ENVIRONMENTAL PRODUCT DECLARATION

IN ACCORDANCE WITH ISO 14025 FOR:

210 SERIES BIFACIAL DUAL-GLASS MONOCRYSTALLINE PHOTOVOLTAIC MODULES

FROM

RISEN ENERGY CO., LTD.

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EPD®

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 4.2)*
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Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification	
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Approved by:	*The International EPD® System*
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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 (Stock Code: 300118) in 2010. Risen Energy Co., Ltd. is one of the pioneers in the solar industry and has committed to this industry as an R&D expert, an integrated manufacturer from wafers to modules, a manufacturer of off-grid systems, and also an investor, a developer, and an Engineering, Procurement and Construction (EPC) of PV projects. Aiming to deliver green energy worldwide, Risen Energy is developing internationally with offices and sales networks in China, Germany, Australia, Mexico, India, Japan, the USA, and others. After years of effort, it has reached a module production capacity of 14.1GW. While growing rapidly, its annual sales exceeded 16.1 billion yuan.

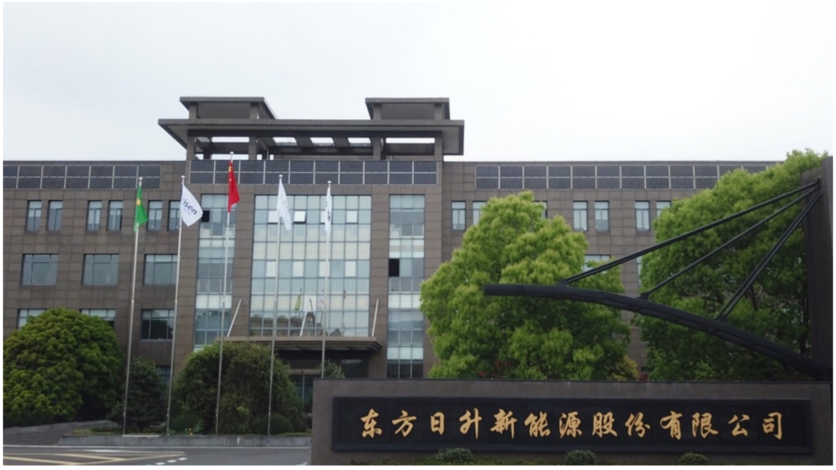

Figure 1 Risen Energy (Changzhou) Co., Ltd.

Product information

Product name:
Risen Energy 210 Series 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, two series of double glass PV module were analyzed: RSM110-8-xxxBMDG and RSM120-8-xxxBMDG.
Note: *RSM: Risen solar module; xxx: different power output values; BMDG: bifacial double glass module; 110/120: Number of half cells; 8: 210 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 (%)
RSM110-8-xxxBMDG	535-560	2384×1096×30/35/40	20.5-21.4
RSM120-8-xxxBMDG	585-610	2172×1303×35/40	20.7-21.6

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.

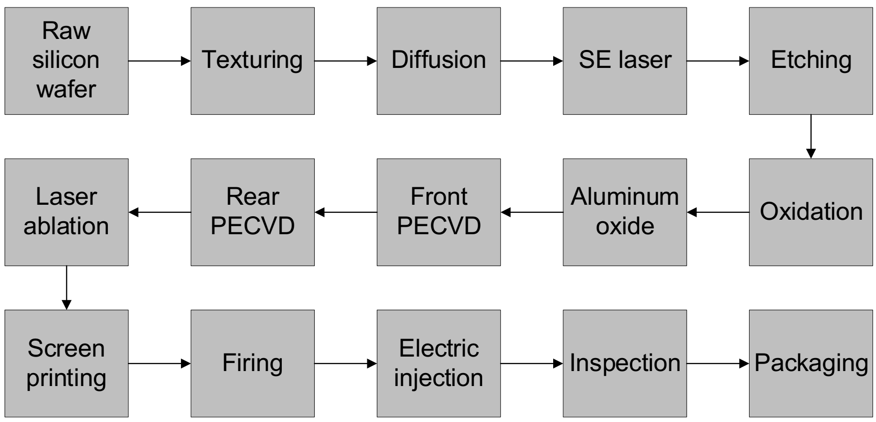

Figure 2 Manufacturing process flowchart of solar cells

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.

