RISEN ENERGY

Environmental Product Declaration

In accordance with ISO 14025

BIFACIAL DUAL-GLASS MONOCRYSTALLINE PHOTOVOLTAIC MODULES

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Programme information

Programme:	The International EPD® System EPD International AB Box 210 60 SE-100 31 Stockholm Sweden www.environdec.com info@environdec.com

Product category rules (PCR):	*PCR 2007:08 Electricity, steam and hot water generation and distribution (Version 4.0)*
PCR review was conducted by:	*Karin Lundmark, Vattenfall AB, karin.lundmark@vattenfall.com* *Sara McGowan, Vattenfall AB, sara.mcgowan@vattenfall.com*
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification	
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Version history

This document has been issued in the following versions:

- 2021-02-20: Version 1.0
- 2021-08-19: Version 2.0. The background electricity data was updated using the updated China Grid Electricity data in 2018

Company information

Owner of the EPD:
Risen Energy Co., Ltd.
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Description of the organisation:
Risen Energy Co., Ltd. was founded in 1986 and listed as a Chinese public company in 2010. Risen Energy Co., Ltd. is one of the pioneers in solar industry and has committed to this industry as a R&D expert, an integrated manufacturer from wafers to modules, a manufacturer of off-grid systems, and also an investor, a developer, and an EPC of PV projects. Aiming to deliver the green energy worldwide, Risen Energy is developing internationally with offices and sales networks in China, Germany, Australia, Mexico, India, Japan, USA and others. After years of efforts, it has reached a module production capacity of 13GW. While growing rapidly, its annual sales exceeded 14.4 billion RMB.

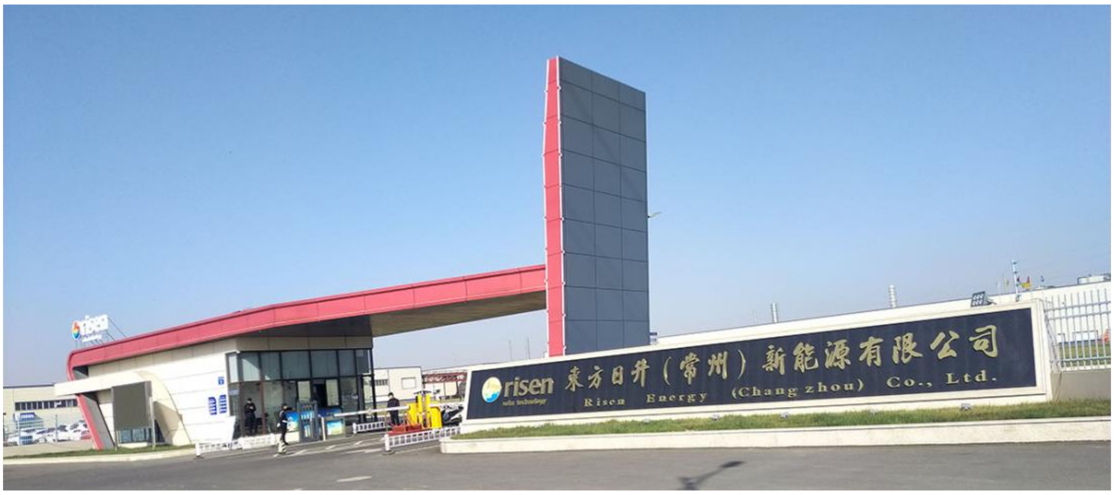

Figure 1 Risen Energy (Changzhou) Co., Ltd.

Product information

Product name:
Risen Energy Bifacial Dual-glass Monocrystalline Photovoltaic Modules

UN CPC code:
171 Electrical Energy

Geographical scope: Global

Product description:
Risen Energy produces more than a dozen series of mono-crystalline silicon PV modules. The PV module products integrate several technologies such as higher efficiency Mono PERC cell technology, low current density technology to decrease the internal power consumption effectively, and MBB and HC technology to reduce the negative effect to yield caused by micro crack and shadow. Besides, bifacial technology enables additional energy harvesting from rear side (up to 30%). The module products have industry leading low thermal co-efficient of power, excellent low irradiance performance, and excellent PID resistance. Risen Energy's modules meet the qualification criteria of TÜV, CE, GS, ROHS, REACH, PAHS and other international certifications, and have taken the lead in passing the ISO14001 environmental management system, ISO9001 quality management system and GB/T28000 occupational health and safety management system certification.

