to be 100 km for simplification purposes.

2.4. Cut-off Criteria

The following procedure was followed for the exclusion of inputs and outputs:

• All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented;

- In case of insufficient input data or data gaps for a unit process, according to the PCR requirement, the cut-off criteria chosen is 2% of the total mass and energy of that unit process. (respectively, of the photovoltaic module's unit weight and the energy needed to produce and assemble it). The neglected flow is demonstrated in table 3.

Table 3 Cut off flows

Flow name	Process stage	Mass %	Reason to cut off
Texturing additives	A1	0.28	<2%
Silane	A1	0.055	<2%
Trimethyl aluminum	A1	3.88E-3	<2%
POCl3	A1	5.05E-3	<2%
Inspection during operation of solar plant	B	N/A	Cut off due to small impact according to PCR
Total cut off mass % estimated		0.34	<2%

2.5. Reference Service life and Estimated Building Service Life

The reference service life of products is 30 years.

2.6. 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 databases in SimaPro 9. SimaPro is the world's most widely used LCA software and the data in it comes predominantly from Ecoinvent 3, the world's most complete and widely used set of data on industrial processes, material production, packaging production, transport and so on.

2.7. Data Quality

Steps were taken to ensure that the life cycle inventory data were reliable and representative. The type of data that was used is clearly stated in the Inventory Analysis, be it measured or calculated from primary sources or whether data are from the life cycle inventory databases.

The data quality requirements for this study were as follows:

- Existing LCI data were, at most, 10 years old. Newly collected LCI data were current or up to 3 years old;
- The LCI data related to the geographical locations where the processes occurred;
- The technology represented the average technologies at the time of data collection.

2.8. Allocation

Allocation refers to 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 processes

For data sets in this study, the allocation of the inputs from coupled processes is generally carried out via the mass. The consumption of raw materials is allocated by mass ratio. The transportation of raw materials is allocated by mass ratio.

Multi-output processes

In the production of Solar Cells and PV modules, the total consumption of energy and water during manufacturing is equally allocated to per unit mass. 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.

Allocation for recovery processes

For the allocation of residuals, the model "allocation cut-off by classification (ISO standard) (called "Allocation Recycled Content", alloc rec, by Ecoinvent) 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 a 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.

During the end of life stage of the solar plant, the extra benefit of recycling the waste modules as well as other equipment is cut off from the boundary, following the PCR's recommendation on end of life scenario. Along with the benefit, the load from waste treatment for recycling purpose such as de-pollution and crushing and etc, is also allocated to the next life cycle of substituted products, but not the primary producers of PV module, hence no burden or benefit will be allocated to the primary producer of the PV module or solar PV plant (cut off approach).

2.9. Period under Review

The study used primary data collected from January 2020—June 2020.

2.10. Comparability and Benchmarking

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.

2.11. Electricity power mix

In this EPD, different electricity mix data is taken where the process takes place based on grid mixes of China. The electricity inventory is based on the year 2015 for Chinese electricity generation (China Energy Statistics Yearbook 2016). Silicon wafer production takes place at the location where Trina Solar's supplier is, mainly in the north of China and the south of China. Therefore, China northern grid mix and southern grid mix electricity is adopted. For the production of solar cells and PV modules, it mainly takes place in Jiangsu province, so China eastern grid mix electricity is adopted. For PV plant construction and operation, it takes place at Inner Mongolia, China northern grid electricity mix is used.

2.12. Units

SI units are used for all LCA results of Trina Solar's products.

3. Life Cycle Assessment Scenarios

3.1. Manufacturing

The PV module products under study includes 2 models (see Table 1). All the products share similar manufacturing processes and life cycle stages. A flowchart depicting the production process stages of Trina Solar PV module products is shown in Figure 3 below. For simplification purpose, only main stages of manufacturing are presented, raw material, auxiliary processes considered in the LCA but not shown in the flowcharts, which include:

- Raw and auxiliary material production and transportation
- Recycling of waste materials;
- Waste water and off gas treatment;
- Water recycling and reuse system;
- Supply of natural gas/water/electricity

Figure 3 PV module production process

3.2. Packaging

There are three main kinds of packaging materials, corrugated box (paper), wood board (wood), PE film (plastic).

3.3. Transportation

After the PV module is manufactured, the PV panels, along with other materials, such as brackets, cable, inverters are transported to the installation site(Inner Mongolia in China). In this study a default value for the distance is given in table 4.