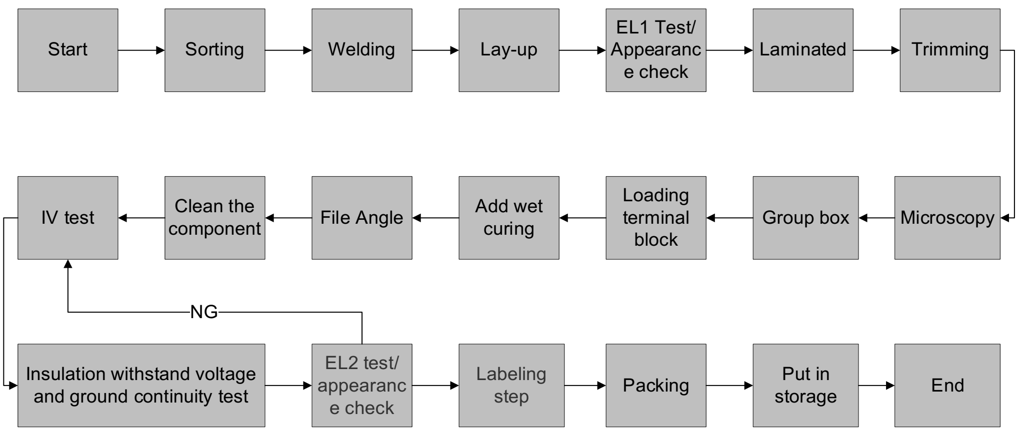

Figure 3 Manufacturing process flowchart for PV modules

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	RSM110-8-xxxBMDG	RSM120-8-xxxBMDG
Glass	kg/pcs	12.60	13.25
Back sheet	kg/pcs	12.60	13.25
Aluminium Frame	kg/pcs	2.82	3.2
Solder	kg/pcs	0.244	0.262
Solar cells	kg/pcs	0.95	1.04
Junction box	kg/pcs	0.129	0.129
Silica gel	kg/pcs	0.315	0.315
Flux	kg/pcs	0.033	0.036
POE	kg/pcs	3.12	3.38
Wood board	kg/pcs	0.84	0.774
Corrugated Box	kg/pcs	0.29	0.189
Paper	kg/pcs	0.00889	0.00889
Packaging film	kg/pcs	0.01759	0.01759

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, and PV modules are produced in 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, with an energy yield capacity of 100MW. 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	771	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 V7.2.5, total electricity generation during RSL can be calculated with following equation:

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

where E_{RSL} is electricity generation during RSL, E_1 is electricity generation for the first year of operation, deg is yearly degradation rate (%), 0.56% was used for double-glass modules. n (n=30) is RSL. Table 4 listed the E_1 (calculated with PVSYST v7.2.5) and E_{RSL} (calculated by *Eqn.* (1)).

Table 4 Electricity generation during RSL of the plant

Module Series	E_1/MWh	PR	DC:AC	Albedo	Deg	E_{RSL}
RSM110-8-560BMDG	210,056	94.17%	1.14	30%	0.46%	5,715,090,012
RSM120-8-610BMDG	206,482	94.44%	1.12	30%	0.56%	5,541,343,518

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 January 2021 to June 2021.

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 3.7 with regional energy and material mix data coming from adapted China local LCI data (1mi1,2021). For the modeling and calculation, the LCA-software SimaPro version 9.2 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 9.2;
- 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.

Internal follow-up procedures:

In order to keep the LCA data representative and reliable, input data for the LCA model as well as information in the EPD, such as raw material acquisition, transportation modes, manufacturing processes, changes in product design etc. will be checked annually by Risen Energy internally. If there would be any significant changes taking place, the LCA model, LCA report and EPD report would be updated accordingly and summited for review.

System diagram:

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; ND = 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	ND	X	ND	ND	ND	ND	ND	X	X	X	X	ND

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

1. *Upstream process*: which include extraction and processing of raw materials (A1).

2. *Core process*: which include transportation of the raw materials to the factory (A2), manufacturing of the solar cells and PV modules (A3) with the supply of the energy and auxiliary material inputs, and emissions, and distribution of PV modules to solar PV plant (A4); the construction of the solar plant (A5), the maintenance (B2) during the RSL (30 years) period; de-construction and demolition of the solar PV plant (C1); transport to waste processing (C2), waste processing (C3), and disposal (C4). However, considering that the studied PV plant has not operated for 30 years, for simplification purposes, assumption was made on the LCI data during the modeling of core processes. According to the PCR, the benefit and avoided loads in module D were not declared (reported in "ND") in the present study as the reuse and recycling processes would take place 30 years later and the technology advancement is hard to predict for now.