Within this project, one model of double glass PV module was analyzed: RSM144-7-xxxBMDG.
Note: *RSM: Risen solar module; xxx: different power output values; BMDG: bifacial double glass module; 144: Number of half cells; 7: 166*83 mm half-cut solar cells.*

Product Application:
Solar PV modules produced by Risen have high reliability and are almost maintenance free. The modules can be ideally applied in remote areas power system, home power system, renewable energy, hydropower station, automobile water pump, communication system or directly compose solar PV plant. These systems can be with storage battery or directly grid-connected without storage battery.

Product identification:

Table 1 Product technical specifications

Series (brand name)	Power output range (W)	Dimensions(mm^3)	Module efficiency (%)
RSM144-7-xxxBMDG	440-455	2128×1048×30/35/40	19.7-20.4

Manufacturing Process:
The manufacturing process of PV modules includes solar cells production and PV modules production. Figure 2 and Figure 3 below are flowcharts depicting the production process stages of the declared products. For simplification purpose, only main stages of manufacturing are presented. Raw material, auxiliary processes that were considered in the LCA but not shown in the flowcharts 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.

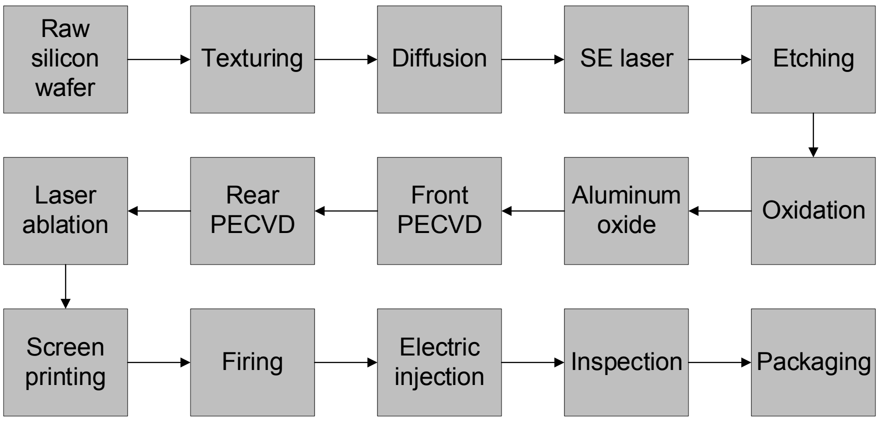

Figure 2 Manufacturing process flowchart of solar cells

Solar cells production

Step 1: Texturing
In order to enhance cell absorbing capability of solar light, silicon surfaces need to be textured into pyramids in micrometer-order, taking advantage of varied etch rate of wafer's different crystal orientations by alkali solution.

Step 2: Diffusion
Phosphorus dopants are introduced into silicon via the chemical reaction between phosphorus oxychloride and silicon at high temperature, taking advantage of the phosphorus concentration gradient and forming the PN junction, which generates photocurrent under solar light.

Step 3: SE Laser
Laser is used to push further phosphorus junction depth, forming selectively heavy diffusion region, and therefore improving open-circuit voltage and short-circuit current, and ultimately improving the solar cell conversion efficiency.

Step 4: Etching
Acid solutions are used to etch away phosphosilicate glass (PSG) at rear and side surfaces, and polish further the rear surfaces, improving the rear surface passivation quality, and therefore improving the solar cell conversion efficiency.

Step 5: Oxidation
Under high temperature, oxygen is used to generate a silicon dioxide thin film on silicon surface, passivating silicon surface defect, absorbing impurity metal ions, suppressing surface recombination, and ultimately improving the solar cell conversion efficiency.

Step 6: Aluminum oxide
Silicon nitride capping layer atop aluminum oxide is deposited to passivate the rear silicon surfaces, exhibiting prominent advantage over the conventional aluminum back field surface (Al-BSF) technology.

Step 7: Front Plasma enhanced chemical vapor deposition (PECVD)
By heating and drying the back passivated silicon wafer, the water vapor can be completely removed through negative pressure ventilation, and the impurities in the silicon wafer can be more fully separated out and defects can be reduced by gradient cooling.

