CSI Solar Co., Ltd.

Environmental Product Declaration

Product name:

Mono-facial mono-crystalline silicon photovoltaic (PV) modules

Site Plants:

- Changshu, China
- Dafeng, China
- Suqian, China

in accordance with ISO 14025 and EN 15804: 2012 + A2: 2019

Program operator	EPDItaly
Publisher	EPDItaly

Declaration Number	CSI_HiKu_Series_01
Registration Number	EPDITALY0340

Issue Date	25/07/2022
Valid to	25/07/2027

Photo: CS7N-MS photovoltaic module

www.epditaly.it

EPD owner:

CSI Solar Co., Ltd.

199 Lushan Road, SND, Suzhou, Jiangsu, China, 215129

www.csisolar.com

support@csisolar.com

Contact information: **Yuan Zhou,**
yuan.zhou@csisolar.com

1. Company introduction

Canadian Solar was founded in 2001 in Canada and is one of the world's largest solar technology and renewable energy companies. It is a leading solar photovoltaic module brand, provider of solar energy and battery storage solutions, and developer of utility-scale solar power and battery storage projects with a geographically diversified pipeline in various stages of development. Over the past 20 years, Canadian Solar has successfully delivered over 55 GW of premium-quality, solar photovoltaic modules to customers across the world. Likewise, since entering the solar project development business in 2010, Canadian Solar has developed, built and connected over 5.7 GWp in over 20 countries across the world. Currently, the Company has around 500 MWp of projects in operation, nearly 6 GWp of projects under construction or in backlog (late-stage), and an additional 15 GWp of projects in pipeline (mid- to early-stage). Additionally, Canadian Solar has 1.2 GWh of battery storage projects under construction, and nearly 17 GWh of battery storage projects in backlog or pipeline. Canadian Solar is one of the most bankable companies in the solar and renewable energy industry, having been publicly listed on the NASDAQ as CSIQ since 2006. Canadian Solar is in the process of publicly listing its Module and System Solutions ("MSS") subsidiary, CSI Solar Co., Ltd. ("CSI Solar") in China since July 2020. CSI Solar is present in 18 countries and has 13 factories in 4 countries, namely in Canada, China, Vietnam, and Thailand.

As a global leading renewable energy company, Canadian Solar aims to power the world with solar energy and to create a cleaner Earth for future generations. The total electricity generated by the 55 GW of cumulative solar modules shipped over the past 20 years is equivalent to displacing approximately 139 million tons of CO2 emissions or powering over 14 million households. At Canadian Solar, we incorporate ESG, or environmental, social and governance factors, across our business and strategic decisions and continue to make efforts to improve our practices to ensure long-term sustainability.

2. General information

EPD owner	CSI Solar Co., Ltd.
Address of EPD owner	199 Lushan Road, Suzhou 215129, China
Product name	Mono-facial mono-crystalline silicon photovoltaic (PV) modules
Name and location of production sites	• Canadian Solar Manufacturing (Changshu) Inc. –Changsheng Road, Yang Yuan, Xin Zhuang Town, 215500, Changshu City; • Canadian Solar Sunenergy (SuQian) Co., Ltd - 177 Tongda Avenue, Suqian Economic and Technological Development Zone, 223800, Jiangsu • CSI Modules (Da Feng) Co., Ltd - No.5, Yong Sheng road, Economic Development Zone, Da Feng District 224100, Yancheng City;
Field of application	Electricity generation
Program operator	EPDItaly - info@epditaly.it Address: Via Gaetano de Castillia, 10, 20124 Milano MI, Italy
CPC code	171 “Electrical energy”
Product category rules (PCR)	EPDItaly014 Rev 1.1 (Core PCR for ELECTRICITY PRODUCED BY PHOTOVOLTAIC MODULES; 08/02/2022)
External audit - Third party verifier	This declaration has been prepared with reference to EPDItaly, in accordance with the General Programme Guide; further information can be found at www.epditaly.it. Independent Verification Statement: Independent verification of the declaration and data, carried out according to ISO 14025: 2010. ☐ Internal ☒ External Third party verification carried out by: ICMQ S.p.A., via Gaetano De Castillia n ° 10 - 20124 Milan, Italy. Accredited by Accredia.
LCA Consultant	The LCA and report is written by: PINK Strategy - www.pink-strategy.fr Address: 38 avenue Léon Gaumont 75020 Paris Contact person: Zsuzsanna FEKI (zsuzsanna.feki@pink-startegy.fr)
Comparability	EPDs from different programs are not necessarily comparable. Full compliance with the PCR only allows EPD comparability if all stages of the life cycle have been considered. Nevertheless, discrepancies are possible. Note that different LCA software and background LCI data sets may lead to different results.
Liability	The owner of the declaration is responsible for the information and supporting evidence. The LCA consultant has no responsibility for the further use of this report for other applications. EPDItaly disclaims all liability in relation to the manufacturer's information.
Further information	This declaration is published on the basis of the EPDItaly regulation, which is available at www.epditaly.com. Further information can be found on the latter website.

3.SCOPE AND TYPE OF EPD

3.1. Scope of EPD

The present EPD study is a cradle-to-grave analysis. All life cycle stages of the products are taken into account, i.e., the extraction of raw materials, manufacturing, upstream and downstream transportation, installation, use, maintenance, and end-of-life.

Table 1 illustrates the life cycle stages included in the LCA study according to the PCR EPDItaly014 and EN15804 norm.

Life cycle stages according to EPDItaly PCR	Life cycle stages according to EN15804			Scope
Upstream Module	Product stage	A1	Raw material supply	X
		A2	Transport (to the manufacturer)	X
Core Module		A3	Manufacturing	X
	Construction stage	A4	Transport (to installation site)	X
		A5	Construction – installation process	X
	Use stage	B1	Use	X
		B2	Maintenance	X
		B3	Repair	X
		B4	Replacement	X
		B5	Refurbishment	X
		B6	Operational energy use	X
		B7	Operational water use	X
	End-of-life stage	C1	De-construction and demolition	X
		C2	Transport (to waste processing)	X
Downstream Module		C3	Waste processing	X
		C4	Disposal	X
	Benefits and loads beyond the system boundary	D	reuse, recovery and/or recycling potentials	MND
Caption: X = modules declared in the Table of Modules; MND = modules not declared in the Table of Modules.				

Table 1. Scope of cradle-to-grave EPD study on CSI Solar's mono-facial modules

3.2. Type of EPD

The present EPD study is product-specific EPD. The following mono-facial mono-crystalline silicon photovoltaic (PV) modules 5 product series are analyzed:

- CS3L-365|370|375|380|385|390MS
- CS3W-440|445|450|455|460|465|470MS
- CS6W-530|535|540|545|550|555MS
- CS7L-580|585|590|595|600|605|610MS
- CS7N-640|645|650|655|660|665|670MS

3.3. Geographical coverage

All products are produced by CSI Solar in Changshu, Suqian or Dafeng factories in China. Most of the parts are manufactured in Asia. Photovoltaic cells are manufactured in China.

The following table shows in which factories the PV modules are manufactured. Results are presented by factories where PV modules are manufactured.

		Dafeng factory	Changshu factory	Suqian factory
Mono-facial photovoltaic modules	CS3L-MS	X	X	
	CS3W-MS	X	X	
	CS6W-MS	X	X	
	CS7L-MS	X		X
	CS7N-MS	X	X	X

Table 2. PV module production by CSI Solar factories

The present EPD study is based on the scenario that the PV power plant is installed in the city of Rome in Italy. The end-of-life of PV modules is considered to be in Italy.

3.4. Applied database

Generic data for raw materials for PV module manufacturing and packaging; natural resources, such as water, energy, waste disposal and transport were taken from the LCI-database Ecoinvent 3.7, allocation, Cut-off by classification -unit with adaptation of regional energy and material data collected by PINK Strategy.

3.5. Software

The Life Cycle Assessment was performed with the software SimaPro 9.2.

4. Detailed product description

4.1. Functional unit and Reference service life

In the EPD study, the functional unit is 1 kWh of electricity generated as output from the solar photovoltaic plant. The environmental impact from this study was calculated and reported per functional unit. The calculation methodology of functional unit is explained in Chapter 6.

Following the EPD PCR, the reference service life (RSL) of CSI Solar modules is assumed to be 30 years.

4.2. Product description

CSI Solar is committed to providing high-quality solar photovoltaic modules. The present study analyses the following 5 product ranges of mono-facial mono-crystalline silicon photovoltaic (PV) modules produced by CSI Solar:

- CS3L-365|370|375|380|385|390MS
- CS3W-440|445|450|455|460|465|470MS
- CS6W-530|535|540|545|550|555MS
- CS7L-580|585|590|595|600|605|610MS
- CS7N-640|645|650|655|660|665|670MS

The maximum power generated by the analyzed module series is up to 670Wp (PV module CS7N-MS) with a module efficiency of up to 21.6%. All PV modules have outstanding shading tolerance, and excellent resistance to heavy snow and wind load, as well as they, minimize micro-crack impacts. The 1st-year power degradation of the photovoltaic module series under analysis is no more than 2% and their subsequent annual power degradation is no more than 0.55%.

Module series	Cell arrangement	Cell size (mm)	Dimensions (mm)	Module efficiency (%)	Power output (W)
CS3L-MS	120	166 x 166	1765 x 1048	19.7 – 21.1	365-390
CS3W-MS	144	166 x 166	2108 x 1048	19.7 – 21.3	440-470
CS6W-MS	144	182 x 182	2261 x 1134	20.7 – 21.6	530-555
CS7L-MS	120	210 x 210	2172 x 1303	20.5 – 21.6	580-610
CS7N-MS	132	210 x 210	2384 x 1303	20.6 – 21.6	640-670

Table 3. Module characteristics

4.3. Material Composition

Components	Main substance	CAS No. of main substance	Units	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Solar cell	Si	7440-21-3	pcs	120	144	144	120	132
Junction box	Cu	7440-50-8	kg/pcs	0.15	0.15	0.15	0.13	0.13
Ribbon string	Cu	7440-50-8	kg/pcs	0.05	0.05	0.05	0.05	0.05
Ribbon interconnection	Cu	7440-50-8	kg/pcs	0.15	0.18	0.24	0.26	0.29
Aluminum frame	Al	7429-90-5	kg/pcs	2.45	2.74	3.04	3.32	3.52
Solar glass	Na2O·nSiO2	1344-09-8; 106985-35-7	kg/pcs	14.66	17.52	20.35	22.47	24.67
Back sheet	(C10H8O4)n	25038-59-9	kg/pcs	0.78	0.94	1.07	1.20	1.32
EVA	(C2H4)x. (C4H6O2)y	24937-78- 8	kg/pcs	1.53	1.84	2.02	2.24	2.45
Silicon	SiO2	112926-00-8	kg/pcs	0.26	0.29	0.33	0.36	0.38
Flux for soldering	Sn	7440-31-5	kg/pcs	<0.04	<0.04	<0.05	<0.06	<0.06
Ethanol	C2H5OH	000064-17-5	kg/pcs	<0.002	<0.002	<0.002	<0.003	<0.003

Table 4. Material composition

4.4. Raw material transportation

The transport of raw materials happens from their place of production to the PV panels' manufacturing sites (in Dafeng, Changshu, or Suqian) in China by trucks.