3. *Downstream process*: which include all the relevant processes that take place outside of the control of the organization proposing the EPD. In this study, the downstream processes include distribution loss of electricity to the customer, and operation and maintenance of the distribution systems. Since Risen Energy cannot obtain the life cycle inventory of distribution station, therefore, downstream processes will not be declared in this study (reported in "ND").

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.

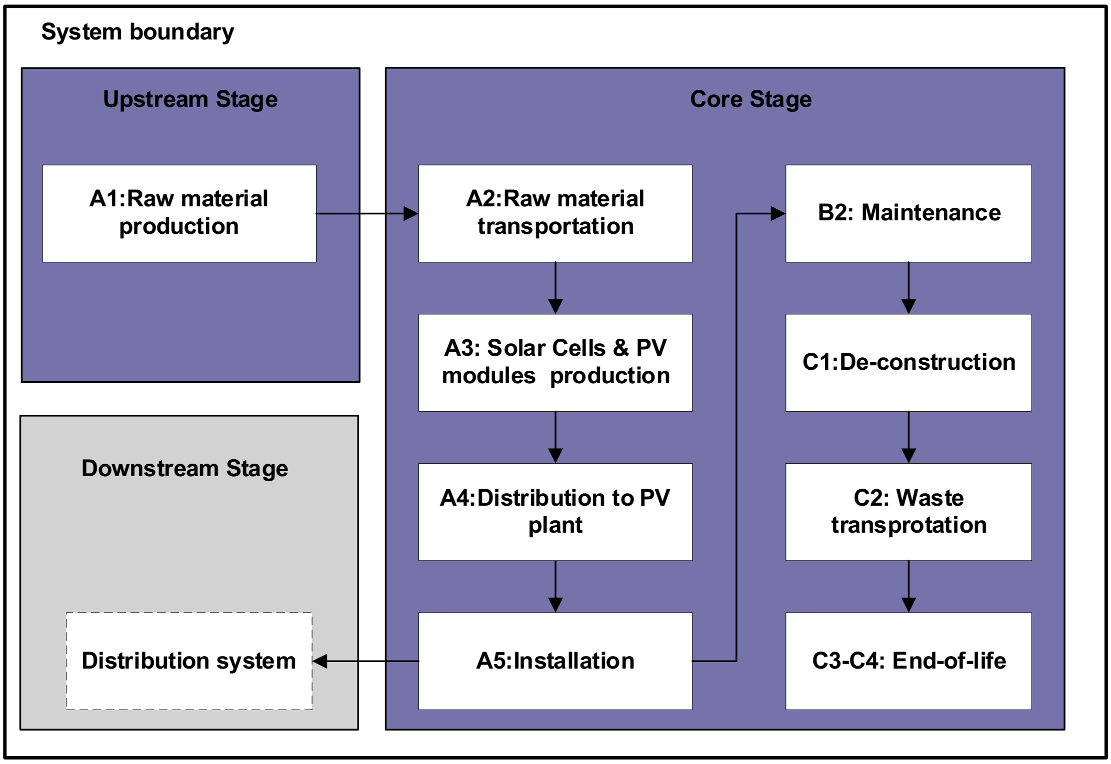

Figure 4 System boundary of PV module products

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 load and benefit of recycling waste solar modules as well as waste equipment from solar plants are excluded from the analysis;
- 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, an average LCI data for China in *IEA PVPS Task 12,2020* is used for modelling;
- The PV plant data inventory from a real solar farm in Hami, Xinjiang with a capacity of 100MW was referred to. The electricity generation during RSL is modelled with real plant via PVSYST V7.2.5, by taking the highest power output for each brand series as the representative;
- 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;

- 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 5 below.

