Jinko Solar Co., Ltd.

ENVIRONMENTAL PRODUCT DECLARATION

N-type and P-type PV Modules

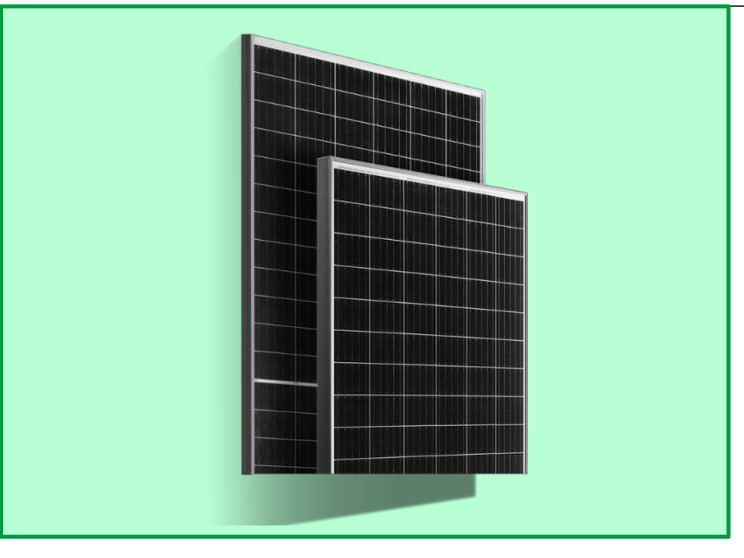
Chuzhou, Anhui province, China.
Haining, Zhejiang Province, China.
Yiwu, Zhejiang Province, China.

In accordance with ISO 14025

Program Operator	EPDItaly
Publisher	EPDItaly

Declaration Number	JKS20230302
Registration Number	EPDITALY0426

Issue date	2023/ 07/ 28
Valid to	2028/ 07/ 28



GENERAL INFORMATION

EPD OWNER	
Name of the company	Jinko Solar Co., Ltd.
Registered office	No.1, Yingbin Road, Economic Development Zone, Shangrao City, Jiangxi, 334100, China
Contacts for information on the EPD	Sophia Sun, simin.sun@jinkosolar.com

PROGRAM OPERATOR	
EPDItaly	Via Gaetano De Castillia n° 10 - 20124 Milano, Italy

INFORMATION ON THE EPD	
Product name (s)	PV modules:JKMXXXN-72HL4-V, JKMXXXN-72HL4-BDV, JKMXXXN-78HL4-BDV, JKMXXXM-72HL4-BDVP
Site (s)	**For the P-type modules** Jinko Solar (Chuzhou) Co., Ltd No.18, Liming Road, Lai'an Economic Development Zone, Chuzhou City, Anhui, 239200, P.R. China Jinko Solar (Yiwu) Co., Ltd No. 1555, Chengxin Road, Niansanli Street, Yiwu city, Zhejiang, P.R. China **For the N type modules** Jinko Solar (Haining) Co., Ltd. No.199, Xinyue Road, Huangwan Town, Haining City, Zhejiang, 314415, P.R.China Jinko Solar (Chuzhou) Co., Ltd No.18, Liming Road, Lai'an Economic Development Zone, Chuzhou City, Anhui, 239200, P.R.
Short description and technical information of the product (s)	3 N-types of PV modules: JKMXXXN-72HL4-V,JKMXXXN-72HL4-BDV, JKMXXXN-78HL4-BDV; 1 P-type of PV modules: JKMXXXM-72HL4-BDVP, Reference service life: 30 years
Field of application of the product (s)	Electricity generation
Product (s) reference standards (if any)	
CPC Code (number) https://unstats.un.org/unsd/classifications/Econ	171

VERIFICATION INFORMATION	
PCR (title, version, date of publication or update)	EPDItaly 014: Electricity Produced by Photovoltaic Modules, version 1.1, 08/02/2022
EPDItaly Regulation (version, date of publication or update)	Regulations of the EPDItaly Programme, version 5.2, 2022/02/16
Project Report LCA	This EPD study is based on the LCA study described in the LCA report
Independent Verification Statement	The PCR review was performed by Ing. Daniele Pace, Arch. Michele Paleari, Ing. Sara Toniolo - info@epditaly.it. 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.
Comparability Statement	Environmental statements published within the same product category, but from different programs, may not be comparable. In particular, EPDs of construction products may not be comparable if they do not comply with EN 15804: 2012 + A2: 2019.

Liability Statement	The EPD Owner releases EPDItaly from any non-compliance with environmental legislation. The holder of the declaration will be responsible for the information and supporting evidence. EPDItaly disclaims any responsibility for the information, data and results provided by the EPD Owner for life cycle assessment.