Step 8: Rear PECVD
Through the reaction between silane, N_2O and ammonia, silicon nitride and silicon oxynitride thin films are deposited at rear side of cell, which can decrease reflectivity, increase solar absorption, and improve the solar cell conversion efficiency.

Step 9: Laser ablation
Silicon nitride and aluminum oxide at rear surface is ablated with laser for the direct contact of screen-printed aluminum and silicon surface, forming aluminum silicon alloy back surface field.

Step 10: Screen printing
Silver and aluminum pastes are screen printed on both sides to create designated patterns for effective carrier transport contacts.

Step 11: Firing
The metallized electrode is formed by high temperature, make the wafer have effective current collection ability.

Step 12: Electric injection
The electric current is injected into the cell, to improve the capability of the light induced degradation.

Step13: Inspection
Make final visual and functional inspection, and then sort them to corresponding cell boxes.

Step 14: Packaging
The same color and efficiency cell are packed and put into storage.

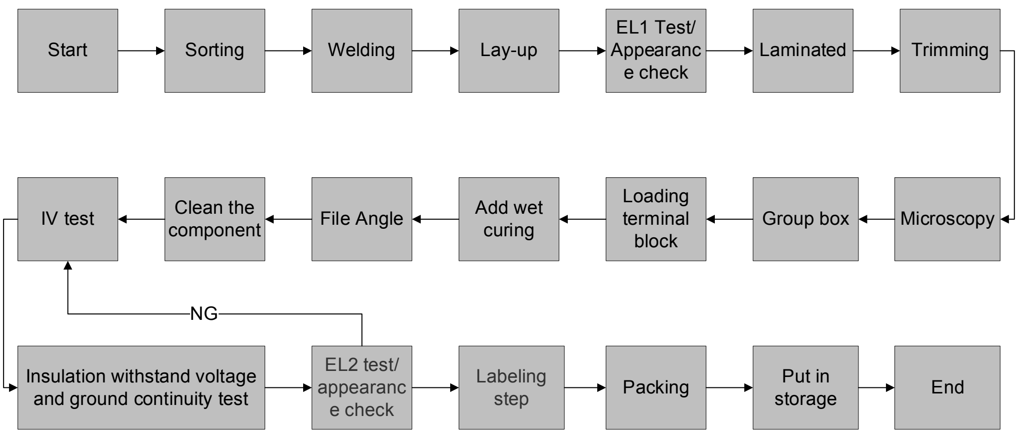

Figure 3 Manufacturing process flowchart for PV modules

PV modules production

Step 1: Sorting
Sort the batteries which meet the requirements of the order and check whether they conform to the standards. Prepare for welding procedure.

Step 2: Welding
Solder the positive and negative electrodes of the single-welded batteries together to form a battery string and prepare for the lamination process. Repair the nonconforming battery string.

Step 3: Lay-up
Connect the soldered battery strings with busbar, and prelay glass, EVA film, TPT or glass back plate to protect the battery.

Step 3: EL1 test/Appearance check
Conduct appearance and electroluminescent imaging (El) inspection on the PV modules before lamination.

Step 4: Lamination
Preliminary inspection on the appearance and EL of laminated components to improve yield and product quality. Rework the undesirable laminated components.

Step 5: Laminated
The lamination process is to melt ethylene-vinyl acetate (EVA) and solidify the laminate at a certain temperature. Laminating process is a key step of component production, which has a key influence on the quality of component products.

Step 6: Trimming
Trim the laminated components to prepare the frame.

Step 7: Microscopy
Re-check the laminated components, isolate the defective products timely and give feedback to improve the quality of components.

Step 8: Group box
The profile and junction box are mounted with sealed silicone on laminates to increase component strength, further seal the battery assembly and extend the service life of the components. Put the automatic glue uneven secondary tonic. Install aluminum frame and junction box on the laminate with sealed silica gel, increase the strength of the component, further seal the battery component, and extend the service life of the component.

Step 9: Loading terminal block
The junction box is glued with silicone to the back of the assembly and the lead-out wire is welded to make the assembly and the wire box work. Then in the AB glue potting.

Step 10: Add wet curing
Solidify the assembled components, and place the poor sealing of components to prepare for cleaning.

Step 11: File Angle
Fix and polish the four corners of the component.

Step 12: Clean the component
The silica gel and other dirt on the surface of the component shall be cleaned with alcohol to make the appearance of the component clean and beautiful, and check whether the appearance of the component meets the standards.