Distances were calculated in accordance with the supplier's address.

4.5. Raw material allocation

The raw materials' allocation was defined by considering the production quantity, dimensions difference between PV panels with different cell sizes and modules with larger wafer sizes, and losses from the manufacturing process. PV module packaging includes paper, plastic packaging as well as wood pallets. The following tables explains the allocation of the material composition of CSI Solar's photovoltaic modules.

Changshu

	Mono-facial CS3L-MS	Mono-facial CS3W-MS	Mono-facial CS6W-MS	Mono-facial CS7N-MS
Weight of PV module (kg) incl. Packaging	22,2	26,2	30,0	35,8
Plastics				
Polypropylene	3,95%	3,97%	3,92%	3,92%
EVA	6,90%	7,02%	6,75%	6,85%
Silicon	1,21%	1,13%	1,14%	1,10%
Metals				
Aluminum	11,02%	10,47%	10,12%	9,83%
Copper	1,09%	1,04%	1,12%	1,07%
Other metals	0,02%	0,02%	0,01%	0,01%
Others				
Cells	2,94%	3,00%	3,05%	3,13%
Glass	66,00%	66,98%	67,86%	68,87%
Ethanol	0,03%	0,03%	0,03%	0,04%
Packaging				
Paper	0,90%	0,87%	0,86%	0,85%
Wood	5,60%	5,20%	4,89%	4,16%
Polyethylene	0,33%	0,28%	0,24%	0,20%

Table 5. Allocation of material composition of PV modules in Changshu factory

Dafeng

	Mono-facial CS3L-MS	Mono-facial CS3W-MS	Mono-facial CS6W-MS	Mono-facial CS7L-MS	Mono-facial CS7N-MS
Weight of PV module (kg) incl. Packaging	22,2	26,2	30,0	32,9	35,9
Plastics					
Polypropylene	3,95%	3,96%	3,92%	3,90%	3,91%
EVA	6,90%	7,01%	6,74%	6,79%	6,84%
Silicon	1,34%	1,26%	1,28%	1,26%	1,23%
Metals					
Aluminum	11,01%	10,46%	10,11%	10,07%	9,82%
Copper	1,09%	1,03%	1,12%	1,06%	1,06%
Other metals	0,02%	0,02%	0,01%	0,01%	0,01%
Others					
Cells	2,94%	3,00%	3,05%	3,10%	3,13%
Glass	65,93%	66,91%	67,79%	68,21%	68,79%
Ethanol	0,01%	0,01%	0,01%	0,01%	0,01%
Packaging					
Paper	0,90%	0,87%	0,85%	0,85%	0,85%
Wood	5,59%	5,19%	4,88%	4,52%	4,15%
Polyethylene	0,33%	0,28%	0,24%	0,21%	0,20%

Table 6. Allocation of material composition of PV modules in Dafeng factory

Suqian

	Mono-facial CS7L-MS	Mono-facial CS7N-MS
Weight of PV module (kg) incl. Packaging	32,9	35,8
Plastics		
Polypropylene	3,91%	3,92%
EVA	6,79%	6,85%
Silicon	1,17%	1,13%
Metals		
Aluminum	10,08%	9,83%
Copper	1,07%	1,07%
Other metals	0,01%	0,01%
Others		
Cells	3,10%	3,13%
Glass	68,28%	68,86%
Ethanol	0,01%	0,01%
Packaging		
Paper	0,86%	0,85%
Wood	4,52%	4,16%
Polyethylene	0,21%	0,20%

Table 7. Allocation of material composition of PV modules in Suqian factory

4.6. Production process

The 5 mono-facial PV module series analyzed in this LCA refer to panels that are manufactured in the same way. The main difference is in the use of cells with larger sizes (in the area) and the number of cells. It leads to changes in the dimensions of some components such as solar-glass, frame, EVA, and back sheet.

For the manufacturing, the following parameters were taken into account as the inputs of this process:

- Raw materials and auxiliary material production and transportation;
- Energy consumption;
- Tap water consumption;
- Steam consumption;
- Waste (including transport to waste treatment plant);
- Wastewater.

The following chart illustrates the production process of photovoltaic modules in CSI Solar's module factories in Dafeng, Changshu and Suqian.

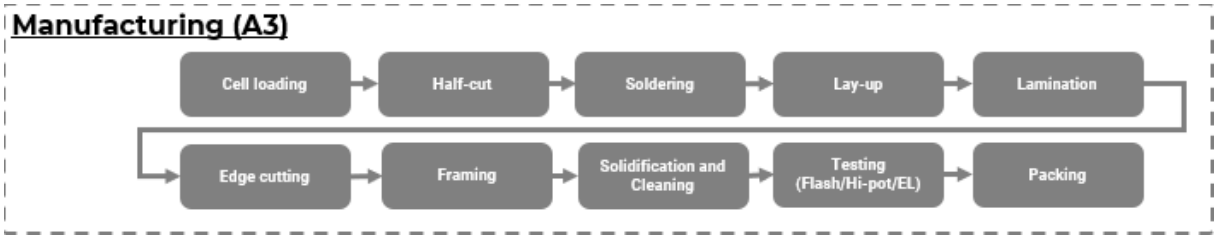

Figure 1. CSI Solar's PV module manufacturing process

The manufacturing process starts with the loading of cells that are half-cut with a laser. Copper tabs are then soldered to the individual solar cells after which the front of one cell is interconnected to the back of the next cell to form a string. This is followed by the lay-up process. During the lay-up process, strings of soldered cells, glass, and foils are placed on top of each other and the connecting of the strings happens.

The manufacturing process continues with the lamination where the encapsulation foil is cured at an elevated temperature. The next stage is edge trimming, where the edges of the encapsulation foil and back sheet foils are cut off. Once edges have been cut, the framing process begins. This phase involves sealing the edges of the module with silicone and framing it with an aluminum frame. Once the silicone has solidified, the PV modules are cleaned. The next step is the assembly of the junction box. The junction box is attached to the laminate with silicone.

Photovoltaic modules are then tested. For example, the solar simulation means that the module power in Wp is measured by flashing 1000 W/m^2 on the module. The finished PV modules are then packaged.

4.7. PV module transportation

This life cycle assessment is promoted by the use of CSI Solar panels for the Italian market. Therefore, the LCA modeling for the transportation data was based on the scenario that the PV modules are transported from the production plant in China to a roof-mounted PV plant in Italy. The mean of transportation is both trucks and ship.

4.8. Installation and reference service life

As CSI Solar is a module manufacturer, PINK Strategy has built a model for the impact of installation based on more than 10 years of Solstyce experience and multiple LCAs performed for other EPC and Photovoltaic developer.

According to industry practices and in order to maximize PV panel efficiency for the present EPD study, the monofacial modules were considered for flat roof applications due to their lighter weight. For the scope of this assessment, the installation activity involves the action of placing the solar panel in a

solar-irradiation-exposed location. Auxiliary equipment is considered including an electric installation system, inverters, and the roof mounting system. The transport of auxiliary equipment and the waste disposal of the packaging materials were also considered in this module.

The impact of the construction site for roof mounted PV plant is limited to the use of large lifting engine to deliver equipment to roof top. The rest of the work is performed with small rechargeable manual equipment with a negligeable impact.

The reference service life for the PV modules is 30 years. The energy produced by a photovoltaic module depends on the installed power peak [Wp] and the module efficiency, the latter decreases with time, due to performance changes during lifespan according to degradation rate. Linear annual degradation was assumed over reference service life (RSL). The current technology of PV modules with monocrystalline silicon cells, used in CSI Solar cells panels, sees its power decrease at most of 0.55 % for mono-facial PV modules per year according to datasheets.

The total electricity generation from the plant to the grid during RSL is listed in the table below.

	Unit	Source	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Specific production	kWh/kWp/year	Pvsyst simulation	1 487	1 477	1 479	1 480	1 497
First-year production	kWh	Pvsyst simulation	150 783	149 919	149 415	148 941	150 458
E_{RSL}	kWh/PV	PINK calculation	16 079	19 244	22 762	25 027	27 811

Table 8. Energy production over Reference service life

4.9. End-of-life

In this EPD study, the end-of-life phase covers the deconstruction of the PV power plant, the transportation of wastes to the waste treatment facility, the waste processing, and the final disposal of wastes. Energy is needed to de-construct the PV power plant. The energy consumption during the deconstruction of the PV plant (C1) was considered the same as the energy consumption during the construction stage (A5).

Then, the product will be first transported to a waste treatment center of recycling for PV panels in Italy. In the waste treatment facility, the sorting of the PV module parts happens. After the recuperation of recyclable parts, the rest of the materials considered as not-recyclable will be transported to disposal for incineration or landfill, while recyclable materials will be transported to each EoL treatment plant according to their nature.

The entire waste treatment process is carried out using mechanical technology only as illustrated in Figure 2. The PV module is deconstructed manually, separated mainly into an aluminum frame, the junction box, and the PV module. Subsequently, the module is first cut into strips and then ground. A mechanical process makes it possible to separate the shredded material into different fractions (glass, ferrous metals, non-ferrous metals, polymers, silicon, and final waste). In this EPD study, according to

the actual scenario on today's market, cells are considered as stored because of economic factors till an efficient recycling process is in practice.

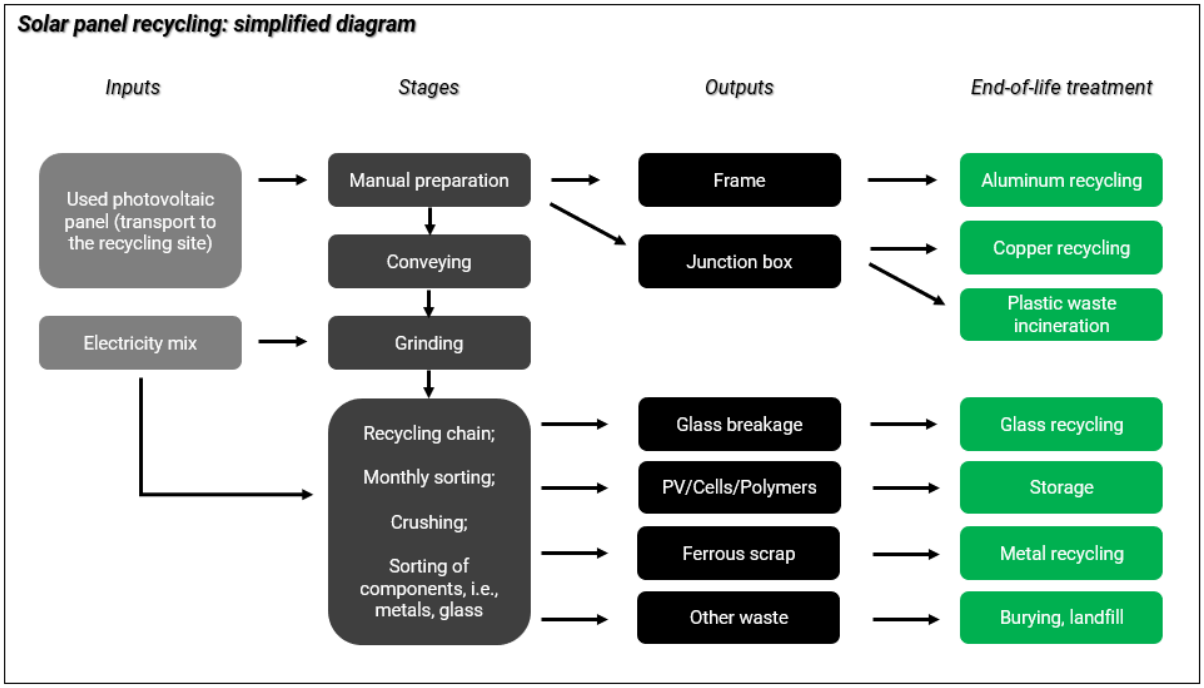

Figure 2. Recycling diagram of Fraunhofer IBP

5.LCA results

The present LCA study is made by following the requirements of PCR EPDItaly014 and based on the recommended impact analysis method for the calculation. Environmental impact indicators have been calculated by following the characterization factors included in EN 15804:2012+A2:2019.