Table 4. Transport to the building site (A4)

NAME	VALUE	UNIT
Fuel type	Diesel	
Liters of fuel	31.11	l/100km
Vehicle type	Truck	
Transport distance	1700	km
Capacity utilization (including empty runs, mass based	100	%
Gross density of products transported	N/A	kg/m^3
Weight of products transported (if gross density not reported)	1612489	kg
Volume of products transported (if gross density not reported)	N/A	m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	=1	-

3.4. Production Installation

The specific data regarding solar PV plant installation was taken from a real PV plant in Inner Mongolia in China, the PV plant has energy yield capacity 30MW.The detailed information about the PV plant is listed in Table 5.

Table 5. PV plant information

Parameters	Value		Source
	Amount	Unit	
Peak power of the plant	30000	KW	Trina Solar
Plant latitude and longitude	N 40°42′26″, E 110°27′19″	°	Trina Solar
Plant altitude	1410	m	Trina Solar
Nominal solar irradiance	1660278	Wh/m²/year	Trina Solar

3.5. Disposal

For the end-of-life stage, De-construction (C1) of the PV plant during the disposal stage is assumed mainly consumes electricity, and the electricity consumption is assumed the same as the construction stage (A5), 100km transportation distance from plant site to waste treatment site (C2) is assumed, electricity used for PV module demolition during waste processing stage is assumed the same as PV module manufacturing stage (A3). For end of life disposal treatment process (C4), the disposal of other components including inverters is regarded as 100% recyclable and following the end of life load and benefit allocation approach, is then cut off from the analysis. 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 recycling rate for waste PV module is 85%. Therefore, 15% of waste PV module end up with waste disposal, waste management scenario of 20% landfill and 80% incineration was adopted.

4. Life Cycle Assessment Results

Table 6. 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: cradle-to-grave	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

4.1. Life Cycle Impact Assessment Results

This EPD follows the PCR EPDItaly014 – Photovoltaic modules guideline and use the recommended impact method for the analysis, the EN 15804+A2:2019 (version 1.00) method was used in this report. The EN 15804 standard covers Environmental Product Declarations (EPDs) of construction products. The A2:2019 revision of this standard has aligned their methodology with the Environmental Footprint (EF) 3.0 method, except for their approach on biogenic carbon. According to the EN 15804, biogenic carbon emissions cause the same amount of Climate Change as fossil carbon, but can be neutralized by removing this carbon from the atmosphere again.

Based on the model of PV module products, the EN 15804 result is calculated and the tables below shows the results. Note that impact results are calculated based on 1 kWh electricity generated by the PV plant. The results have been demonstrated through different processes according to the PCR, namely upstream, core, and downstream processes.

Table 7. Life Cycle Impact Assessment Results- TSM-DE15M(II)

IMPACT CATEGORY	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
Climate change -total	kg CO2 eq	5.66E-03	5.95E-03	1.10E-03	1.27E-02
Climate change - fossil	kg CO2 eq	6.36E-03	6.00E-03	1.11E-03	1.35E-02
Climate change - biogenic	kg CO2 eq	-7.03E-04	-5.46E-05	-8.08E-06	-7.66E-04
Climate change - land use and change in land use	kg CO2 eq	3.80E-06	9.21E-06	3.78E-07	1.34E-05
Ozone depletion	kg CFC-11 eq	4.70E-10	1.22E-09	3.73E-11	1.72E-09
Acidification	molc H+ eq	6.08E-05	9.64E-05	8.21E-06	1.65E-04
Eutrophication of water	kgPO_4eq	2.65E-05	4.57E-05	1.95E-06	7.41E-05

Photochemical ozone formation	kg NMVOC eq	2.59E-05	3.01E-05	3.77E-06	5.98E-05
Consumption of abiotic resources - minerals and materials	kg Sb eq	9.74E-06	3.22E-05	4.22E-08	4.20E-05
Consumption of abiotic resource use – fossil resources	MJ, calculated using lower calorific values	6.99E-02	7.70E-02	1.03E-02	1.57E-01
Water consumption	m3 eq	1.58E-03	8.10E-06	1.45E-07	1.59E-03

Table 8. Life Cycle Impact Assessment Results- TSM-DE17M (II)