Table 5 Cut-off flows

Flow name	Process stage	Mass %	Reason to cut off
Trimethyl aluminum	A1	0.003	<1%
Static Var Generator (SVG)	A5	9.2E-05	<1%
High voltage switch box	A5	0.003	<1%
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	<1%

Electricity mix

In this LCA study, different electricity mix was used based on grid mixes of China. The electricity inventory is based on the year 2018 for Chinese electricity generation (China Energy Statistics Yearbook 2019). For the upstream process, the production of solar cells and PV modules takes place in Jiangsu and Zhejiang province, Eastern China grid electricity mix was used. For the core process, the PV plant construction and operation take place in Xinjiang, Northwest China grid electricity mix was used.

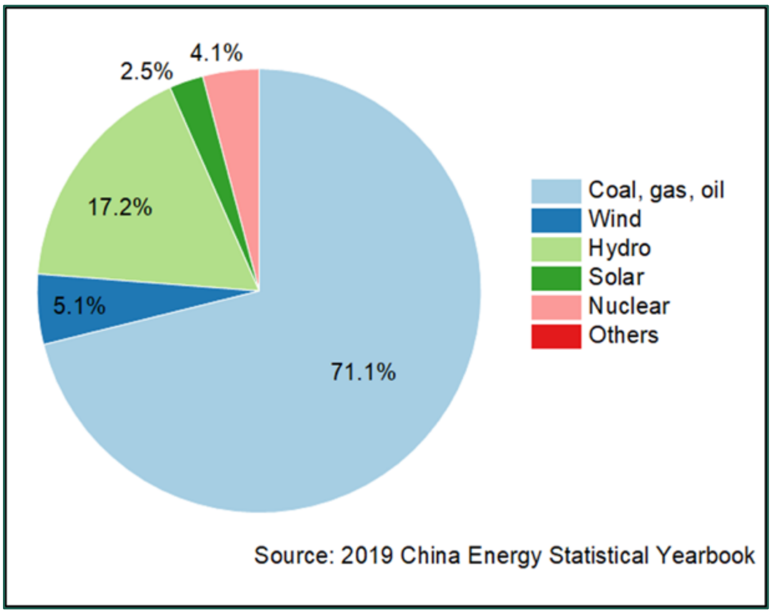

Figure 5 China's electricity production mix-2018

Environmental performance

Since all the PV modules share the same production processes and have similar life cycle stages, thus RSM110-8-560BMDG and RSM120-8-610BMDG were chosen as the representative to show the results. The result was allocated by stages, as shown in tables below. The contribution analysis of the PV module products on various impact categories reveals that PV module including raw materials stage (A1) and PV plant installation stage (A5) are the main contributions to environmental impact categories. In terms of raw materials stage, solar cell, glass, and frame are three key impact components, and for the PV plant installation stage, cable and bracket used for PV plant infrastructures are the key impact components.

Table 6 Environmental impacts of RSM110-8-560BMDG

Parameter	Unit	Upstream	Core								Downstream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Global warming potential – Fossil (GWP-fossil)	kg CO_2 eq.	1.03E-02	8.48E-05	1.18E-03	6.06E-04	3.71E-03	2.28E-07	6.32E-05	3.37E-05	4.95E-04	1.50E-06	ND	1.65E-02
Global warming potential – Biogenic (GWP-biogenic)	kg CO_2 eq.	4.15E-05	3.27E-09	1.54E-07	2.34E-08	7.73E-05	3.85E-10	6.27E-09	1.30E-09	4.69E-08	2.05E-09	ND	1.19E-04
Global warming potential - Land use and Land transformation (GWP-luluc)	kg CO_2 eq.	1.12E-05	1.53E-08	1.86E-07	1.09E-07	4.19E-06	1.09E-11	2.17E-09	6.05E-09	1.57E-08	2.70E-08	ND	1.57E-05
Global warming potential (GWP) - Total	kg CO_2 eq.	1.04E-02	8.48E-05	1.18E-03	6.07E-04	3.79E-03	2.29E-07	6.32E-05	3.37E-05	4.95E-04	1.53E-06	ND	1.66E-02
Acidification potential (AP)	Kg SO_2 eq.	5.01E-05	3.94E-07	5.67E-06	2.82E-06	2.76E-05	1.31E-09	3.06E-07	1.56E-07	2.39E-06	1.01E-08	ND	8.95E-05
Eutrophication potential (EP)	kg PO_4^{3-} eq.	1.65E-05	6.17E-08	1.23E-06	4.41E-07	1.53E-05	1.82E-10	6.28E-08	2.45E-08	4.80E-07	2.01E-09	ND	3.41E-05
Photochemical oxidant formation potential (POFP)	kg di NMVOC eq.	3.54E-05	4.56E-07	3.78E-06	3.26E-06	1.66E-05	7.31E-10	2.02E-07	1.81E-07	1.58E-06	9.89E-09	ND	6.15E-05
Particulate matter	kg PM2.5 eq.	9.14E-06	3.68E-08	1.38E-06	2.63E-07	4.00E-06	8.36E-11	7.47E-08	1.46E-08	5.83E-07	2.31E-09	ND	1.55E-05
Abiotic depletion potential – Elements	Kg Sb eq.	3.43E-07	2.27E-10	1.17E-09	1.62E-09	1.08E-07	4.95E-13	2.07E-10	9.01E-11	4.74E-10	1.29E-11	ND	4.55E-07
Abiotic depletion potential – Fossil fuels	MJ, net calorific value	1.31E-01	1.25E-03	1.04E-02	8.94E-03	4.27E-02	1.85E-06	5.65E-04	4.96E-04	4.42E-03	2.61E-05	ND	1.99E-01
Water scarcity footprint	m^3 H_2O eq.	1.43E-02	7.29E-06	6.19E-04	5.21E-05	1.10E-03	2.19E-05	5.40E-06	2.89E-06	4.15E-05	2.21E-07	ND	1.62E-02