Results are showed by environmental impact indicators, resource use indicators and output flows and waste categories indicators. Due to the number limitation of datasets presented in one EPD document, it was decided that the LCA results of CS7N-MS photovoltaic module will be presented only from Dafeng and Suqian factories. CS7N-MS module is produced only in a low amount in Suqian factory and the LCA results of the module in the three factories are coherent (<1% difference), this decision can be justified.

5.1. LCA Results – Environmental impact per functional unit

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,85E-02**	1,15E-02	7,01E-05	3,45E-04	5,11E-04	5,11E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,71E-07	1,08E-06	2,14E-05	9,15E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,85E-02**	1,17E-02	6,99E-05	3,44E-04	5,10E-04	5,01E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,58E-07	1,08E-06	2,14E-05	8,92E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-3,16E-05**	-1,39E-04	1,59E-07	7,20E-08	5,51E-07	8,43E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,28E-08	8,41E-10	5,11E-08	2,27E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,19E-05**	9,58E-06	2,71E-08	4,18E-08	2,49E-07	1,18E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,21E-10	8,47E-11	7,18E-09	2,25E-07	0,00E+00
ODP	kg CFC11 eq	**2,83E-09**	2,40E-09	1,54E-11	2,14E-12	1,11E-10	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,40E-14	2,30E-13	4,85E-12	1,82E-11	0,00E+00
AP	mol H+ eq	**1,25E-04**	6,72E-05	4,00E-07	1,77E-06	9,38E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,96E-09	6,68E-09	8,55E-08	1,32E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,73E-07	6,58E-10	8,18E-09	2,82E-09	5,13E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,81E-11	3,53E-12	1,57E-10	1,22E-08	0,00E+00
POCP	kg NMVOC eq	**9,50E-05**	5,96E-05	4,48E-07	1,05E-06	7,03E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,17E-09	8,53E-09	8,73E-08	8,91E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,37E-06**	1,03E-06	2,19E-10	3,23E-10	9,33E-10	2,31E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,69E-12	4,31E-13	7,69E-11	3,34E-08	0,00E+00
ADP-fossil	MJ	**2,02E-01**	1,25E-01	1,05E-03	3,05E-03	7,22E-03	6,23E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
WDP	m3 depriv.	**2,28E-02**	1,99E-02	4,01E-06	3,32E-05	1,85E-05	2,62E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,51E-05	2,12E-08	9,18E-07	1,32E-04	0,00E+00

Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential

Table 9. LCA results of CS3L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,84E-02**	1,14E-02	6,95E-05	3,44E-04	4,91E-04	5,12E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,71E-07	1,08E-06	2,12E-05	9,01E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,84E-02**	1,16E-02	6,93E-05	3,44E-04	4,91E-04	5,03E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-07	1,08E-06	2,11E-05	8,80E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-3,09E-05**	-1,30E-04	1,57E-07	7,19E-08	5,30E-07	7,73E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,28E-08	8,46E-10	5,06E-08	2,13E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,17E-05**	9,35E-06	2,69E-08	4,17E-08	2,40E-07	1,18E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,20E-10	8,53E-11	7,11E-09	2,17E-07	0,00E+00
ODP	kg CFC11 eq	**2,82E-09**	2,40E-09	1,53E-11	2,13E-12	1,07E-10	2,73E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,39E-14	2,32E-13	4,79E-12	1,74E-11	0,00E+00
AP	mol H+ eq	**1,25E-04**	6,65E-05	3,96E-07	1,77E-06	9,03E-06	4,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,96E-09	6,73E-09	8,45E-08	1,27E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,69E-07	6,53E-10	8,16E-09	2,71E-09	5,16E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,80E-11	3,55E-12	1,56E-10	1,17E-08	0,00E+00
POCP	kg NMVOC eq	**9,46E-05**	5,93E-05	4,44E-07	1,05E-06	6,77E-06	2,60E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,17E-09	8,59E-09	8,63E-08	8,58E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,37E-06**	1,02E-06	2,17E-10	3,23E-10	8,98E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,68E-12	4,34E-13	7,60E-11	3,13E-08	0,00E+00
ADP-fossil	MJ	**2,00E-01**	1,24E-01	1,04E-03	3,04E-03	6,95E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
WDP	m3 depriv.	**2,28E-02**	1,99E-02	3,98E-06	3,31E-05	1,78E-05	2,64E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,50E-05	2,13E-08	9,08E-07	1,26E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 10. LCA results of CS3W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,83E-02**	1,14E-02	6,77E-05	3,37E-04	4,75E-04	5,07E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,64E-07	1,08E-06	2,06E-05	8,63E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,83E-02**	1,16E-02	6,75E-05	3,37E-04	4,75E-04	4,98E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,50E-07	1,08E-06	2,05E-05	8,42E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-2,46E-05**	-1,17E-04	1,53E-07	7,05E-08	5,13E-07	7,07E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,26E-08	8,45E-10	4,92E-08	2,07E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,15E-05**	9,23E-06	2,62E-08	4,09E-08	2,32E-07	1,17E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,10E-10	8,52E-11	6,91E-09	2,08E-07	0,00E+00
ODP	kg CFC11 eq	**2,80E-09**	2,38E-09	1,49E-11	2,09E-12	1,03E-10	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-14	2,31E-13	4,66E-12	1,69E-11	0,00E+00
AP	mol H+ eq	**1,24E-04**	6,65E-05	3,86E-07	1,74E-06	8,73E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,92E-09	6,72E-09	8,22E-08	1,21E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,75E-07	6,36E-10	8,00E-09	2,62E-09	5,14E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,75E-11	3,54E-12	1,51E-10	1,11E-08	0,00E+00
POCP	kg NMVOC eq	**9,44E-05**	5,96E-05	4,33E-07	1,03E-06	6,54E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E-09	8,57E-09	8,40E-08	8,19E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,38E-06**	1,03E-06	2,12E-10	3,16E-10	8,68E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,65E-12	4,33E-13	7,40E-11	2,94E-08	0,00E+00
ADP-fossil	MJ	**1,99E-01**	1,23E-01	1,02E-03	2,98E-03	6,72E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,99E-06	1,47E-05	3,11E-04	2,30E-03	0,00E+00
WDP	m3 depriv.	**2,30E-02**	2,02E-02	3,87E-06	3,25E-05	1,73E-05	2,63E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,41E-05	2,13E-08	8,83E-07	1,19E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 11. LCA results of CS6W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,82E-02**	1,14E-02	6,82E-05	3,39E-04	4,82E-04	5,07E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,65E-07	1,08E-06	2,06E-05	8,65E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,82E-02**	1,15E-02	6,80E-05	3,39E-04	4,81E-04	4,99E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,52E-07	1,08E-06	2,06E-05	8,45E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-2,35E-05**	-1,10E-04	1,54E-07	7,08E-08	5,20E-07	6,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,26E-08	8,45E-10	4,93E-08	2,01E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,13E-05**	9,05E-06	2,64E-08	4,11E-08	2,35E-07	1,17E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,12E-10	8,51E-11	6,93E-09	2,07E-07	0,00E+00
ODP	kg CFC11 eq	**2,81E-09**	2,39E-09	1,50E-11	2,10E-12	1,05E-10	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,36E-14	2,31E-13	4,68E-12	1,68E-11	0,00E+00
AP	mol H+ eq	**1,24E-04**	6,60E-05	3,89E-07	1,74E-06	8,86E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,93E-09	6,71E-09	8,24E-08	1,20E-06	0,00E+00
EP-freshwater	kg P eq	**1,33E-06**	7,93E-07	6,41E-10	8,03E-09	2,66E-09	5,14E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,76E-11	3,54E-12	1,52E-10	1,10E-08	0,00E+00
POCP	kg NMVOC eq	**9,44E-05**	5,95E-05	4,36E-07	1,03E-06	6,64E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E-09	8,57E-09	8,42E-08	8,17E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,38E-06**	1,03E-06	2,13E-10	3,18E-10	8,81E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,66E-12	4,33E-13	7,42E-11	2,92E-08	0,00E+00
ADP-fossil	MJ	**1,97E-01**	1,22E-01	1,02E-03	3,00E-03	6,82E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,01E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
WDP	m3 depriv.	**2,23E-02**	1,95E-02	3,90E-06	3,26E-05	1,75E-05	2,63E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,43E-05	2,13E-08	8,85E-07	1,19E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 12. LCA results of CS7L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,80E-02**	1,12E-02	6,72E-05	3,35E-04	4,81E-04	5,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,60E-07	1,07E-06	2,03E-05	8,49E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,80E-02**	1,13E-02	6,70E-05	3,35E-04	4,81E-04	4,93E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,48E-07	1,07E-06	2,03E-05	8,30E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-1,92E-05**	-9,89E-05	1,52E-07	7,00E-08	5,19E-07	5,93E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,25E-08	8,35E-10	4,85E-08	1,96E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,10E-05**	8,85E-06	2,60E-08	4,06E-08	2,35E-07	1,16E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,06E-10	8,42E-11	6,82E-09	2,02E-07	0,00E+00
ODP	kg CFC11 eq	**2,77E-09**	2,36E-09	1,48E-11	2,08E-12	1,04E-10	2,68E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,33E-14	2,28E-13	4,60E-12	1,64E-11	0,00E+00
AP	mol H+ eq	**1,22E-04**	6,50E-05	3,83E-07	1,72E-06	8,84E-06	4,48E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,90E-09	6,64E-09	8,11E-08	1,17E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,82E-07	6,31E-10	7,95E-09	2,66E-09	5,08E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,73E-11	3,50E-12	1,49E-10	1,07E-08	0,00E+00
POCP	kg NMVOC eq	**9,33E-05**	5,87E-05	4,29E-07	1,02E-06	6,63E-06	2,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,14E-09	8,47E-09	8,28E-08	7,93E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,34E-06**	1,02E-06	2,10E-10	3,14E-10	8,80E-10	2,29E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,64E-12	4,28E-13	7,30E-11	2,80E-08	0,00E+00
ADP-fossil	MJ	**1,95E-01**	1,20E-01	1,01E-03	2,96E-03	6,81E-03	6,14E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,22E-03	0,00E+00
WDP	m3 depriv.	**2,21E-02**	1,93E-02	3,84E-06	3,22E-05	1,75E-05	2,60E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,37E-05	2,10E-08	8,71E-07	1,15E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 13. LCA results of CS7N-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,84E-02**	1,16E-02	3,04E-05	3,26E-04	4,86E-04	5,11E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,71E-07	1,08E-06	2,14E-05	9,15E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,85E-02**	1,17E-02	3,03E-05	3,29E-04	4,85E-04	5,01E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,58E-07	1,08E-06	2,14E-05	8,92E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-3,24E-05**	-1,37E-04	6,16E-08	-2,92E-06	5,09E-07	8,43E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,28E-08	8,41E-10	5,11E-08	2,27E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,19E-05**	9,60E-06	1,09E-08	4,00E-08	2,42E-07	1,18E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,21E-10	8,47E-11	7,18E-09	2,25E-07	0,00E+00
ODP	kg CFC11 eq	**2,83E-09**	2,43E-09	6,67E-12	1,74E-12	1,05E-10	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,40E-14	2,30E-13	4,85E-12	1,82E-11	0,00E+00
AP	mol H+ eq	**1,25E-04**	6,73E-05	1,73E-07	1,70E-06	9,28E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,96E-09	6,68E-09	8,55E-08	1,32E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,73E-07	2,88E-10	7,41E-09	2,61E-09	5,13E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,81E-11	3,53E-12	1,57E-10	1,22E-08	0,00E+00
POCP	kg NMVOC eq	**9,47E-05**	5,96E-05	1,95E-07	1,01E-06	6,92E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,17E-09	8,53E-09	8,73E-08	8,91E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,36E-06**	1,02E-06	1,04E-10	3,09E-10	8,77E-10	2,31E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,69E-12	4,31E-13	7,69E-11	3,34E-08	0,00E+00
ADP-fossil	MJ	**2,01E-01**	1,26E-01	4,57E-04	2,90E-03	6,85E-03	6,23E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
WDP	m3 depriv.	**2,28E-02**	2,00E-02	1,67E-06	5,98E-05	1,71E-05	2,62E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,51E-05	2,12E-08	9,18E-07	1,32E-04	0,00E+00

Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential

Table 14. LCA results of CS3L-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,83E-02**	1,15E-02	3,02E-05	3,25E-04	4,68E-04	5,12E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,71E-07	1,08E-06	2,12E-05	9,01E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,83E-02**	1,16E-02	3,01E-05	3,28E-04	4,67E-04	5,03E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-07	1,08E-06	2,11E-05	8,80E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-3,19E-05**	-1,28E-04	6,14E-08	-2,92E-06	4,90E-07	7,73E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,28E-08	8,46E-10	5,06E-08	2,13E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,17E-05**	9,37E-06	1,08E-08	3,99E-08	2,33E-07	1,18E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,20E-10	8,53E-11	7,11E-09	2,17E-07	0,00E+00
ODP	kg CFC11 eq	**2,82E-09**	2,42E-09	6,64E-12	1,74E-12	1,01E-10	2,73E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,39E-14	2,32E-13	4,79E-12	1,74E-11	0,00E+00
AP	mol H+ eq	**1,24E-04**	6,66E-05	1,73E-07	1,70E-06	8,93E-06	4,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,96E-09	6,73E-09	8,45E-08	1,27E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,68E-07	2,87E-10	7,40E-09	2,51E-09	5,16E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,80E-11	3,55E-12	1,56E-10	1,17E-08	0,00E+00
POCP	kg NMVOC eq	**9,42E-05**	5,93E-05	1,94E-07	1,00E-06	6,66E-06	2,60E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,17E-09	8,59E-09	8,63E-08	8,58E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,37E-06**	1,01E-06	1,03E-10	3,08E-10	8,43E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,68E-12	4,34E-13	7,60E-11	3,13E-08	0,00E+00
ADP-fossil	MJ	**2,00E-01**	1,24E-01	4,55E-04	2,90E-03	6,59E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
WDP	m3 depriv.	**2,28E-02**	1,99E-02	1,66E-06	5,97E-05	1,65E-05	2,64E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,50E-05	2,13E-08	9,08E-07	1,26E-04	0,00E+00

Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential

Table 15. LCA results of CS3W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,82E-02**	1,15E-02	2,96E-05	3,19E-04	4,52E-04	5,07E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,64E-07	1,08E-06	2,06E-05	8,63E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,82E-02**	1,16E-02	2,95E-05	3,22E-04	4,52E-04	4,98E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,50E-07	1,08E-06	2,05E-05	8,42E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-2,56E-05**	-1,15E-04	6,01E-08	-2,86E-06	4,74E-07	7,07E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,26E-08	8,45E-10	4,92E-08	2,07E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,15E-05**	9,25E-06	1,06E-08	3,91E-08	2,25E-07	1,17E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,10E-10	8,52E-11	6,91E-09	2,08E-07	0,00E+00
ODP	kg CFC11 eq	**2,80E-09**	2,40E-09	6,51E-12	1,70E-12	9,80E-11	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-14	2,31E-13	4,66E-12	1,69E-11	0,00E+00
AP	mol H+ eq	**1,24E-04**	6,66E-05	1,69E-07	1,66E-06	8,64E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,92E-09	6,72E-09	8,22E-08	1,21E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,74E-07	2,81E-10	7,26E-09	2,43E-09	5,14E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,75E-11	3,54E-12	1,51E-10	1,11E-08	0,00E+00
POCP	kg NMVOC eq	**9,40E-05**	5,96E-05	1,90E-07	9,85E-07	6,44E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E-09	8,57E-09	8,40E-08	8,19E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,38E-06**	1,03E-06	1,01E-10	3,02E-10	8,16E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,65E-12	4,33E-13	7,40E-11	2,94E-08	0,00E+00
ADP-fossil	MJ	**1,98E-01**	1,24E-01	4,46E-04	2,84E-03	6,37E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,99E-06	1,47E-05	3,11E-04	2,30E-03	0,00E+00
WDP	m3 depriv.	**2,31E-02**	2,02E-02	1,63E-06	5,86E-05	1,60E-05	2,63E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,41E-05	2,13E-08	8,83E-07	1,19E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 16. LCA results of CS6W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,82E-02**	1,14E-02	8,21E-05	3,38E-04	5,03E-04	5,07E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,65E-07	1,08E-06	2,06E-05	8,65E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,82E-02**	1,15E-02	8,19E-05	3,41E-04	5,02E-04	4,99E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,52E-07	1,08E-06	2,06E-05	8,45E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-2,63E-05**	-1,10E-04	1,67E-07	-2,98E-06	5,55E-07	6,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,26E-08	8,45E-10	4,93E-08	2,01E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,13E-05**	9,05E-06	2,94E-08	4,18E-08	2,41E-07	1,17E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,12E-10	8,51E-11	6,93E-09	2,07E-07	0,00E+00
ODP	kg CFC11 eq	**2,81E-09**	2,39E-09	1,80E-11	2,32E-12	1,09E-10	2,71E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,36E-14	2,31E-13	4,68E-12	1,68E-11	0,00E+00
AP	mol H+ eq	**1,24E-04**	6,59E-05	4,69E-07	1,76E-06	8,94E-06	4,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,93E-09	6,71E-09	8,24E-08	1,20E-06	0,00E+00
EP-freshwater	kg P eq	**1,33E-06**	7,91E-07	7,80E-10	7,96E-09	2,84E-09	5,14E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,76E-11	3,54E-12	1,52E-10	1,10E-08	0,00E+00
POCP	kg NMVOC eq	**9,45E-05**	5,94E-05	5,26E-07	1,04E-06	6,73E-06	2,59E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E-09	8,57E-09	8,42E-08	8,17E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,38E-06**	1,03E-06	2,80E-10	3,19E-10	9,29E-10	2,32E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,66E-12	4,33E-13	7,42E-11	2,92E-08	0,00E+00
ADP-fossil	MJ	**1,98E-01**	1,22E-01	1,24E-03	3,03E-03	7,14E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,01E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
WDP	m3 depriv.	**2,23E-02**	1,94E-02	4,51E-06	4,59E-05	1,87E-05	2,63E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,43E-05	2,13E-08	8,85E-07	1,19E-04	0,00E+00
Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential																		

Table 17. LCA results of CS7L-MS module in Suqian factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
GWP total	kg CO2 eq	**1,80E-02**	1,12E-02	8,07E-05	3,35E-04	5,02E-04	5,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,60E-07	1,07E-06	2,03E-05	8,49E-04	0,00E+00
GWP fossil	kg CO2 eq	**1,80E-02**	1,13E-02	8,05E-05	3,38E-04	5,01E-04	4,93E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,48E-07	1,07E-06	2,03E-05	8,30E-04	0,00E+00
GWP biogenic	kg CO2 eq	**-2,20E-05**	-9,87E-05	1,64E-07	-2,95E-06	5,55E-07	5,93E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,25E-08	8,35E-10	4,85E-08	1,96E-05	0,00E+00
GWP luluc	kg CO2 eq	**2,10E-05**	8,86E-06	2,90E-08	4,13E-08	2,41E-07	1,16E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,06E-10	8,42E-11	6,82E-09	2,02E-07	0,00E+00
ODP	kg CFC11 eq	**2,78E-09**	2,36E-09	1,77E-11	2,29E-12	1,09E-10	2,68E-10	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,33E-14	2,28E-13	4,60E-12	1,64E-11	0,00E+00
AP	mol H+ eq	**1,22E-04**	6,49E-05	4,61E-07	1,74E-06	8,93E-06	4,48E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,90E-09	6,64E-09	8,11E-08	1,17E-06	0,00E+00
EP-freshwater	kg P eq	**1,31E-06**	7,81E-07	7,67E-10	7,87E-09	2,83E-09	5,08E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,73E-11	3,50E-12	1,49E-10	1,07E-08	0,00E+00
POCP	kg NMVOC eq	**9,34E-05**	5,86E-05	5,18E-07	1,03E-06	6,72E-06	2,56E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,14E-09	8,47E-09	8,28E-08	7,93E-07	0,00E+00
ADP-minerals & metals	kg Sb eq	**3,34E-06**	1,02E-06	2,75E-10	3,16E-10	9,28E-10	2,29E-06	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,64E-12	4,28E-13	7,30E-11	2,80E-08	0,00E+00
ADP-fossil	MJ	**1,95E-01**	1,20E-01	1,22E-03	3,00E-03	7,13E-03	6,14E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,22E-03	0,00E+00
WDP	m3 depriv.	**2,20E-02**	1,92E-02	4,44E-06	4,54E-05	1,87E-05	2,60E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,37E-05	2,10E-08	8,71E-07	1,15E-04	0,00E+00