Step 13: IV test
Verify the output power of the battery component, test its output characteristics, and determine the power level of the component.

Step 14: Insulation withstand voltage and ground continuity test
Insulation test: test whether the current-carrying part of the component is well insulated with the frame or external;
Voltage withstand test: the insulation material and insulation structure of the voltage withstand test;
Grounding test: to determine whether the safety grounding wire can bear the current flow of the fault under the condition of the fault of the measured object.

Step 15: EL2 test/appearance check
Check whether there is any problem of battery cells in the component, such as hidden cracking, fragment, black plate, etc., and determine the level of component EL.

Step 16: Labeling step
Separate components in different gear positions to prepare for packaging.

Step 17: Packing
Packing finished components in specified quantity for easy transportation and sale.

Step 18: Put in storage
Put the packed components into the warehouse procedure.

Content declaration

Raw materials of the different PV modules are mostly the same, including solar cells, solar glass, aluminium frame, silica gel, junction box and packaging etc. The type and ratio of raw materials per module are listed in Table 2.

Table 2 Raw materials of double glass PV modules

Materials	Units	RSM144-7-xxxBMDG	Ratio
Solar cells	kg	0.7776	2.64%
Glass	kg	22.12	74.99%
POE	kg	2.66	9.02%
Aluminium Frame	kg	2.29	7.76%
Ribbon (bus bar)	kg	0.038	0.13%
Ribbon (interconnect bar)	kg	0.166	0.56%
Silica gel	kg	0.295	1.00%
Junction Box	kg	0.129	0.44%
Corrugated Box	kg	0.12155	0.41%
Wood board	kg	0.8571	2.91%
Flux	kg	0.0264	0.09%
Packaging film	kg	0.01759	0.06%

Transportation

The transportation mainly takes place on the upstream of raw material supply and downstream of PV modules and other equipment delivery to the solar PV plant. According to Risen Energy, the production of solar cells is located in Changzhou, Jiangsu province. As for the production of PV modules, RSM144-7-xxxBMDG is produced in both Changzhou and Yiwu, Zhejiang province. The raw materials are mainly sourced from Jiangsu and Zhejiang province, and delivered by lorry. The transportation distances provided by Risen Energy were used. For packaging materials, Risen Energy purchased from several local markets, largest transportation distance 100 km was used. For all transportation vehicles, since it was not specified, 20t lorry was used for LCA modelling.

Product Installation

The specific data regarding solar PV plant installation was taken from a real PV plant in Hami, Xinjiang in China, the PV plant with energy yield capacity at 100MW is constructed with RSM144-7-450M PV modules. The detailed information about the PV plant is listed in Table 3.

Table 3 PV plant information

Parameters	Value		Source
	Amount	Unit	
Peak power of the plant	100,000	KW	Risen Energy
Plant latitude and longitude	42.83°N,93.52°E	°	Risen Energy
Plant altitude	21	m	Risen Energy
Nominal solar irradiance	2,147,900	Wh/m²/year	Risen Energy

Use, Maintenance, and Reference Service Life

In terms of electricity generation during RSL (30 years), as provided by Risen Energy, the electricity generation in the first year was calculated with the aid of PVSYST V6.85, total electricity generation during RSL can be calculated with following equation:

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

where E_{RSL} is electricity generation during RSL, E_1 is electricity generation for the first year of operation, deg is yearly degradation rate (%), 1.50% in the first year and 0.45% in the rest of year during RSL. n (n=30) is RSL. Table 4 listed the E_1 (calculated with PV system) and E_{RSL} (calculated by *Eqn.* (1)).

Table 4 Electricity generation during RSL of the plant

Year	Electricity generation, kWh	Deg, %
1	185,557,255	1.5
2	184,722,247	0.45
3	183,890,997	0.45
4	183,063,488	0.45
5	182,239,702	0.45
6	181,419,623	0.45
7	180,603,235	0.45
8	179,790,521	0.45
9	178,981,463	0.45
10	178,176,047	0.45
11	177,374,254	0.45
12	176,576,070	0.45
13	175,781,478	0.45
14	174,990,461	0.45
15	174,203,004	0.45
16	173,419,091	0.45
17	172,638,705	0.45
18	171,861,831	0.45
19	171,088,452	0.45
20	170,318,554	0.45
21	169,552,121	0.45
22	168,789,136	0.45
23	168,029,585	0.45
24	167,273,452	0.45
25	166,520,722	0.45
26	165,771,378	0.45
27	165,025,407	0.45
28	164,282,793	0.45
29	163,543,520	0.45
30	162,807,574	0.45
E_{RSL}	**5,218,292,168**	