OTHER INFORMATION

Technical support	TÜV Rheinland (China) Ltd.
LCA software	SimaPro 9.4.0.1 (2021)
LCI database	Ecoinvent v3.8 (2021)
LCIA methodology	EN 15804 + A2 Method V1.02

CONTENTS

DESCRIPTION OF THE ORGANIZATION

JinkoSolar Co., Ltd. ("JinkoSolar", stock code: 688223) is a world-renowned and innovative solar technology company. Adhering to the mission of "changing the energy structure and assuming future responsibility", the company strategically lays out the core links of the photovoltaic industry chain. It focuses on the integrated R&D and manufacturing of photovoltaic products and the provision of clean energy overall solutions and leads the global mainstream photovoltaic market in terms of sales.

JinkoSolar's products serve over 3,000 customers in more than 160 countries and regions worldwide and have been ranked as the global module shipment champion for many years. In the first quarter of 2022, the company became the first PV company in the world to ship more than 100GW of modules.

The company is an industry opinion leader in various international frameworks, including B20, and joined the RE100 Green Initiative in 2019. JinkoSolar is the first in the industry to establish "vertically integrated" production capacity from polysilicon processing to wafer, cell, and module production, with 14 global production bases in China, Malaysia, Vietnam, and the United States. At the end of the first half of 2022, the total production capacity of monocrystalline silicon wafers, cells, and modules was about 40GW, 40GW, and 50GW, respectively. The company has more than 1,000 R&D and technical personnel, won many awards, such as "National Enterprise Technology Center", "National Technology Innovation Demonstration Enterprise", "Manufacturing Single Champion", and led the formulation of IEC and other international and domestic industry standards.

JinkoSolar was listed on the Science and Technology Innovation Board of the Shanghai Stock Exchange in 2022. Its indirect controlling shareholder, JinkoSolar Holdings Co., Ltd., was listed on the New York Stock Exchange in 2010.

Name and location of production site(s) within the organization

Table1. Location of PV module assembly sites

P type module		
Component / Process	Manufacturing company name and address	Manufacturing country
Ingots	**Sichuan Jinko Solar Co., Ltd.** No.10, Cross Street, Qiaogou Town, Wutongqiao District, Leshan City, Sichuan	China
Wafers	**Jinko Solar (Shangrao) Co., Ltd.** No.1, Yingbin Road, Economic Development Zone, Shangrao City, Jiangxi, 334100, P.R. China **Jinko Solar Co., Ltd** No.1 Jinko Road, Shangrao Economic Development Zone, Jiangxi, 334100, P. R. China	China
Cells	**Jinko Solar (Shangrao) Co., Ltd.** No.1, Yingbin Road, Economic Development Zone, Shangrao City, Jiangxi, 334100, P.R. China	China
Modules assembly	**Jinko Solar (Chuzhou) Co., Ltd** No.18, Liming Road, Lai'an Economic Development Zone, Chuzhou City, Anhui, 239200, P.R. **Jinko Solar (Yiwu) Co., Ltd** No. 1555, Chengxin Road, Niansanli Street, Yiwu city, Zhejiang, P.R. China	China

N type module		
Component / Process	Manufacturing company name and address	Manufacturing country

Ingots	**Sichuan Jinko Solar Co., Ltd.** No.10, Cross Street, Qiaogou Town, Wutongqiao District, Leshan City, Sichuan	China
Wafers	**Leshan Jinko Solar Co. LTD** No. 333, Group 2, Gongyu Village, Jinsu Town, Wutongqiao District, Leshan City, Sichuan Province	China
Cells	**Jinko Solar (Haining) Co., Ltd.** No.199, Xinyue Road, Huangwan Town, Haining City, Zhejiang, 314415, P.R.China	China
Modules assembly	**Jinko Solar (Haining) Co., Ltd.** No.199, Xinyue Road, Huangwan Town, Haining City, Zhejiang, 314415, P.R.China **Jinko Solar (Chuzhou) Co., Ltd** No.18, Liming Road, Lai'an Economic Development Zone, Chuzhou City, Anhui, 239200, P.R.	China

PRODUCT INTRODUCTION

The JinKo's PV modules under analysis integrate various advanced technologies such as half-cut cells providing with the highest power up to 625W and up to 22.36% module efficiency. The most advanced technology enables a linear degradation rate as low as 0.4% over the 30 years maintaining the performance of the PV modules in the long-run.