Caption: GWP total = Global Warming Potential total; GWP fossil = Global Warming Potential fossil; GWP biogenic = Global Warming Potential biogenic; GWP luluc = Global Warming Potential land use and change in land use; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP-freshwater = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic Depletion for non-fossil resources potential; ADP-fossil = Abiotic Depletion for fossil resources potential; WDP = Water deprivation potential

Table 18. LCA results of CS7N-MS module in Suqian factory

5.2. LCA Results – Resource use per functional unit

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**2,02E-01**	1,25E-01	1,05E-03	3,05E-03	7,23E-03	6,23E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
PERE	MJ, net CV	**2,50E-02**	1,72E-02	1,33E-05	3,00E-04	6,80E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,57E-07	7,59E-08	4,35E-06	3,26E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**2,01E-01**	1,25E-01	1,05E-03	3,04E-03	7,22E-03	6,22E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
PERT	MJ, net CV	**2,50E-02**	1,72E-02	1,33E-05	3,00E-04	6,80E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,57E-07	7,59E-08	4,35E-06	3,26E-04	0,00E+00
FW	m3	**5,46E-04**	4,76E-04	1,10E-07	9,59E-07	5,45E-07	6,35E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-06	5,89E-10	3,18E-08	3,76E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 19. LCA results of CS3L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**2,00E-01**	1,24E-01	1,04E-03	3,04E-03	6,95E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
PERE	MJ, net CV	**2,47E-02**	1,68E-02	1,32E-05	3,00E-04	6,54E-05	7,22E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,56E-07	7,64E-08	4,30E-06	3,11E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**2,00E-01**	1,24E-01	1,04E-03	3,04E-03	6,95E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
PERT	MJ, net CV	**2,47E-02**	1,68E-02	1,32E-05	3,00E-04	6,54E-05	7,22E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,56E-07	7,64E-08	4,30E-06	3,11E-04	0,00E+00
FW	m3	**5,46E-04**	4,76E-04	1,09E-07	9,58E-07	5,25E-07	6,39E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-06	5,93E-10	3,14E-08	3,59E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 20. LCA results of CS3W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,99E-01**	1,23E-01	1,02E-03	2,98E-03	6,72E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,99E-06	1,47E-05	3,11E-04	2,30E-03	0,00E+00
PERE	MJ, net CV	**2,46E-02**	1,67E-02	1,29E-05	2,94E-04	6,33E-05	7,17E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,41E-07	7,63E-08	4,18E-06	2,96E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,99E-01**	1,23E-01	1,02E-03	2,98E-03	6,72E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,98E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERT	MJ, net CV	**2,46E-02**	1,67E-02	1,29E-05	2,94E-04	6,33E-05	7,17E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,41E-07	7,63E-08	4,18E-06	2,96E-04	0,00E+00
FW	m3	**5,52E-04**	4,82E-04	1,06E-07	9,39E-07	5,07E-07	6,37E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-06	5,92E-10	3,05E-08	3,40E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 21. LCA results of CS6W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,97E-01**	1,22E-01	1,02E-03	3,00E-03	6,82E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,01E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERE	MJ, net CV	**2,42E-02**	1,63E-02	1,30E-05	2,95E-04	6,42E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,44E-07	7,63E-08	4,19E-06	2,95E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,97E-01**	1,22E-01	1,02E-03	2,99E-03	6,82E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,00E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERT	MJ, net CV	**2,42E-02**	1,63E-02	1,30E-05	2,95E-04	6,42E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,44E-07	7,63E-08	4,19E-06	2,95E-04	0,00E+00
FW	m3	**5,35E-04**	4,65E-04	1,07E-07	9,43E-07	5,14E-07	6,37E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-06	5,92E-10	3,06E-08	3,39E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 22. LCA results of CS7L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,95E-01**	1,20E-01	1,01E-03	2,96E-03	6,81E-03	6,14E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,22E-03	0,00E+00
PERE	MJ, net CV	**2,37E-02**	1,59E-02	1,28E-05	2,92E-04	6,41E-05	7,09E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,35E-07	7,54E-08	4,13E-06	2,85E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,95E-01**	1,20E-01	1,01E-03	2,96E-03	6,81E-03	6,13E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,21E-03	0,00E+00
PERT	MJ, net CV	**2,37E-02**	1,59E-02	1,28E-05	2,92E-04	6,41E-05	7,09E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,35E-07	7,54E-08	4,13E-06	2,85E-04	0,00E+00
FW	m3	**5,28E-04**	4,60E-04	1,05E-07	9,32E-07	5,14E-07	6,29E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,02E-06	5,85E-10	3,01E-08	3,27E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 23. LCA results of CS7N-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**2,01E-01**	1,26E-01	4,57E-04	2,90E-03	6,85E-03	6,23E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
PERE	MJ, net CV	**2,51E-02**	1,72E-02	5,71E-06	2,89E-04	6,39E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,57E-07	7,59E-08	4,35E-06	3,26E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**2,01E-01**	1,25E-01	4,57E-04	2,90E-03	6,85E-03	6,22E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,11E-06	1,46E-05	3,23E-04	2,51E-03	0,00E+00
PERT	MJ, net CV	**2,51E-02**	1,72E-02	5,71E-06	2,89E-04	6,39E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,57E-07	7,59E-08	4,35E-06	3,26E-04	0,00E+00
FW	m3	**5,47E-04**	4,76E-04	4,60E-08	1,57E-06	5,08E-07	6,35E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-06	5,89E-10	3,18E-08	3,76E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 24. LCA results of CS3L-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**2,00E-01**	1,24E-01	4,55E-04	2,90E-03	6,59E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
PERE	MJ, net CV	**2,47E-02**	1,68E-02	5,68E-06	2,89E-04	6,15E-05	7,22E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,56E-07	7,64E-08	4,30E-06	3,11E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,99E-01**	1,24E-01	4,55E-04	2,89E-03	6,59E-03	6,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,10E-06	1,47E-05	3,19E-04	2,41E-03	0,00E+00
PERT	MJ, net CV	**2,47E-02**	1,68E-02	5,68E-06	2,89E-04	6,15E-05	7,22E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,56E-07	7,64E-08	4,30E-06	3,11E-04	0,00E+00
FW	m3	**5,47E-04**	4,76E-04	4,58E-08	1,57E-06	4,89E-07	6,39E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-06	5,93E-10	3,14E-08	3,59E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 25. LCA results of CS3W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,98E-01**	1,24E-01	4,46E-04	2,84E-03	6,38E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,99E-06	1,47E-05	3,11E-04	2,30E-03	0,00E+00
PERE	MJ, net CV	**2,46E-02**	1,67E-02	5,57E-06	2,83E-04	5,95E-05	7,17E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,41E-07	7,63E-08	4,18E-06	2,96E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,98E-01**	1,24E-01	4,46E-04	2,84E-03	6,37E-03	6,20E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,98E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERT	MJ, net CV	**2,46E-02**	1,67E-02	5,57E-06	2,83E-04	5,95E-05	7,17E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,41E-07	7,63E-08	4,18E-06	2,96E-04	0,00E+00
FW	m3	**5,52E-04**	4,82E-04	4,49E-08	1,54E-06	4,73E-07	6,37E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-06	5,92E-10	3,05E-08	3,40E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 26. LCA results of CS6W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,98E-01**	1,22E-01	1,24E-03	3,03E-03	7,14E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,01E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERE	MJ, net CV	**2,42E-02**	1,63E-02	1,54E-05	2,97E-04	6,76E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,44E-07	7,63E-08	4,19E-06	2,95E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,98E-01**	1,22E-01	1,24E-03	3,02E-03	7,14E-03	6,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,00E-06	1,47E-05	3,11E-04	2,29E-03	0,00E+00
PERT	MJ, net CV	**2,42E-02**	1,63E-02	1,54E-05	2,97E-04	6,76E-05	7,18E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,44E-07	7,63E-08	4,19E-06	2,95E-04	0,00E+00
FW	m3	**5,34E-04**	4,64E-04	1,24E-07	1,25E-06	5,46E-07	6,37E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-06	5,92E-10	3,06E-08	3,39E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 27. LCA results of CS7L-MS module in Suqian factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
PENRE	MJ, net CV	**1,95E-01**	1,20E-01	1,22E-03	3,00E-03	7,13E-03	6,14E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,22E-03	0,00E+00
PERE	MJ, net CV	**2,37E-02**	1,59E-02	1,52E-05	2,93E-04	6,75E-05	7,09E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,35E-07	7,54E-08	4,13E-06	2,85E-04	0,00E+00
PENRM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERM	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ, net CV	**1,95E-01**	1,20E-01	1,22E-03	2,99E-03	7,13E-03	6,13E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,93E-06	1,45E-05	3,06E-04	2,21E-03	0,00E+00
PERT	MJ, net CV	**2,37E-02**	1,59E-02	1,52E-05	2,93E-04	6,75E-05	7,09E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,35E-07	7,54E-08	4,13E-06	2,85E-04	0,00E+00
FW	m3	**5,28E-04**	4,59E-04	1,22E-07	1,24E-06	5,45E-07	6,29E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,02E-06	5,85E-10	3,01E-08	3,27E-06	0,00E+00
MS	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ, net CV	**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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; PÈRE = Use of renewable primary energy excluding renewable primary energy resources used as raw material; PENRM = Use of non-renewable primary energy resources used as raw material; PERM = Use of renewable primary energy resources used as raw material; PENRT = Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials); PERT = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); FW = Net use of fresh water; MS = Use of secondary raw materials; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels;																	