For double glass module RSM144-7-xxxBMDG, ground albedo 30% was used for electricity generation calculation. As for other power outputs of this module series analyzed in this study, the relevant number of modules employed and electricity generation during RSL are listed in Table 5. During the operation of the plant, the electricity consumption E_c is 48,457,600 kWh, and the distribution loss D_{loss} from the plant to the grid is 1.09%. Therefore, the net electricity generation $E_{RSL,net}$ was calculated and listed in Table 5. A sensitivity analysis was also conducted to analyze the variation of environmental impacts for different power outputs.

Table 5 Electricity generation during RSL for all power outputs

RSM144-7-xxxBMDG				
Power output, W	455	450	445	440
E_1, kWh	203,587,000	203,480,000	203,593,000	203,386,000
E_{RSL}, kWh	5,639,449,672	5,636,485,725	5,639,615,874	5,633,881,883
E_c, kWh	48,457,600			
D_{loss}, %	1.09			
$E_{RSL,net}$, kWh	5,530,050,258	5,527,118,618	5,530,214,649	5,524,543,158

Reuse, Recycling, Energy Recovery, and Disposal

For the end-of-life stage, De-construction (C1) of the PV plant during the disposal stage was assumed to consume mainly electricity, and the electricity consumption was assumed to be the same as the construction stage (A5). 100km transportation distance from plant site to waste treatment site (C2) was assumed, and electricity used for PV module demolition during waste processing (C3) stage was assumed to be the same as PV module manufacturing stage (A3). For end of life disposal treatment process (C4), the infrastructures of PV plants such as inverters were considered fully reused, most of the PV modules will be collected and recycled. However, the PV plant has just operated, there is lack of existing data of recycling rate vs. disposal rate for PV modules. At present, hardly any regulations about PV recycle rate could be found in China. Thus, this study refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE) under EU scenario. In 2012/19/EU-Article 11 & ANNEX V, and the required recycling rate for waste PV module is 85%. Therefore, 15% of waste PV module end up with waste disposal, mostly are waste glass. Waste management scenario of 20% landfill and 80% incineration was adopted for the waste disposal. A sensitivity analysis was further conducted to see the various disposal scenarios' impact on the results.

LCA information

Functional unit:

In this report, the functional unit is defined as 1 kWh net of electricity generated by PV modules and thereafter distributed to the customer.

Time representativeness:

The study used primary data collected from May 2020 to November 2020.

Database(s) and LCA software used:

Generic data including material, energy as well as waste disposal and transportation are taken from the LCI-database Ecoinvent 3.4 with regional energy and material mix data coming from adapted China local LCI data (1mi1,2020). For the modeling and calculation, the LCA-software SimaPro version 9.1 was used.

The data quality requirements for this study were as follows:

- *Foreground data* of the considered system: such as materials or energy flows that enter the production system). These data were calculated and submitted by Risen Energy;
- *Generic data* related to the life cycle impacts of the material or energy flows that enter the production system. These data were sourced from the databases in SimaPro 9.1;
- 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 took place;
- The scenarios represented the average technologies at the time of data collection.

System diagram:

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)																
Manufacturing Stage			Distribution stage	Installation Stage	Use Stage							De-Installation Stage	End-of-life Stage			Resource recovery stage
Raw Material	Transport	Manufacturing	Transport	Assembly / Install	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction and demolition	Transport	Waste processing	disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

The system boundary considered in this LCA study is from cradle to grave. According to the PCR, the life cycle stage must refer to segmentation in the following three processes:

1. *Upstream process*: which includes all the processes upstream of the production of the PV modules and distribution to the solar PV plant. According to the PCR, the gate in this study is defined as the fence of solar PV plant. The upstream includes extraction and processing of raw materials (A1), transportation of the raw material to the factory (A2), manufacturing of the solar cells and PV modules (A3) with the supply of the energy and auxiliary material inputs, emissions, and distribution of PV modules to solar PV plant (A4). The upstream ends at the beginning of PV plant construction;