Within this EPD, four types of modules will be analyzed covering conventional P-type module, N-type module and their advanced bifacial double glass modules. The detailed information is given in the Table 2 below

Table 2. Different PV module products models

Serious (brand name)	Power output range (W)	Dimensions (mm)	Weight(KG)	Cell number
JJKMXXXN-72HL4-V	565-585	2278×1134×35	28	72
JKMXXXM-72HL4-BDVP	530-550	2278×1134×35	32	72
JJKMXXXN-72HL4-BDV	560-580	2278×1134×30	32	72
JJKMXXXN-78HL4-BDV	605-625	2465×1134×30	34.6	78

These PV modules are widely used to generate electricity on ultra-large ground power station and Large-scale industrial and commercial projects. The detailed materials composition for the four PV modules are provided in the Table 3 below.

MATERIALS COMPOSITION

Table 3: The PV material composition including packaging

In kg unless specified	JKMXXXN-72HL4-V	JKMXXXN-72HL4-BDV	JKMXXXN-78HL4-BDV	JKMXXXM-72HL4-BDVP
Solar cells (pcs)	72	72	78	72
Busbar& ribbon	0.234	0.234	0.245	0.219
Membrane(LRF)		0.247	0.247	
Solar glass	20.554	12.846	13.903	12.822
Back sheet/Back glass	1.203	12.846	13.903	12.822
POE back	1.001	0.973	1.055	1.052
EVA	0.975	1.001	1.051	1.052
Silica gel	0.342	0.362	0.379	0.294
Frame	2.621	2.552	2.704	2.890
Junction box	0.110	0.110	0.110	0.110
Solder wire & Isopropanol	0.026	0.026	0.026	0.026
Wood pallets	1.194	1.360	1.360	1.360
Packaging paper	0.479	0.479	0.479	0.479
Packing film	0.056	0.054	0.054	0.054

LCA BACKGROUND INFORMATION

DECLARED UNIT (FUNCTIONAL UNIT)

In this study the functional unit is 1 kWh of electricity generated as output from the solar PV plant. To derive such a value, total energy output from the PV plant should be calculated. Once total energy 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.

SYSTEM BOUNDARIES

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

The upstream module contains extraction and processing of raw materials, including silicon, ingot block, wafer, PV cell with packaging, and the transportation of the raw material to the factory.

The core module includes manufacturing PV modules, transportation of PV modules to solar plant, construction of the solar plant, the use, maintenance, repair, replacement, refurbishment and the operational energy use and water use, de-construction and demolition of the solar plant, transport to waste processing

the downstream module In this study covers the processes of the final waste processing and disposal. According to the PCR, the benefit and avoided loads beyond the product system boundary are not reported within this study, nor will the benefit and loads be reported in other stages by following a cut-off allocation approach.

Figure 1 below illustrates the system boundaries for the PV modules, including raw material production and transportation, manufacturing, distribution, installation, and End-of-life. The figure demonstrates our tweaks:

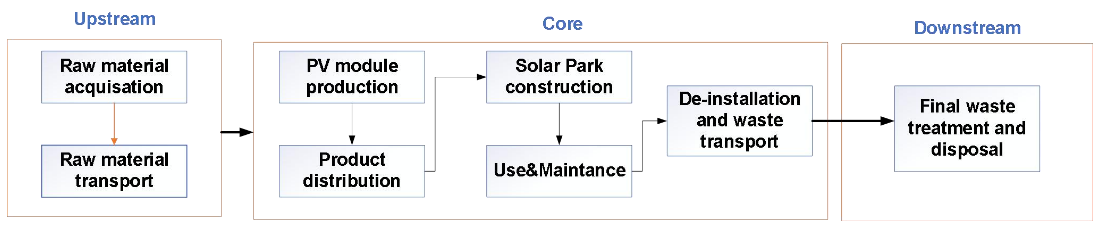


Figure 1 System boundary of PV modules

Detailed information on the segmentation for the upstream, core and downstream modules are presented in the following. To better illustrate the contents within each module, life cycle stages interpretations according to the EN15804 is also provided.

Table 4: Division and declarations of life cycle stages

PCR setting	Inclusion	Stages according to the EN15804	
Upstream module	X	A1	Raw material supply
	X	A2	Transport (to the manufacturer)
Core module	X	A3	Manufacturing
	X	A4	Transport
	X	A5	PV module installation
	X	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	C1	De-construction and demolition
	X	C2	Transport (to waste processing)
Downstream stage	X	C3	Waste processing
	X	C4	Disposal
Benefits and loads beyond the system	MND	D	reuse, recovery and/or recycling potentials

Note: X=Declared Module, MND=Module not Declared in this LCA study

TEMPORAL AND GEOGRAPHICAL BOUNDARIES

All primary data collected from JinKo are from May 1st 2022 to Apr. 30th 2023 for P-type and N-type modules, which is a representative production year. Secondary data are also representative for this year, as provided by ecoinvent v3.8.

The PV modules involves multiple manufacturing sites for the PV module production and their predecessors. The manufacturing sites are listed in the Table 5. The selected ecoinvent processes in the LCA model have a global representativeness, due to the unclear origin of each component. In this way, a conservative approach has been adopted.