Table 28. LCA results of CS7N-MS module in Suqian factory

5.3. LCA Results – Output flows and waste categories per functional unit

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,93E-03**	7,96E-04	1,25E-06	2,22E-05	5,52E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-08	9,83E-09	2,19E-07	1,02E-04	0,00E+00
NHWD	kg	**4,83E-02**	1,33E-02	7,66E-05	4,01E-04	3,98E-04	3,35E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,22E-07	8,35E-08	1,81E-05	5,76E-04	0,00E+00
RWD	kg	**4,48E-07**	2,30E-07	6,97E-09	1,84E-09	4,98E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-11	1,02E-10	2,21E-09	8,45E-09	0,00E+00
MER	kg	**5,97E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,97E-05	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	0,00E+00
MFR	kg	**1,09E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,09E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 29. LCA results of CS3L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,92E-03**	7,83E-04	1,24E-06	2,21E-05	5,31E-06	1,01E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,34E-08	9,90E-09	2,17E-07	9,96E-05	0,00E+00
NHWD	kg	**4,83E-02**	1,31E-02	7,60E-05	4,00E-04	3,83E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,22E-07	8,41E-08	1,79E-05	5,44E-04	0,00E+00
RWD	kg	**4,43E-07**	2,28E-07	6,92E-09	1,83E-09	4,79E-08	1,49E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-11	1,03E-10	2,19E-09	8,11E-09	0,00E+00
MER	kg	**5,43E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,43E-05	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	0,00E+00
MFR	kg	**1,07E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,07E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 30. LCA results of CS3W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,91E-03**	7,81E-04	1,21E-06	2,17E-05	5,14E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,30E-08	9,88E-09	2,11E-07	9,62E-05	0,00E+00
NHWD	kg	**4,83E-02**	1,32E-02	7,40E-05	3,93E-04	3,71E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,16E-07	8,39E-08	1,74E-05	5,14E-04	0,00E+00
RWD	kg	**4,40E-07**	2,27E-07	6,74E-09	1,80E-09	4,63E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,50E-11	1,03E-10	2,13E-09	7,74E-09	0,00E+00
MER	kg	**4,93E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,93E-05	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	0,00E+00
MFR	kg	**1,05E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 31. LCA results of CS6W-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,90E-03**	7,78E-04	1,22E-06	2,18E-05	5,21E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,31E-08	9,88E-09	2,11E-07	9,61E-05	0,00E+00
NHWD	kg	**4,81E-02**	1,31E-02	7,45E-05	3,94E-04	3,76E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,17E-07	8,39E-08	1,74E-05	5,12E-04	0,00E+00
RWD	kg	**4,35E-07**	2,21E-07	6,79E-09	1,80E-09	4,70E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,51E-11	1,03E-10	2,13E-09	7,71E-09	0,00E+00
MER	kg	**4,54E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,54E-05	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	0,00E+00
MFR	kg	**1,05E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 32. LCA results of CS7L-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,88E-03**	7,64E-04	1,20E-06	2,15E-05	5,20E-06	9,89E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,28E-08	9,76E-09	2,08E-07	9,41E-05	0,00E+00
NHWD	kg	**4,75E-02**	1,29E-02	7,34E-05	3,90E-04	3,75E-04	3,33E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,13E-07	8,29E-08	1,71E-05	4,92E-04	0,00E+00
RWD	kg	**4,29E-07**	2,18E-07	6,69E-09	1,78E-09	4,69E-08	1,46E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,47E-11	1,01E-10	2,10E-09	7,47E-09	0,00E+00
MER	kg	**4,10E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,10E-05	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	0,00E+00
MFR	kg	**1,03E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 33. LCA results of CS7N-MS module in Dafeng factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,93E-03**	7,96E-04	4,44E-07	2,12E-05	5,20E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-08	9,83E-09	2,19E-07	1,02E-04	0,00E+00
NHWD	kg	**4,82E-02**	1,33E-02	3,34E-05	3,86E-04	3,63E-04	3,35E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,22E-07	8,35E-08	1,81E-05	5,76E-04	0,00E+00
RWD	kg	**4,42E-07**	2,31E-07	3,01E-09	1,69E-09	4,73E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-11	1,02E-10	2,21E-09	8,45E-09	0,00E+00
MER	kg	**5,97E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,97E-05	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	0,00E+00
MFR	kg	**1,09E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,09E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 34. LCA results of CS3L-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,92E-03**	7,83E-04	4,42E-07	2,11E-05	5,00E-06	1,01E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,34E-08	9,90E-09	2,17E-07	9,96E-05	0,00E+00
NHWD	kg	**4,81E-02**	1,31E-02	3,32E-05	3,85E-04	3,49E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,22E-07	8,41E-08	1,79E-05	5,44E-04	0,00E+00
RWD	kg	**4,38E-07**	2,28E-07	2,99E-09	1,68E-09	4,55E-08	1,49E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,57E-11	1,03E-10	2,19E-09	8,11E-09	0,00E+00
MER	kg	**5,43E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,43E-05	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	0,00E+00
MFR	kg	**1,07E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,07E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 35. LCA results of CS3W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,90E-03**	7,81E-04	4,33E-07	2,07E-05	4,84E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,30E-08	9,88E-09	2,11E-07	9,62E-05	0,00E+00
NHWD	kg	**4,81E-02**	1,32E-02	3,26E-05	3,78E-04	3,38E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,16E-07	8,39E-08	1,74E-05	5,14E-04	0,00E+00
RWD	kg	**4,34E-07**	2,27E-07	2,93E-09	1,65E-09	4,40E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,50E-11	1,03E-10	2,13E-09	7,74E-09	0,00E+00
MER	kg	**4,93E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,93E-05	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	0,00E+00
MFR	kg	**1,05E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 36. LCA results of CS6W-MS module in Changshu factory

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,90E-03**	7,78E-04	1,20E-06	2,18E-05	5,48E-06	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,31E-08	9,88E-09	2,11E-07	9,61E-05	0,00E+00
NHWD	kg	**4,81E-02**	1,31E-02	9,02E-05	3,96E-04	4,06E-04	3,37E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,17E-07	8,39E-08	1,74E-05	5,12E-04	0,00E+00
RWD	kg	**4,38E-07**	2,21E-07	8,13E-09	1,89E-09	4,91E-08	1,48E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,51E-11	1,03E-10	2,13E-09	7,71E-09	0,00E+00
MER	kg	**4,54E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,54E-05	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	0,00E+00
MFR	kg	**1,05E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,05E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 37. LCA results of CS7L-MS module in Suqian

Parameter	Unit	Total	Upstream Module		Core Module												Downstream module	
			A1. Raw Material	A2. Transport RM	A3. Manufacturing	A4. Distribution	A5. Installation	B1. Use	B2. Maintenance	B3. Replacement	B4. Repair	B5. Refurbishment	B6. Operational energy use	B7. Operational water use	C1. De-construction	C2. Transport Waste	C3. Waste processing	C4. Disposal
HWD	kg	**1,88E-03**	7,64E-04	1,18E-06	2,15E-05	5,47E-06	9,89E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,28E-08	9,76E-09	2,08E-07	9,41E-05	0,00E+00
NHWD	kg	**4,75E-02**	1,29E-02	8,88E-05	3,92E-04	4,05E-04	3,33E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,13E-07	8,29E-08	1,71E-05	4,92E-04	0,00E+00
RWD	kg	**4,32E-07**	2,18E-07	8,00E-09	1,87E-09	4,90E-08	1,46E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,47E-11	1,01E-10	2,10E-09	7,47E-09	0,00E+00
MER	kg	**4,10E-05**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,10E-05	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	0,00E+00
MFR	kg	**1,03E-03**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E-03	0,00E+00
CRU	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	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	**0,00E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	**3,60E+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	0,00E+00	3,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption: HWD = Hazardous landfill waste; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; MER = Materials for energy recovery; MFR = Material for recycling; CRU = Components for reuse; ETE = Exported thermal energy; EEE = Exported electricity energy;																		

Table 38. LCA results of CS7N-MS module in Suqian factory

Focusing on life cycle stages, the Raw Material supply (A1) stage contributes for a very large majority on most of the impact indicators for PV panel life cycle (between 62% and 63% in GWP total). The extraction of raw materials, especially cells, and processes to obtain them are the most impacting activities on the life of a PV panel. Following, the second most impacting stage in most of the impact indicators is the Installation stage (A5), the mounting system is the highest contributor of impact. Distribution (A4) is the third most impacting stage, regarding the long distances to travel from China to Italy. However, the big quantities than can be transported in one same ship, helps to reduce the impact of this process.

Use (B1), Maintenance (B2), Replacement (B3), Repair (B4), Refurbishment (B5) and Operational energy use (B6) stages are considered to be completely non-impacting, regarding that the product do not requires any type of modification. Moreover, except the Operational water use (B7) for manual cleaning, PV modules do not produce any other kind of emission during these phases.

Waste processing stage represents the impacts of waste treatment process.

The following table shows the comparison between mono-facial photovoltaic modules produced in different locations on their Global Warming Potential (GWP). We constate less than 0.45% of difference between mono-facial PV modules.

	Mono-facial				
	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Dafeng	X	X	X	X	X
Changshu	X	X	X		X
Suqian				X	X
Standard denomination gap	0,28%	0,31%	0,30%	0,11%	0,45%

Table 39. Standard denomination gap analysis – Total GWP results

6. Calculation rules

6.1. Functional unit

In the EPD study, the functional unit is 1 kWh of electricity generated as output from the solar photovoltaic plant. The environmental impact of this study was calculated and reported per functional unit.

To report the environmental impacts generated by each CSI Solar photovoltaic (PV) module during its life cycle in the functional unit, the total energy produced by the solar PV plant during the reference service life (RSL) needs to be calculated. Once the total energy of the solar plant has been calculated, the overall environmental impacts generated throughout the entire life cycle are divided by this value to return the results in the individual kWh produced.

The total energy produced by the plant will therefore be equal to

$$Etot[kWh] = Eyear * RSL$$

Where:

E_{tot} represents the total energy produced by the plant (or, in an extreme case, by the individual module) during its entire life cycle;

E_{year} represents the energy produced annually by the plant.

The present EPD study calculates the annual energy production in the case of plants under construction but not yet operational. Therefore, an estimate is provided of the annual production of the plant, which will be a function of various parameters (average irradiation, exposure, temperature, optical factors, etc.) however known at the design stage.

Following the EPDItaly PCR, the reference service life (RSL) of CSI Solar modules is assumed to be 30 years.

The calculation of the total energy production of a PV plant during its reference service life was done with the following equation used by PINK Strategy's project developers:

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

Where (example for CSN-MS)

n = year of operation, here 0<n<30

E_1 = energy produced during first year

RSL = reference service life = 30 years (according to PCR)

deg = yearly degradation rate = 0.55%

To get the most precise value, energy production in the first year of operation was modeled in PVsyst software using the scenario that the power plant is installed in Rome in Italy. The table below explains the characteristics of the power plant for each module.

Parameter	Unit	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Reference service life	years	30	30	30	30	30
Peak power of the plant	kWp	101,4	101,52	101,01	100,65	100,5
Plant latitude and longitud	°	41.89°N 12.51°E	41.89°N 12.51°E	41.89°N 12.51°E	41.89°N 12.51°E	41.89°N 12.51°E
Plant altitude	m	49	49	49	49	49
Nominal solar irradiance	Wh/m²/year	1 703 400	1 703 400	1 703 400	1 703 400	1 703 400
Number of modules	pcs	260	216	182	165	150
Module power	Wp	390	470	555	610	670
Specific production	kWh/kWp/year	1 487	1 477	1 479	1 480	1 497

Table 40. PV Plant characteristics

6.2. LCI data origin and LCA period

CSI Solar's monocrystalline silicon photovoltaic (PV) modules are already certified for the French market with ECS (Evaluation Carbone Simplifiée/Simplified Carbon Assessment in English). CSI Solar module, wafer, and ingot factories have LCAs validated by ADEME (Agence de la Transition Ecologique/the French Environment and Energy Management Agency). This EPD study is based on the LCI performed in those LCAs.