2. *Core process*: which includes core operation and core infrastructure. The core process in this study includes the 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. However, considering that the studied PV plant has just started operation, for simplification purpose, assumption was made on the LCI data during the modelling of core processes;

3. *Downstream process*: which includes all the relevant processes that take place outside of the control of the organization proposing the EPD. In this study, the downstream module includes de-construction and demolition of the solar plant (C1), transport to waste processing (C2), waste processing (C3) and disposal (C4). The benefit and avoided loads beyond the product system boundary were considered in module D within this study. However, due to the fact that it will take 30 years to enter the end-of-life stage for the PV modules, scenarios have to be developed for end-of-life treatment. For simplification purpose, assumption was made during the modeling of downstream modules, and the results of module D were not declared in the present study as the technology development in 30 years is hard to be predicted.

Figure 4 below illustrates the system boundaries for Risen Energy's PV module products, including raw material production and transportation, manufacture, delivery, solar plant installation and End-of-life.

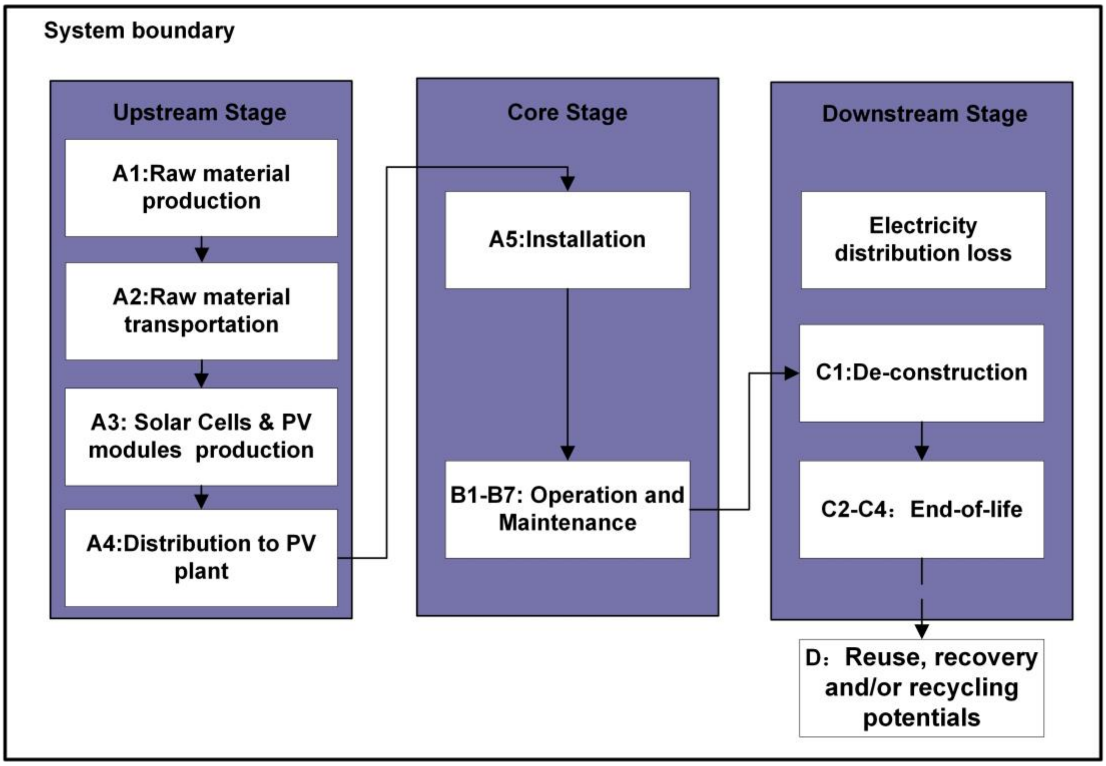

Figure 4 System boundary of PV module products

Excluded Processes:
The following steps/stages were not included in the system boundary due to the reason that the elements below are considered irrelevant or not within the boundary to the LCA study of PV module products：

- Production and disposal of the infrastructure and capital equipment (buildings, machines, transport media, roads, etc.) during PV modules manufacturing and solar plant construction and maintenance;
- The packaging for silicon wafer and solar cells is reused internally and its impact was excluded from the system;
- Emissions during the solar PV plant construction and operation due to no obvious emission observation.
- Storage phases and sales of PV products due to no observable impact;
- Product losses due to abnormal damage such as natural disaster or fire accident. These losses would mostly be accidental;
- Recycling process of defective products as it is reused internally for manufacturing process;
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.