Table 5: Geographical boundary for the PV production and its upstream

	Ingot	Wafer	Cell	PV modules
JKMXXXN-72HL4-V	Sichuan	Sichuan	Zhejiang	Anhui
JKMXXXN-72HL4-BDV	Sichuan	Sichuan	Zhejiang	Zhejiang
JKMXXXN-78HL4-BDV	Sichuan	Sichuan	Zhejiang	Zhejiang
JKMXXXM-72HL4-BDVP	Sichuan	Jiangxi	Jiangxi	Anhui/Zhejiang

EXCLUDED PROCESSES

The following steps/stages are not included in the system boundary for the reason that the elements below are considered irrelevant or can be omitted according to the PCR

- Production and disposal of the infrastructure and capital equipment (buildings, machines, transport media, roads, etc.) during products manufacturing, installation, and maintenance;
- The load and benefit of recycling waste solar module as well as waste equipment from solar plant are excluded from the analysis
- The packaging for ingot, wafer and solar cell is reused internally and its impact was excluded from the system
- Storage phases and sales of PV modules
- Product losses due to abnormal damage such as natural disasters or fire accidents. These losses would mostly be accidental;
- The recycling process of defective products as it is reused internally for the manufacturing process;
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.

KEY ASSUMPTIONS

The key assumptions of this LCA study are as follows：

- For missing background data, substitution of missing data using similar background data approach was taken to shorten the gap.
- Besides transportation of PV module, transportation of other infrastructures for the installation of the solar plant uses assumed distance (100km) and transportation vehicles (Euro 5 truck) for simplification purpose.
- For PV plant construction, the study assumes that the mounting system is based on the steel and its use (e.g. the mounting system and electric devices except for the inverter) is linearly

associated with total mass of the PV modules. The cables and inverters application are determined by the peak power of the PV modules.

- Electricity used during the PV plant operation is assumed to be powered by the plant itself.
- PV maintenance is largely determined by cleaning. This study assumes that PV module cleaning occurs one time per month. The water use is linearly associated with the dimension of the PV module
- PV modules are assumed to be replaced by 3%. The service life of the inverter is 15years.
- The electricity consumption during deconstruction of PV plant (C1) is assumed same to the electricity consumption of construction stage (A5)
- The transport distance for the PV modules to the waste treatment site is assumed to be the same value (500km) as in the e-waste treatment.
- The waste processing for the PV modules is assumed to be done through mechanical treatment by shredding and separation.

CUT-OFF CRITERIA

In case of insufficient input data or data gaps for a unit process, according to the PCR requirement, the cut-off criteria chosen is 2% of the total mass and energy of that unit process. (Respectively, of the photovoltaic module’s unit weight and the energy needed to produce and assemble it). The neglected flow is demonstrated in Table 6. For missing background data, substitution of missing data using similar background data was taken to shorten the gap.

Table 6: Cut-off flows

Flow name	Process stage	Mass %	Criteria to cut-off
Trimethyl aluminum	Upstream	<0.001%	<2%
Annular diamond wire		<0.001%	<2%
Production, use, and disposal of the packaging of components and semi-finished intermediates;		<2%	Specified in PCR
Any extraordinary maintenance done on the PV modules	Downstream	Not applicable	Specified in PCR
Total cut-off mass % estimated			<2%

DATA QUALITY

In this EPD, both primary and secondary data are used. Site specific foreground data have been provided by JinKo. Main data sources are the bill of materials available on theenterprise resource planning. For all processes for which primary are not available, generic data originating from the ecoinvent v3.8 database, allocation cut-off by classification, are used. The ecoinvent database is available in the SimaPro 9.4.0.1 software used for the calculations.

ALLOCATION RULES

Multi-Output allocation is based on a quantitative calculation of the resource consumption and the emissions for example in relation to the distribution of functions, physical properties or economic aspects. Physical properties, such as mass, net calorific values, etc., shall be preferred, otherwise economic aspects, such as man-hours, operating hours or manufacturing cost may be used. In this study, mass allocation is applied in case of inputs partitioning is needed.

The allocation strategy for the EoL process per PCR follows the same strategy listed in the EN15804. Thus, the “cut-off” strategy is applied. This scenario allocates the entire environmental impacts of waste treatment procedures (from deconstruction to the waste processing) to the producer. The recycled materials, on the other hand, are burden-free. An important note is that when materials have reached a so-called “end-of-waste” state, the coverage of the waste processing is thus terminated. Any inputs/flows related to refine gross recycled materials for actual applications are beyond the product system boundary.