Addresses of CSI Solar module factories:

Module	**Changshu factory:** 2 Changsheng Road, Xinzhuang Industrial Park, Changshu, 215562 China
	Dafeng factory: Yongsheng Road, Dafeng, China
	Suqian factory: 177 #Tongda Avenue, Suqian Economic Development Zone, Suqian City, 223800 Jiangsu, P.R. China
Wafer	**Luoyang factory:** Canadian Solar Manufacturing, No.10 Guanlin Road Luolong Industrial Park, Luoyang - China
	Funing factory: NO.9 Jichao Road, Funing EDA, Yancheng City, Jiangsu Province, China
Ingot	**Baotou factory:** Sino German Cooperation Park, Yuanda Road, Equipment Manufacturing Industrial Park of Qingshan District, Baotou City, Inner Mongolia Autonomous Region, 014030, P.R. China

Data about product manufacturing is based on the Life Cycle Inventories (LCI) performed in the validated LCAs for CSI Solar plants with an update on the period from January 1st, 2021 to December 31st, 2021.

6.3. System boundaries

For each process step, all energy and material inputs and outputs are collected. The process inputs are the energy consumption, the material consumption, the infrastructure, the transport of materials to the factory, the transport of the PV modules to the installation site, and the transport of the wastes to the waste treatment center. The process outputs are products, waste to treatment, and emissions to water and air.

EPDItaly Regulations state that the life cycle stages must refer to segmentation in the following three modules:

1. Upstream module which includes all the processes upstream of the production of the photovoltaic module. In this EPD study, the upstream module includes the extraction and processing of raw materials covering silicon, ingot, wafer, PV cell, other raw materials, semi-finished goods, and packaging materials (A1), as well as the transportation of the raw material to the manufacturing factories (A2);

2. Core module contains most of the environmental impacts related to the production of electricity by photovoltaic modules. The core module includes all the relevant processes managed by the CSI Solar. The core module in the present study covers the manufacturing process of the photovoltaic modules (A3) including the consumption of energy and natural resources, like water; the treatment and emission of wastewater; the treatment, emission and transport of solid wastes generated during the PV module manufacturing as well as the packaging waste. Align with the EPDItaly PCR, the core module also includes the transportation of photovoltaic modules to solar plant (A4); the construction of the solar plant (A5) with all the auxiliary and infrastructure equipment needed to ensure that electricity is properly generated and fed into the grid, the transportation of auxiliary and infrastructure equipment, the treatment and emission of packaging wastes during the solar plant construction; the use (B1), the maintenance (B2), the repair (B3), the replacement (B4), the refurbishment (B5) and the operational energy use (B6) and the water use (B7) during the 30-year reference service life; the de-construction and demolition of the solar plant (C1), the transport of PV modules to waste processing (C2).

3. Downstream module which includes all the relevant processes that are outside of the control of the CSI Solar. The downstream module includes the waste processing (C3) and the final disposal of wastes (C4). According to the EPDItaly PCR, the benefit and avoided loads beyond the product system boundary were not reported in module D separately within this EPD study, neither were the benefit and loads be reported in other stages by following a cut-off allocation approach.

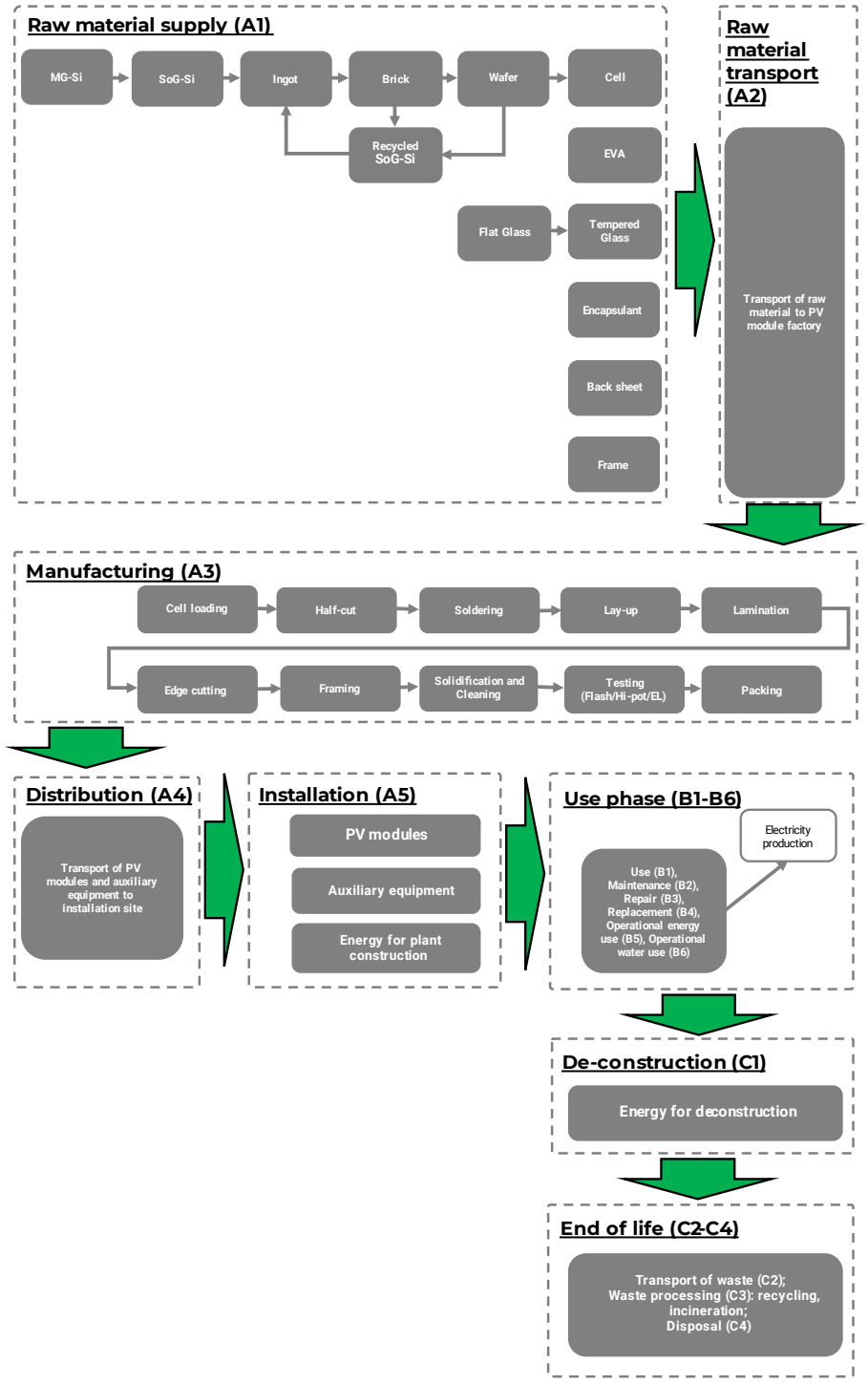

Figure 3. Life cycle stages EPD (according to ISO 14025)

6.4. Assumptions

The key assumptions of this LCA study are as listed below.

- This EPD study is based on the LCI performed in CSI Solar's for LCA's submitted to a third-party review and validated by ADEME (French Environment Agency). Those LCAs have been performed for photovoltaic modules, wafers, and ingots. CSI Solar's photovoltaic module, wafer, and ingot factories are already certified for the French market with ECS certificates validated by ADEME.
- This EPD study uses the scenario that the PV power plant of CSI Solar modules is located in Rome in Italy. PVsyst simulations, transportation distances, and electricity mix have been chosen to be aligned with that assumption.
- Following the PCR EPDItaly 014, the reference service life (RSL) of CSI Solar modules is assumed to be 30 years.
- Concerning the electricity generation by the PV power plant, linear annual degradation was assumed over reference service life (RSL). The current technology of PV modules with monocrystalline silicon cells, used in CSI Solar cells panels, sees its power decrease at most of 0.55 % for mono-facial PV modules according to datasheets.
- As CSI Solar is a module manufacturer, PINK Strategy has built a model for the impact of installation (auxiliary equipment and construction site) based on more than 10 years of Solstyce experience and multiple LCAs performed for other EPC and Photovoltaic developer (Over 50 LCAs performed on PV plants in the last two years).
- The transport distance of auxiliary equipment to the installation site in Rome in Italy was estimated to be 100 km by lorry to the project location site.
- Energy is needed to de-construct the PV power plant. The energy consumption during the deconstruction of the PV plant (C1) was assumed the same as the energy consumption during the construction stage (A5).
- The waste allocation ratios for the waste disposal of the packaging materials are based on the information given by ADEME (ADEME: Packaging recovery in France: https://www.actu-environnement.com/media/pdf/news-28108-emballages-ademe-chiffres-2014.pdf)
- The distribution of PV module products is considered as the distance between each manufacturing plant in China and the city of Rome in Italy. There are two possible roads for transport from China, either from Shanghai port or from Ningbo port. In this study, we took the greater distance to be conservative.

6.5. Excluded processes

This study is a cradle-to-grave analysis from the extraction of raw materials (mining) up to the end-of-life of CSI Solar's photovoltaic modules. Excluded in this analysis are:

- the transport of workers;

- EoL processes of the packaging wastes of module input materials such as cells, aluminum frame, glass, etc.;
- the electricity, water, and heat consumption of support functions not linked directly to manufacturing;
- the building hall and metal working machines whose impacts are negligible due to the high amount of production;
- the recycling process for faulty products;
- PV module storage phases;
- management of operations in the distribution center and retail shop;
- small rechargeable manual equipment during installation;
- load and benefit from recycling and waste to energy treatment (module D).

6.6. Cut-off rules

To exclude inputs and outputs, the procedures below were followed:

- All inputs and outputs of a (unit) process were included in the calculation if data were available. Data gaps were completed with conservative assumptions, using average or general data. Any assumption used for such decisions was documented;
- Where sufficient input data were not available or were incomplete for a unit process, a cut-off criterion was chosen following the PCR requirement. These cut-off criteria were 2% of the total mass and energy of that unit process. (According to the specific weight of the photovoltaic module and the energy required to manufacture and assemble it.)
- The overall neglected input flow of the cradle-to-grave stages, i.e. A1-A3, A4-A5, B1-B7, C1-C4, should be no more than 2% of the energy consumption and mass per module. The neglected flow of this EPD study is shown in the following table.

Flow name	**Life cycle stage**	**Justification for cut-off**	**Total cut off mass estimated (%)**
Rolls for ribbon string (reused at supplier)	A1	Negligible	<0.1%
Inspection and transport of maintenance agent	B	Negligible	<0.1%
Waste packaging for transport to waste processing site	C3	<2%	<1%
Total			**<2%**

Table 41. Cut-off flows

6.7. Data quality

CSI Solar's monocrystalline silicon photovoltaic (PV) modules are already certified for the French market with ECS (Evaluation Carbone Simplifiée / Simplified Carbon Assessment in English). CSI Solar module, wafer, and ingot factories have LCAs validated by ADEME (Agence de la Transition Ecologique / the French Environment and Energy Management Agency). This EPD study is based on the LCI performed in those LCAs.