Assumption and limitations:
In order to carry out the LCA study, the following main assumptions were made:

- For missing background data, substitution of missing data using similar background data approach was taken to shorten the gap. A sensitivity analysis was conducted.
- For production of silicon ingot and silicon wafer, background data in SimaPro was adopted. However, the electricity consumption data for silicon ingot and silicon wafer in the background database is beyond the time frame and geographical boundary of this study. To be more representative, electricity consumption of silicon ingot production and silicon wafer refers to the information provided in *China's Technical specification for green-design product assessment photovoltaic silicon wafer (T/CESA 1074—2020 T/CPIA 0021—2020)*;

- The PV plant data inventory from a real solar farm in Hami, Xinjiang with a capacity of 100MW was referred to, and the solar farm was built with RSM144-7-450M PV module. For other products with different power outputs analyzed in this study, it was assumed to be simulated and calculated based on the same energy output of the PV plant;
- Water used for cleaning the PV panels was assumed to be 0.23L (source: www.polywater.com) per module per time and two times per year. Replacement of inverter refers to *Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity (3rd Edition)*, it was assumed to be 30 years with 10% part-replacement every 10 years, which is 1 inverter every 2 years during RSL in this study;
- De-construction (C1) of the PV plant during the disposal stage consumes mainly electricity, and the electricity consumption was assumed the same as the electricity consumption in PV plant construction stage (A5). And electricity consumption for PV module dismantling at waste processing stage (C3) was assumed the same as the electricity consumption of PV module manufacturing stage (A3);
- 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 was assumed to be 100 km for simplification purposes. A sensitivity analysis was conducted.

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 was generally carried out via the mass. The consumption of raw materials and the transportation of raw materials was allocated by mass ratio.

Multi-output processes

During the production of Solar Cells and PV modules, the total consumption of energy and water during manufacturing was equally allocated to per unit mass. There are no by-products that need to be allocated.

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) was 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.

As for the end-of-life stage of the solar PV plant, following the PCR’s recommendation on end-of-life scenario of reuse, recycling and recover, along with the benefit, the load from waste treatment for recycling purpose such as de-pollution and crushing and etc., was also 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 PV module or solar PV plant (cut off approach). Since today’s average data of reuse & recycling does not represent the technology development in 30 years later. The results of reuse, recovery and/or recycling potentials (module D) was not declared in this study.

Cut-off rules:
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;
- According to PCR, data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts shall be included. Therefore, the cut off criteria was set to 1% in this study. The neglected flows are demonstrated in Table 6 below.

Table 6 Cut-off flows

Flow name	Process stage	Mass %	Reason to cut off
Silane (SiH_4)	A1	0.09	<2%
Trimethyl aluminum	A1	0.003	<2%
$POCl_3$	A1	0.004	<2%
Static Var Generator (SVG)	A5	9.2E-05	<2%
High voltage switch box	A5	0.003	<2%
Inspection during operation of solar plant	B	N/A	Cut off due to small impact according to PCR
Total cut off mass % estimated		0.1	<2%

Environmental performance

The result was allocated by stages, as shown in tables below. A sensitivity study was carried out to see the impact results of PV panels with different power output values. It can be seen that, for the module RSM144-7-xxxBMDG, higher power output results in a lower environmental impact, and the largest difference (between the highest and lowest power output) of all the environmental impacts are within 4%. Therefore, it is likely to conclude that using a single power output to represent the module's environmental performance would not generate large difference. RSM144-7-450BMDG was chosen as representative for this module.