ENVIRONMENTAL IMPACT INDICATORS

The information obtained from the inventory analysis is aggregated according to the effects related to the various environmental issues. According to PCR EPDItaly014 the environmental impact indicators must be determined using the characterization factors and impact assessment methods specified in EN 15804 + A2 Method V1.03. Meanwhile PCR EPDItaly014 also stipulates to include resource and waste disposed descriptive indicators.

Table 7: Environmental, resource and waste indicators

Impact categories		**Units**
Global Warming potential (GWP)	Fossil (GWP, f)	kg CO_2 eq.
	Biogenic (GWP,b)	kg CO_2 eq.
	Land use and land transformation (GWP, luluc)	kg CO_2 eq.
	TOTAL(GWP, t)	kg CO_2 eq.
Ozone Depletion (ODP)		kg of CFC-11 equivalents
Acidification potential (AP)		mol H+ eq
Eutrophication of water potential (EP-freshwater)		kg P eq.
Photochemical ozone formation potential (POCP)		kg NMVOC-eq.
Consumption of abiotic resources - minerals and materials (ADPE)		kg Sb eq.
Consumption of abiotic resources - fossil resources (ADPF)		MJ, net calorific value
Water consumption (WDP)		m^3 water eq. deprived
Resource consumption		
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material (PENRE)		MJ, net calorific value
Use of renewable primary energy excluding renewable primary energy resources used as raw material (PERE)		MJ, net calorific value
Use of non-renewable primary energy resources used as raw material (PENRM)		MJ, net calorific value
Use of renewable primary energy resources used as raw material (PERM)		MJ, net calorific value
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) (PENRT)		MJ, net calorific value
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (PERT)		MJ, net calorific value
Net use of fresh water (FW)		m^3
Use of secondary raw materials (MS)		MJ, net calorific value
Use of renewable secondary fuels (RSF)		MJ, net calorific value
Use of non-renewable secondary fuels (NRSF)		MJ, net calorific value
Waste Disposed		
Hazardous waste disposed (HWD)		kg
Non-hazardous waste disposed (NHWD)		kg

Radio active waste disposed (RWD)	kg
Material for energy recovery (MER)	kg
Materials for recycling (MFR)	kg
Components for reuse (CRU)	kg
Exported thermal energy (ETE)	MJ
Exported electricity energy (EEE)	MJ

ELECTRICITY MIX

In this LCA, different electricity mix data is taken where the process takes place based on grid mixes of China from the Ecoinvent database. For example, the electricity production mix in Sichuan is sourced from "electricity, high voltage, production mix CN-SC". Since ingot production is mainly produced in the Sichuan province, thus, this dataset is used with adjustment the transmission and distribution of loss of grid. For others, their electricity product mixes are applied with adjustments for the grid loss (see Table 8). The electricity production mix and transmission loss are based on the China Energy Statistics Yearbook 2021. The detailed information can be found in Table 4-4.

Table 8: electricity profiles

Province involved	Associated Process for P-type	Associated Process for N-type	Production mix	Electricity mix technology reference	Transmission loss
Sichuan	Ingot production	Ingot and wafer production	Electricity, high voltage {CN-SC}| electricity, high voltage, production mix | Cut-off, U	2020	8.04%
Jiangxi	Wafer and cell production	/	Electricity, high voltage {CN-JX}| electricity, high voltage, production mix | Cut-off, U	2020	4.2%
Anhui	Module assembly	Module assembly	Electricity, high voltage {CN-AH}| electricity, high voltage, production mix | Cut-off, U	2020	6.2%
Zhejiang	Module assembly	Cell and module assembly	Electricity, high voltage {CN-ZJ}| electricity, high voltage, production mix | Cut-off, U	2020	3.72%

INVENTORY ANALYSIS

The ecoinvent v3.8 by cut-off classification system processes are used to model the background system of the processes.

The raw material inputs are modelled with data from ecoinvent representing a global market (GLO) or rest-of-world (ROW) coverage. These datasets are assumed to be representative.

UPSTREAM

Raw materials extraction includes materials needed to produce ingot, wafer, cell and PV module. Ingot, wafer and cell can be regarded as the intermediate products along the PV module production line. The raw materials extraction for the four Jinko PV modules are similar. The main deviates for the same solar cells stem from the conversion efficiencies. Since the cells with increased efficiency are fabricated using the same process and material. For the PV module, the major difference lies in back sheet or back glass. The single glaze PV module, i.e., JKMXXXN-72HL4-V, contains PET back sheet. For double glazed PV modules, they employ the back glass. Other minor difference is that whether or not include the LRF membrane, which is laminated plastic, representing less than 0.1% of the total weight of the PV modules. The P type module, i.e., JKMXXXM-72HL4-BDVP, is produced in two manufacturing sites: Chuzhou (Anhui Province) and Yiwu (Zhejiang Province). The impact results are separately documented and reported in the EPD.