Table 7 Environmental impacts of RSM120-8-610BMDG

Parameter	Unit	Upstream	Core									Downstream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Global warming potential – Fossil (GWP-fossil)	kg CO_2 eq.	1.14E-02	9.24E-05	1.31E-03	6.83E-04	3.83E-03	2.32E-07	6.52E-05	3.66E-05	5.46E-04	1.60E-06	ND	1.79E-02
Global warming potential – Biogenic (GWP-biogenic)	kg CO_2 eq.	4.63E-05	3.57E-09	1.71E-07	2.64E-08	7.97E-05	3.90E-10	6.47E-09	1.41E-09	5.18E-08	2.18E-09	ND	1.26E-04
Global warming potential - Land use and Land transformation (GWP-luluc)	kg CO_2 eq.	1.24E-05	1.66E-08	2.06E-07	1.23E-07	4.32E-06	1.10E-11	2.24E-09	6.58E-09	1.73E-08	2.88E-08	ND	1.71E-05
Global warming potential (GWP) - Total	kg CO_2 eq.	1.14E-02	9.24E-05	1.31E-03	6.83E-04	3.91E-03	2.32E-07	6.52E-05	3.66E-05	5.46E-04	1.63E-06	ND	1.81E-02
Acidification potential (AP)	Kg SO_2 eq.	5.53E-05	4.29E-07	6.29E-06	3.17E-06	2.85E-05	1.33E-09	3.16E-07	1.70E-07	2.63E-06	1.07E-08	ND	9.68E-05
Eutrophication potential (EP)	kg PO_4^{3-} eq.	1.82E-05	6.72E-08	1.36E-06	4.97E-07	1.58E-05	1.84E-10	6.48E-08	2.66E-08	5.30E-07	2.14E-09	ND	3.66E-05
Photochemical oxidant formation potential (POFP)	kg di NMVOC eq.	3.91E-05	4.96E-07	4.19E-06	3.67E-06	1.71E-05	7.42E-10	2.09E-07	1.96E-07	1.74E-06	1.05E-08	ND	6.67E-05
Particulate matter	kg PM2.5 eq.	1.01E-05	4.01E-08	1.53E-06	2.96E-07	4.13E-06	8.48E-11	7.70E-08	1.59E-08	6.43E-07	2.47E-09	ND	1.68E-05
Abiotic depletion potential – Elements	Kg Sb eq.	3.78E-07	2.47E-10	1.29E-09	1.83E-09	1.12E-07	5.02E-13	2.13E-10	9.79E-11	5.23E-10	1.38E-11	ND	4.94E-07
Abiotic depletion potential – Fossil fuels	MJ, net calorific value	1.43E-01	1.36E-03	1.15E-02	1.01E-02	4.40E-02	1.87E-06	5.82E-04	5.39E-04	4.88E-03	2.78E-05	ND	2.16E-01
Water scarcity footprint	m^3 H_2O eq.	1.59E-02	7.94E-06	6.87E-04	5.87E-05	1.13E-03	2.22E-05	5.57E-06	3.14E-06	4.58E-05	2.35E-07	ND	1.78E-02