Table 7 Environmental impacts of RSM144-7-450BMDG

Parameter	Unit	Upstream	Core	Downstream	Total
Global warming potential – Fossil (GWP-fossil)	kg CO_2 eq.	1.18E-02	2.59E-03	3.45E-04	1.47E-02
Global warming potential – Biogenic (GWP-biogenic)	kg CO_2 eq.	-4.34E-04	-1.48E-05	-2.50E-06	-4.52E-04
Global warming potential - Land use and Land transformation (GWP-luluc)	kg CO_2 eq.	1.55E-06	2.20E-06	6.08E-08	3.81E-06
Global warming potential (GWP) - Total	kg CO_2 eq.	1.13E-02	2.58E-03	3.43E-04	1.42E-02
Acidification potential (AP)	Kg SO_2 eq.	6.64E-05	2.67E-05	1.97E-06	9.50E-05
Eutrophication potential (EP)	kg PO_4^{3-} eq.	2.88E-06	4.05E-06	3.94E-08	6.97E-06
Photochemical oxidant formation potential (POFP)	kg di NMVOC eq.	3.91E-05	1.31E-05	1.23E-06	5.35E-05
Particulate matter	kg PM2.5 eq.	4.67E-06	2.71E-06	1.26E-07	7.51E-06
Abiotic depletion potential – Elements	Kg Sb eq.	5.68E-07	9.34E-08	2.27E-10	6.62E-07
Abiotic depletion potential – Fossil fuels	MJ, net calorific value	1.08E-01	3.18E-02	2.89E-03	1.43E-01
Water scarcity footprint	m^3 H_2O eq.	9.06E-03	8.53E-04	1.53E-05	9.93E-03

Use of resources

Table 8 Resource use of RSM144-7-450BMDG

PARAMETER		UNIT	Upstream	Core	Downstream	Total
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	2.44E-02	2.58E-03	4.86E-04	2.75E-02
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TOTAL	MJ, net calorific value	2.44E-02	2.58E-03	4.86E-04	2.75E-02
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.43E-01	3.42E-02	4.39E-03	1.81E-01
	Used as raw materials	MJ, net calorific value	1.34E-02	0.00E+00	0.00E+00	1.34E-02
	TOTAL	MJ, net calorific value	1.61E-01	3.42E-02	4.39E-03	2.00E-01
Secondary material		kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Net use of fresh water		m^3	1.11E-01	4.32E-03	2.48E-05	1.15E-01

Waste production and output flows

Table 9 Waste production of RSM144-7-450BMDG

PARAMETER	UNIT	Upstream	Core	Downstream	Total
Hazardous waste disposed	kg	2.10E-04	0.00E+00	0.00E+00	2.10E-04
Non-hazardous waste disposed	kg	2.15E-05	0.00E+00	1.75E-04	1.96E-04
Radioactive waste disposed	kg	1.37E-10	1.28E-10	6.40E-12	2.72E-10

Table 10 Output flows of RSM144-7-450BMDG

PARAMETER	UNIT	Upstream	Core	Downstream	Total
Components for reuse	kg	1.61E-05	0.00E+00	0.00E+00	1.61E-05
Material for recycling	kg	0.00E+00	0.00E+00	1.95E-03	1.95E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Additional environmental information

Radiology, Electro Magnetic Fields and Noise

The impact of photovoltaic power generation is mainly the noise of power generation equipment such as inverters and transformers, the low-level radiation generated by photovoltaic cells, and electromagnetism. The noise is within a controllable range and below the legally set limits. Acoustic environmental quality achieves the third class of "*Emission standard for industrial enterprises noise at boundary (GB12348-2008)*".

The radiation has little impact on the human body and the environment, similar to the battery of mobile phones and cameras. The electromagnetic field and the radio and TV interferences that will be generated by the operation of the connection line will not exceed the recommended limits.

Environmental risks

According to the analysis of atmospheric environmental impact, the atmospheric pollutants discharged by the project have a small impact on the surrounding environment, and the surrounding environment can basically maintain the status quo and meet the secondary class of *"Environmental Air Quality Standard" (GB3095-2012)* and other relevant standards.

The nitrogen-phosphorus waste water of the project is treated by the nitrogen-phosphorus waste water treatment system of the plant and then returned to the pure water station to reproduce pure water.

Non-nitrogen and non-phosphorus waste water after pretreatment meets the secondary class of *"Battery industrial pollutant discharge standard (GB30484-2013)"* and *"Sewage discharged into urban sewage water quality standard (GB/T 31962-2015)"*, eventually taken over by central treatment of sewage treatment plant. Therefore, there is no direct impact on surface water.

All the soil monitoring projects in the region where the project is located can meet the second class of the selected value of the *"Soil Pollution Risk Control Standards for Construction Land of Soil Environmental Quality (Trial) (GB36600-2018)"*, and the soil environmental quality of the region is good.

References

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ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework

ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines

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