IMPACT CATEGORY	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
Climate change -total	kg CO2 eq	5.15E-03	6.24E-03	9.27E-04	1.23E-02
Climate change - fossil	kg CO2 eq	5.87E-03	6.29E-03	9.33E-04	1.31E-02
Climate change - biogenic	kg CO2 eq	-7.18E-04	-5.70E-05	-6.74E-06	-7.82E-04
Climate change - land use and change in land use	kg CO2 eq	3.67E-06	9.21E-06	3.74E-07	1.32E-05
Ozone depletion	kg CFC-11 eq	4.71E-10	1.22E-09	3.67E-11	1.73E-09
Acidification	molc H+ eq	5.70E-05	9.78E-05	7.20E-06	1.62E-04
Eutrophication of water	kgPO_4eq	3.30E-05	4.59E-05	1.83E-06	8.07E-05
Photochemical ozone formation	kg NMVOC eq	2.57E-05	3.07E-05	3.28E-06	5.97E-05
Consumption of abiotic resources - minerals and materials	kg Sb eq	9.47E-06	3.22E-05	4.19E-08	4.17E-05
Consumption of abiotic resource use – fossil resources	MJ, calculated using lower calorific values	6.77E-02	7.96E-02	9.01E-03	1.56E-01
Water consumption	m3 eq	1.31E-03	7.69E-06	1.69E-07	1.32E-03

Table 9. TRACI Results- TSM-DE15M(II)

IMPACT CATEGORY	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
Ozone depletion	kg CFC-11 eq	5.60E-10	1.25E-09	4.60E-11	1.86E-09
Global warming	kg CO2 eq	6.06E-03	5.44E-03	1.04E-03	1.25E-02
Smog	kg O3 eq	4.83E-04	4.83E-04	7.70E-05	1.04E-03
Acidification	kg SO2 eq	4.96E-05	7.64E-05	6.89E-06	1.33E-04
Eutrophication	kg N eq	5.73E-05	1.02E-04	3.78E-06	1.63E-04
Carcinogenics	CTUh	6.33E-10	5.58E-09	3.50E-10	6.56E-09
Non carcinogenics	CTUh	1.30E-08	3.25E-08	7.68E-10	4.63E-08
Respiratory effects	kg PM2.5 eq	5.89E-06	9.76E-06	9.22E-07	1.66E-05
Ecotoxicity	CTUe	3.01E-01	6.26E-01	2.09E-02	9.48E-01
Fossil fuel depletion	MJ surplus	6.98E-03	5.84E-03	5.79E-04	1.34E-02

Table 10. TRACI Results- TSM-DE17M (II)

IMPACT CATEGORY	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
Ozone depletion	kg CFC-11 eq	5.61E-10	1.25E-09	4.41E-11	1.86E-09
Global warming	kg CO2 eq	5.60E-03	5.69E-03	8.76E-04	1.22E-02
Smog	kg O3 eq	4.80E-04	4.83E-04	6.64E-05	1.03E-03

Acidification	kg SO2 eq	4.66E-05	7.68E-05	6.02E-06	1.29E-04
Eutrophication	kg N eq	7.33E-05	1.03E-04	3.61E-06	1.79E-04
Carcinogenics	CTUh	7.62E-10	5.58E-09	3.48E-10	6.69E-09
Non carcinogenics	CTUh	1.69E-08	3.26E-08	7.56E-10	5.02E-08
Respiratory effects	kg PM2.5 eq	5.58E-06	9.85E-06	8.29E-07	1.63E-05
Ecotoxicity	CTUe	4.05E-01	6.26E-01	2.05E-02	1.05E+00
Fossil fuel depletion	MJ surplus	6.76E-03	5.82E-03	5.50E-04	1.31E-02

4.2. Life Cycle Inventory Results

To analysis the contribution of life stage to the environmental impact, a LCIA was conducted using EN 15804 method. The result was allocated by stages, as shown in tables below.

Table 11. Resource Use- TSM-DE15M(II)

PARAMETER	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
PENRE:Non-renewable primary resources used as an energy carrier (fuel)	MJ	7.86E-02	7.61E-02	1.40E-02	1.69E-01
PERE:Renewable primary energy used as energy carrier (fuel)	MJ	2.43E-02	5.67E-03	5.28E-04	3.05E-02
PENRM:Non-renewable primary resources with energy content used as material	MJ	3.51E-03	6.66E-03	0.00E+00	1.02E-02
PERM:Renewable primary resources with energy content used as material	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT:Total use of non-renewable primary energy resources	MJ	8.21E-02	8.28E-02	1.40E-02	1.79E-01
PERT:Total use of renewable primary energy resources	MJ	2.43E-02	5.67E-03	5.28E-04	3.05E-02
FW:Use of net fresh water	m3	1.31E-01	1.18E-02	8.27E-04	1.43E-01
MS: Use of secondary raw materials	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF:Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF:Use of none renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12. Output Flows and Waste Categories- TSM-DE15M(II)