Use of resources

Table 8 Resource use of RSM110-8-560BMDG

Parameter		Unit	Upstream	Core									Down-stream	Total
			A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	2.59E-02	1.55E-05	7.31E-04	1.11E-04	3.73E-03	3.08E-07	6.12E-05	6.16E-06	4.77E-04	2.82E-06	ND	3.10E-02
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0. 00E+00
	TOTAL	MJ, net calorific value	2.59E-02	1.55E-05	7.31E-04	1.11E-04	3.73E-03	3.08E-07	6.12E-05	6.16E-06	4.77E-04	2.82E-06	ND	3.10E-02
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.62E-01	1.25E-03	1.70E-02	8.93E-03	5.14E-02	2.89E-06	9.23E-04	4.96E-04	7.22E-03	2.73E-05	ND	2.49E-01
	Used as raw materials	MJ, net calorific value	3.04E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	3.04E-02
	TOTAL	MJ, net calorific value	1.92E-01	1.25E-03	1.70E-02	8.93E-03	5.14E-02	2.89E-06	9.23E-04	4.96E-04	7.22E-03	2.73E-05	ND	2.80E-01
Secondary material		kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Net use of fresh water		m^3	3.57E-04	1.71E-07	1.43E-05	1.22E-06	3.67E-05	5.10E-07	1.61E-07	6.79E-08	1.24E-06	9.09E-09	ND	4.12E-04

Table 9 Resource use of RSM120-8-610BMDG

Parameter		Unit	Upstream	Core									Down-stream	Total
			A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	2.85E-02	1.69E-05	8.10E-04	1.25E-04	3.84E-03	3.13E-07	6.31E-05	6.70E-06	5.26E-04	2.82E-06	ND	3.39E-02
	Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
	TOTAL	MJ, net calorific value	2.85E-02	1.69E-05	8.10E-04	1.25E-04	3.84E-03	3.13E-07	6.31E-05	6.70E-06	5.26E-04	2.82E-06	ND	3.39E-02
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	1.78E-01	1.36E-03	1.89E-02	1.01E-02	5.30E-02	2.93E-06	9.52E-04	5.39E-04	7.98E-03	2.73E-05	ND	2.71E-01
	Used as raw materials	MJ, net calorific value	3.29E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	3.29E-02
	TOTAL	MJ, net calorific value	2.11E-01	1.36E-03	1.89E-02	1.01E-02	5.30E-02	2.93E-06	9.52E-04	5.39E-04	7.98E-03	2.73E-05	ND	3.04E-01
Secondary material		kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Non-renewable secondary fuels		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Net use of fresh water		m^3	3.96E-04	1.86E-07	1.59E-05	1.38E-06	3.78E-05	5.17E-07	1.66E-07	7.38E-08	1.37E-06	9.09E-09	ND	4.53E-04

Waste production and output flows

Table 10 Waste production of RSM110-8-560BMDG

Parameter	Unit	Upstream	Core									Down-stream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Hazardous waste disposed	kg	0.00E+00	0.00E+00	7.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	7.96E-05
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	ND	8.49E-05
Radioactive waste disposed	kg	0.00E+00	0.00E+00	2.06E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	2.06E-11

Table 11 Waste production of RSM120-8-610BMDG

Parameter	Unit	Upstream	Core									Down-stream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Hazardous waste disposed	kg	0.00E+00	0.00E+00	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	8.83E-05
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	1.48E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.41E-05	ND	8.89E-05
Radioactive waste disposed	kg	0.00E+00	0.00E+00	2.41E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	2.41E-11

Table 12 Output flows of RSM110-8-560BMDG

Parameter	Unit	Upstream	Core									Down-stream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Components for reuse	kg	0.00E+00	0.00E+00	0.00E+00	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	1.70E-05
Material for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-03	ND	1.85E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00

Table 13 Output flows of RSM120-8-610BMDG

Parameter	Unit	Upstream	Core									Down-stream	Total
		A1	A2	A3	A4	A5	B2	C1	C2	C3	C4		
Components for reuse	kg	0.00E+00	0.00E+00	0.00E+00	1.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	1.72E-05
Material for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E-03	ND	2.02E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	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.

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