The raw materials inputs for ingot, wafer and solar cells production are manufactured by JinKo as well. Thus these data are also retrieved from the PV module producers. For the N-type PV modules, their ingots and wafers are produced in the Sichuan province where the electricity is mainly sourced from hydropower. The cell fabrications are implemented in Haining, Zhejiang province. For the P-type PV module, their ingots are produced in Sichuan province and wafers and cells are both implemented in Shangrao, Jiangxi Province.

Raw materials transport: Concerning the raw material transportation, all the raw materials are sourced from domestic suppliers and are transported by truck, EURO5 is used for modelling in this study. Three types of transportation are applied: <7.5t, 7.5~16t, and >16t. All the transportation data are organized below. In case that no specific transportation type is designed. The 7.5-16t scenario is assumed. The study applies an aggregated approach for the raw materials transportation summarizing all the transport data through multiplying the weight and the transportation distance.

CORE

PV module manufacturing: The PV module products under study includes 4 models. All the products share similar manufacturing processes. The main stages of manufacturing are presented in the flowcharts below (Figure 4). The production inventory is from May 1st 2022 to Apr. 30th 2023 for N-type and P-type modules.

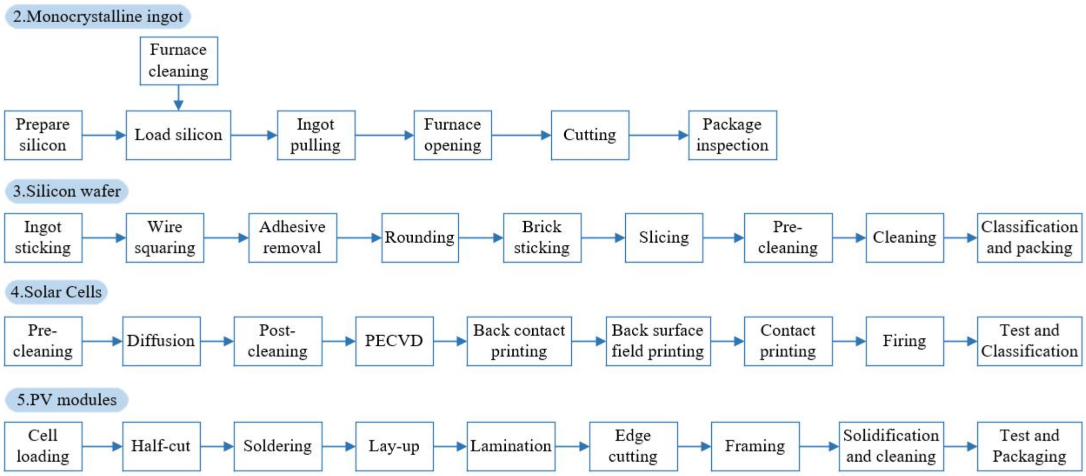


Figure 2 the manufacturing processes for the PV module in JinKo

Product distribution: The products are assumed to be transported to Yinchuan China for application.

Table 9: Product distributions for the PV modules

	JKMXXXN-72HL4-V	JKMXXXN-72HL4-BDV	JKMXXXN-78HL4-BDV	JKMXXXM-72HL4-BDVP
Mass (kg)	28	32	34.6	32
Haining-Yinchuan (km)	-	1932	1932	-
YiWu-Yinchuan (km)	-	-	-	2034
Chuzhou-Yinchuan (km)	1591	-	-	1591

DOWNSTREAM

Installation: The Bill-of-materials (other than modules) for installation include mounting, inverter, and PV cables. The transformer is not included for the LCA of the PV installation system since it is part of the grid distribution and transmission system. The study utilizes the real-ground mounted large scale PV plant in China as the reference to derive the bill of materials for PV module installation. The scaled PV plant per PV module are provided in the following table to illustration the final composition with mounting system and substation.

Table 10: The PV plant scaled by PV module

In kg	JKMXXXN-72HL4-V	JKMXXXN-72HL4-BDV	JKMXXXN-78HL4-BDV	JKMXXXM-72HL4-BDVP
PV module	28	32	34.6	32
Steel	14.28	16.32	17.646	16.32
copper	1.4375	1.425	1.5375	1.35
PP	1.02	1.01	1.09	0.96
inverter	4.14	4.10	4.43	3.89
oil	0.56	1.56	2.56	3.56
Total mass	49.44	56.42	61.86	58.08

Use and maintenance: the reference service life (RSL) of the PV MODULE is assumed to be 30 years. The energy production is simulated by the technicians in JinKo through PVsyst 7.2.16 software. Various types of array losses are considered including thermal losses, degradation loss, LID degradation loss, module quality loss, mismatch loss, and DC wiring loss and etc. Energy production in RSL is simulated according to the power station in Table 9. The PV plant maintenance is assumed to be done by once per month within 10km driving distance. The reference PV plant applies a 0.765L/m^2 water use rate. This factor is used in this study.