Data about product manufacturing is based on the Life Cycle Inventories (LCI) performed in the validated LCAs for CSI Solar plants with an update on the period from January 1st, 2021 to December 31st, 2021.

LCI data were compared with literature and other studies performed or reviewed by PINK Strategy. Data quality is assessed as follows:

- Technological representativeness: Rather conservative for silicon production. Good of the rest of the data. The scenarios represent the average technologies used at the time of data collection.
- Geographical representativeness: Good – Background data may be global data. LCI data linked to the geographical locations of the processes, such as electricity and transport data from China and Italy, were used.
- Time-related representativeness: Very good – very recent data. The period is from January 1st, 2021 to December 31st, 2021.
- Completeness: Good
- Precision/uncertainty: Good, some hypotheses are taken, as explained in Chapter 6.4.
- Methodological appropriateness and consistency: Good (substitution, etc.).

The overall data quality is good.

6.8. Allocations

Multi-input processes:

When information on energy flow was available in LCI with detailed meters (especially for lamination which is the highest energy consumption in the assembly module), the allocation was performed based on lamination cycles per module and lamination power. In the other cases, attribution was performed via the surface of the PV panel, this being the most representative of the consumption in the manufacturing process.

All material inputs were allocated on an average breakage and loss ratio for that material, applied to the quantity of the material in BoM. Breakage and loss ratios were measured in each factory.

Multi-output processes:

Multiple output allocation is defined based on a quantitative calculation of resource consumption and emissions, for example in the context of the allocation of functions, physical attributes, or economic aspects. Physical attributes (mass, net calorific value, etc.) are preferred, otherwise economic aspects (man-hours, operating hours, production costs) may be taken into consideration.

In this study, since there are no coproducts, the only multi-output process is waste generated during the manufacturing process, which is calculated based on the area (m^2) of PV modules.

Allocation for recovery processes:

The allocation key for recovery processes determines the share of each input and emission related to the reference product and to the by-products that have economic value. The Ecoinvent database is based on economic allocation (for example the allocation based on price) with few exceptions, like for energy, for which allocation is based on exergy.

The model used for the allocation for recovery processes is the Ecoinvent cut-off system model (Allocation, cut-off by classification). According to this approach, wastes are the producer's responsibility, and there is an incentivization to use recyclable products, that are available burden-free (cut-off).

The underlying philosophy of this approach is that the primary (first) production of materials is always allocated to the primary user of a material. If material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials. As a consequence, recyclable materials are available burden-free to recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes. Furthermore, producers of waste do not receive any credit for recycling or reuse of products resulting from any waste treatment.

7.LCA scenarios

CSI Solar's mono-facial photovoltaic modules are produced either in Changshu, Suqian, or Dafeng factories in China. In each factory, all models are manufactured with the same technics and machinery. The processes covered by modules A1-A3 are explained in Chapter 4.

The following tables summarize the LCA scenarios included within system boundaries for the downstream module (A4 - C4).

7.1. Distribution (A4)

This assessment is promoted by the use of CSI Solar panels for the Italian market. Therefore, the transport distribution of this product is considered as the average distance between the production plants in China and the city of Rome in Italy. There are two possible roads for transport from China, either from Shanghai port or from Ningbo port. In this study, we took the greater distance to be conservative. In this way,

- transport in ship represents 20 750 km from all factories (Changshu, Dafeng, Suqian) to the project location site,
- transport in lorry overall represents 1 930 km from Changshu, 2130 km from Dafeng, and 2 310 km from Suqian to the product location site.

The following table explains the transportation from factories to Rome, Italy.

Gate to site transport							
Route	**Origin / Factory**	**China Port**	**Europe port**	**warehouse**	**Project site Location**	**TOTAL Lorry (km)**	**TOTAL Ship (km)**
Route 1	Changshu	Shanghai	Rotterdam	/	Rome	**1 880**	**20 510**
Route 2	**Changshu**	**Ningbo**	**Rotterdam**	**/**	**Rome**	**1 930**	**20 750**
Route 3	Dafeng	Shanghai	Rotterdam	/	Rome	**2 060**	**20 510**
Route 4	**Dafeng**	**Ningbo**	**Rotterdam**	**/**	**Rome**	**2 130**	**20 750**
Route 5	Suqian	Shanghai	Rotterdam	/	Rome	**2 270**	**20 510**
Route 6	**Suqian**	**Ningbo**	**Rotterdam**	**/**	**Rome**	**2 310**	**20 750**

Table 42. Gate to project location site transport

7.2. Installation (A5)

For roof mounted PV plants, the following design was taken into consideration:

- Inverters used in the PV plant are string inverters replaced once over RSL.
- No transformers are used for roof mounted PV plants as plant is directly connected to low voltage switchgear.
- Module supports are aluminum supports for flat roofs welded onto the roofing membrane.
- Electric installation contains the standard DC cables (2x6 mm) and the standard AC cables are (4x150 mm).

To assess the energy flow, it was assumed that the carpentry was transported from Italy in trucks with a capacity of 32 metric tons. The transportation distance was estimated to be 100 km. The impact of the construction site for roof mounted PV plant is limited to the use of large lifting engine to deliver equipment to roof top. The rest of the work is performed with small rechargeable manual equipment with a negligeable impact.

Another impact to be considered in this module is the waste disposal of the packaging materials. The following table shows the quantity and allocation of the packaging waste.

Waste from packaging	Unit	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Cardboard - recycled	kg	1,86E-01	2,11E-01	2,39E-01	2,63E-01	2,84E-01
Cardboard - incinerated	kg	1,18E-02	1,33E-02	1,51E-02	1,66E-02	1,79E-02
Plastic - Recycled	kg	1,84E-02	1,84E-02	1,84E-02	1,74E-02	1,78E-02
Plastic - incinerated	kg	5,45E-02	5,45E-02	5,45E-02	5,15E-02	5,28E-02
Paper - recycled	kg	2,11E-03	2,11E-03	2,11E-03	2,04E-03	2,04E-03
Paper -incinerated	kg	1,33E-04	1,33E-04	1,33E-04	1,29E-04	1,29E-04
Wood - recycled	kg	3,51E-01	3,84E-01	4,13E-01	4,20E-01	4,20E-01
Wood - incinerated	kg	8,93E-01	9,76E-01	1,05E+00	1,07E+00	1,07E+00

Table 43. Packaging waste disposal share

7.3. USE phase (B1-B7)

USE Stages	Consideration	Value
B1. Use	Not concerned; for water, air or soil emissions	
B2. Maintenance	Not concerned; no maintenance is needed	
B3. Replacement	Not concerned; no replacement planned	
B4. Repair	Not concerned; no repair planned	

B5. Refurbishment	Not concerned; no replacement planned	
B6. Operational energy use	No energy consumption; but energy production according to FU	Energy production during reference service life (30 years) is explained below.
B7. Operational water use	Water is used to clean PV panels.	9.091 kg/m^2

7.4. End-of-Life phases (C1-C4)

	Unit	Value	Comment
De-construction (C1)			
Energy is needed to de-construct the PV power plant. The energy consumption during deconstruction of PV plant (C1) was assumed the same as the energy consumption of construction stage (A5).			
Waste transport (C2)			
Total mass of module waste		Explained in Table 44	
Road transport	km	100	lorry 16-32 metric ton, EURO5

The total mass of the product uninstalled is:

PV module	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Total mass (kg)	20.69	24.48	28.17	31.05	33.94

Table 44. Weight of total mass

Waste processing (C3) and disposal (C4):

Components	EoL process	Unit	Mono-facial				
			CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Glass	sorting for recycling	kg	1,47E+01	1,75E+01	2,03E+01	2,25E+01	2,47E+01
Aluminum frame	sorting for recycling	kg	2,45E+00	2,74E+00	3,04E+00	3,32E+00	3,52E+00
Junction box (copper)	sorting for recycling	kg	4,68E-02	4,68E-02	4,68E-02	3,78E-02	3,78E-02
Junction box (plastic)	sorting for recycling	kg	1,03E-01	1,03E-01	1,03E-01	8,67E-02	8,72E-02
Junction box (diodes)	incineration	kg	4,36E-03	4,36E-03	4,36E-03	3,00E-03	3,00E-03
Metals	sorting for recycling	kg	1,96E-01	2,24E-01	2,88E-01	3,13E-01	3,44E-01
Silicon (cells)	stored	kg	6,54E-01	7,85E-01	9,14E-01	1,02E+00	1,12E+00
Polymers	incineration	kg	2,31E+00	2,77E+00	3,10E+00	3,44E+00	3,77E+00
Silicone	incineration	kg	2,62E-01	2,86E-01	3,32E-01	3,60E-01	3,80E-01

Table 45. EoL treatment of PV module parts

8.Additional environmental information

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.

Following the PCR, the calculation is done using the following formula:

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

Where:

$E_{invested}$ = total amount of energy (thermal and electrical) required to produce the photovoltaic module (or solar park).

This number is the sum of the indicators PENRT + PERT.

$E_{produced,annual}$ = total amount of electricity generated in a year by the photovoltaic module (or solar park).

The results are explained by the following table:

	CS3L-MS	CS3W-MS	CS6W-MS	CS7L-MS	CS7N-MS
Dafeng factory	1.89	1.87	1.86	1.85	1.82
Changshu factory	1.88	1.87	1.85		1.81
Suqian factory				1.85	1.82

Table 46. RoE results of CSI Solar's PV modules in Dafeng, Changshu and Suqian factories

9.Reference

EPDItaly:

EPDItaly Regulation 5.2. (16 February 2022)

PCR for PV Panel: EPDItaly014 Rev 1.1 (08/02/2022)

Sustainability reporting standards:

European Standards. (2019). EN 15804:2012+A2:2019 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.

European Standards. (2019). EN 50693:2019 Product category rules for life cycle assessments of electronic and electrical products and systems

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

ISO. (2009). ISO 14040: Environmental management - Life cycle assessment - principles and frameworks.

ISO. (2011). ISO 14025: Environmental labels and declarations - Type III environmental declarations - principles and procedures.

Literature:

IBP, Fraunhofer. *LCA screening of a recycling process for silicon based PV modules.* Fraunhofer : Fraunhofer, 2012.

ADEME: Packaging recovery in France: https://www.actu-environnement.com/media/pdf/news-28108-emballages-ademe-chiffres-2014.pdf

LCA reports:

Dafeng factory: The Global Warming Potential for the CRE tenders - Crystalline silicon photovoltaic modules Produced by CSI Dafeng, Yongsheng Road, Dafeng, China (written by Smart Green Scans on 28 October 2020).

Suqian factory: Life cycle assessment for CRE tenders - Module production by Canadian Solar in Suqian, China (written by AltaEnergy on 28 October 2021).

Changshu factory: The Global Warming Potential for the CRE tenders - Crystalline silicon photovoltaic modules (written by Smart Green Scans on 31 August 2019).