PARAMETER	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
HWD:Hazardous waste disposed	kg	6.73E-06	1.10E-08	0.00E+00	6.74E-06
NHWD:Non-hazardous waste disposed	kg	1.36E-07	2.76E-05	1.31E-03	1.34E-03
RWD:Radioactive waste disposed	kg	1.38E-11	2.57E-10	8.89E-13	2.72E-10
MRF:Materials for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU:Components for re-use	kg	0.00E+00	9.25E-05	1.71E-03	1.80E-03
ETE: Exported thermal energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE: Exported electricity energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 13. Resource Use- TSM-DE17M(II)

PARAMETER	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
PENRE:Non-renewable primary resources used as an energy carrier (fuel)	MJ	7.61E-02	7.99E-02	1.19E-02	1.68E-01

PERE:Renewable primary energy used as energy carrier (fuel)	MJ	2.47E-02	5.80E-03	4.72E-04	3.10E-02
PENRM:Non-renewable primary resources with energy content used as material	MJ	3.42E-03	6.66E-03	0.00E+00	1.01E-02
PERM:Renewable primary resources with energy content used as material	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT:Total use of non-renewable primary energy resources	MJ	7.95E-02	8.66E-02	1.19E-02	1.78E-01
PERT:Total use of renewable primary energy resources	MJ	2.47E-02	5.80E-03	4.72E-04	3.10E-02
FW:Use of net fresh water	m3	1.33E-01	3.81E-02	8.24E-04	1.72E-01
MS: Use of secondary raw materials	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF:Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF:Use of none renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 14. Output Flows and Waste Categories- TSM-DE17M(II)

PARAMETER	UNIT	UPSTREAM	CORE STREAM	DOWNSTREAM	TOTAL
HWD:Hazardous waste disposed	kg	8.54E-06	0.00E+00	0.00E+00	8.54E-06
NHWD:Non-hazardous waste disposed	kg	2.56E-07	2.28E-08	1.30E-03	1.30E-03
RWD:Radioactive waste disposed	kg	8.90E-12	2.61E-10	7.09E-13	2.70E-10
MRF:Materials for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU:Components for re-use	kg	0.00E+00	9.33E-05	1.71E-03	1.80E-03
ETE: Exported thermal energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE: Exported electricity energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5. LCA Interpretation

The contribution analysis of the PV module products on various impact categories reveals that PV module including raw components production stage and PV plant construction stage are the main contributions to environmental impact categories. In terms of production stage, electricity consumption for ingot, wafer, cell and PV module and supply of solar glass are two key impact components, and for the PV plant construction stage, cable and bracket used for PV plant infrastructure are the two key impact components.

6. Additional Environmental Information

6.1. Additional Environmental Indicators

An additional indicator is the Return On Energy (RoE). This parameter gives an estimate of the efficiency of the photovoltaic park's solar energy production. The results are shown on Table 23.

The calculation of RoE is done using the following formula:

$$\text{RoE[years]}=\frac{E_{invested}}{E_{produced,annual}}$$

where: $E_{invested}$ =PENRT+PERT, $E_{produced,annual}$ = total amount of electricity generated in a year by the solar park

Table 23. RoE results of Trina Solar PV modules

MODULE	DE15M(II)	DE17M(II)
RoE	1.63	1.63

6.2. 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
- ISO45001: 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

8. References

BS EN 50693:2019, Product category rules for life cycle assessments of electronic and electrical products and systems

EN 15804:2012+A2:2019, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

(EU)1907/2006 (REACH): Regulation (EC) No 1907/2006

GB 50797-2012 Design specification for photovoltaic power station

ISO 14025 - ISO14025:2011-10, Environmental labels and declarations - Type III environmental declarations - Principles and procedures

PCR EPDItaly007: Electronic and Electrical Products and Systems.

PCR EPDItaly014: Electricity Produced by Photovoltaic Modules.

T/CESA 1074—2020 T/CPIA 0021—2020 Technical specification for green-design product assessment - photovoltaic silicon wafer

www.polywater.com: Water Consumption in PV Panel Cleaning

LCA Report - LCA Report for photovoltaic modules (TSM-DE15M(II), TSM-DEG15M.20(II), TSM-DEG15MC.20(II), TSM-DE17M(II), TSM-DEG17M.20(II), TSM-DEG17MC.20(II)) by Qiang Yang & Bill Kung, Ecovane Environmental Co., Ltd, November 8. 2020

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