Table 11: Power station information for simulation

Item	Value
Location	Yinchuan-China
Peak power of the plant	40MW
Latitude	38.47°N
Longitude:	106.32°E
Altitude	1110m
Nominal solar irradiance	1897.5 kWh/m2/year

END OF LIFE

For the end-of-life stage, De-construction (C1) of the PV plant during the disposal stage is assumed mainly consuming electricity, and the electricity consumption is assumed the same as the construction stage (A5), 500km transportation distance from plant site to waste treatment site (C2) is assumed, After deinstallation, mounting system, cables and insulation oil are considered reaching “end-of-waste” state. The PV module and inverter is assumed to be treated with shredding and sorting the same as applied for the waste electronic equipment (Ecoinvent dataset, Waste electric and electronic equipment {GLO}| treatment of, shredding | Cut-off, U). Since there is lack of existing data of recycling rate for PV module, this study refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE). In 2012/19/EU-Article 11 & ANNEX V, the required recycling rate for waste PV module is 85%. Therefore, 15% of waste PV module end up with waste disposal, waste management scenario of 45% landfill and 55% incineration was adopted. A sensitivity analysis is further conducted to see the various disposal scenarios’ impact on the final results.

IMPACT INDICATORS

This EPD follows the PCR EPDItaly014 ± Photovoltaic modules guideline and use the recommended impact method for the analysis, the EN 15804+A2:2019 (version 1.03) method was used in this report. The EN 15804 standard covers

Environmental Product Declarations (EPDs) of construction products. The A2:2019 revision of this standard has aligned their methodology with the Environmental Footprint (EF) 3.0 method, except for their approach on biogenic carbon. According to the EN 15804, biogenic carbon emissions cause the same amount of Climate Change as fossil carbon, but can be neutralized by removing this carbon from the atmosphere again. Based on the model of PV module products, the EN 15804 result is calculated and the tables below shows the results. Note that impact results are calculated based on 1 kWh electricity generated by the PV plant. The results have been demonstrated through different processes according to the PCR, namely upstream, core, and downstream processes. The indicators are divided into the contribution of the processes to the different modules (upstream, core and downstream) and stages (manufacturing, distribution, use and end-of-life).

JKMXXXN-72HL4-V(CHUZHOU)

Table 12: LCIA results for JKMXXXN-72HL4-V(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream

GWP, t	kg CO2 eq	1.41E-02	6.68E-03	1.03E-03	6.35E-03	1.45E-05
GWP, f	kg CO2 eq	1.39E-02	6.63E-03	1.01E-03	6.25E-03	1.44E-05
GWP, b	kg CO2 eq	1.39E-04	3.65E-05	9.56E-06	9.32E-05	5.67E-09
GWP, luluc	kg CO2 eq	2.13E-05	1.11E-05	3.27E-06	6.95E-06	2.57E-08
ODP	kg CFC-11 eq	1.90E-09	1.45E-09	7.85E-11	3.67E-10	8.24E-13
AP	mole H+ eq	1.36E-04	4.41E-05	1.50E-05	7.65E-05	8.39E-08
EP	kg P eq	9.23E-06	3.11E-06	1.14E-06	4.97E-06	6.82E-09
POCP	kg NMVOC eq	6.49E-05	2.94E-05	5.64E-06	2.99E-05	4.59E-08
ADP, m	kg Sb eq	1.74E-06	4.02E-07	2.76E-07	1.06E-06	2.12E-10
ADP, f	MJ	1.70E-01	8.48E-02	1.22E-02	7.32E-02	1.98E-04
WDP	m3 water eq	1.28E-02	8.52E-03	1.57E-03	2.67E-03	3.38E-06

Table 12: Resource consumption results for JKMXXXN-72HL4-V(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
PENRE	MJ	1.62E-01	7.87E-02	1.22E-02	7.14E-02	1.98E-04
PERE	MJ	3.08E-02	1.89E-02	1.36E-03	1.05E-02	2.25E-05
PENRM	MJ	7.93E-03	6.12E-03	0.00E+00	1.80E-03	0.00E+00
PERM	MJ	8.48E-04	8.48E-04	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.70E-01	8.48E-02	1.22E-02	7.32E-02	1.98E-04
PERT	MJ	3.17E-02	1.98E-02	1.36E-03	1.05E-02	2.25E-05
FW	m^3	3.84E-04	2.81E-04	3.66E-05	6.62E-05	1.05E-07
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12: Waste deposed results for JKMXXXN-72HL4-V(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
HWD	kg	1.81E-07	1.80E-07	0.00E+00	2.78E-10	0.00E+00
NHWD	kg	3.11E-04	3.57E-07	2.84E-05	0.00E+00	2.82E-04
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	1.86E-03	1.07E-04	1.61E-04	2.66E-08	1.60E-03
CRU	kg	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

JKMXXXN-72HL4-BDV(HAINING)

Table 13: LCIA results for JKMXXXN-72HL4-BDV(Haining)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
GWP, t	kg CO2 eq	1.46E-02	6.62E-03	1.15E-03	6.81E-03	1.62E-05
GWP, f	kg CO2 eq	1.44E-02	6.58E-03	1.14E-03	6.69E-03	9.28E-13
GWP, b	kg CO2 eq	1.53E-04	3.31E-05	1.07E-05	1.07E-04	2.27E-06
GWP, luluc	kg CO2 eq	2.17E-05	1.09E-05	3.53E-06	7.28E-06	5.16E-08
ODP	kg CFC-11	1.36E-09	8.37E-10	9.98E-11	4.19E-10	8.67E-13

	eq					
AP	mole H+ eq	1.39E-04	4.49E-05	1.57E-05	7.80E-05	5.66E-13
EP	kg P eq	9.31E-06	3.06E-06	1.20E-06	5.04E-06	1.07E-14
POCP	kg NMVOC eq	6.74E-05	2.95E-05	6.24E-06	3.15E-05	9.42E-08
ADP, m	kg Sb eq	1.74E-06	4.01E-07	2.83E-07	1.05E-06	7.66E-09
ADP, f	MJ	1.76E-01	8.26E-02	1.40E-02	7.91E-02	1.82E-08
WDP	m3 water eq	1.29E-02	8.42E-03	1.78E-03	2.75E-03	1.96E-07

Table 13: Resource consumption results for JKMXXXN-72HL4-BDV(Haining)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
PENRE	MJ	1.69E-01	7.78E-02	1.40E-02	7.73E-02	2.23E-04
PERE	MJ	3.14E-02	1.88E-02	1.76E-03	1.08E-02	2.52E-05
PENRM	MJ	6.62E-03	4.84E-03	0.00E+00	1.77E-03	0.00E+00
PERM	MJ	9.01E-04	9.01E-04	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.76E-01	8.26E-02	1.40E-02	7.91E-02	2.23E-04
PERT	MJ	3.23E-02	1.97E-02	1.76E-03	1.08E-02	2.52E-05
FW	m^3	3.91E-04	2.78E-04	4.38E-05	6.84E-05	1.19E-07
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 13: Waste deposed results for JKMXXXN-72HL4-BDV(Haining)

Categories	Unit	Total	Core-process	Core-infrastructure	Downstream	Upstream
HWD	kg	2.04E-07	1.79E-07	0.00E+00	2.47E-08	0.00E+00
NHWD	kg	3.47E-04	4.92E-09	2.81E-05	0.00E+00	3.19E-04
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	2.16E-03	1.06E-04	1.62E-04	8.26E-05	1.81E-03
CRU	kg	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

JKMXXXN-78HL4-BDV(HAINING)

Table 14: LCIA results for JKMXXXN-78HL4-BDV(Haining)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
GWP, t	kg CO2 eq	1.45E-02	6.67E-03	1.16E-03	6.64E-03	1.79E-05
GWP, f	kg CO2 eq	1.43E-02	6.62E-03	1.14E-03	6.53E-03	1.79E-05
GWP, b	kg CO2 eq	1.54E-04	3.85E-05	1.30E-05	1.02E-04	6.97E-09
GWP, luluc	kg CO2 eq	2.18E-05	1.08E-05	3.56E-06	7.34E-06	3.19E-08
ODP	kg CFC-11 eq	1.36E-09	8.39E-10	1.01E-10	4.18E-10	9.92E-13
AP	mole H+ eq	1.40E-04	4.53E-05	1.58E-05	7.86E-05	1.04E-07
EP	kg P eq	9.40E-06	3.09E-06	1.21E-06	5.09E-06	8.49E-09
POCP	kg NMVOC eq	6.79E-05	2.98E-05	6.29E-06	3.17E-05	5.63E-08
ADP, m	kg Sb eq	1.75E-06	4.07E-07	2.85E-07	1.06E-06	2.64E-10

ADP, f	MJ	1.77E-01	8.32E-02	1.41E-02	7.94E-02	2.45E-04
WDP	m3 water eq	1.31E-02	8.51E-03	1.80E-03	2.77E-03	4.11E-06

Table 14: Resource consumption results for JKMXXXN-78HL4-BDV(Haining)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
PENRE	MJ	1.70E-01	7.82E-02	1.41E-02	7.77E-02	2.45E-04
PERE	MJ	3.16E-02	1.89E-02	1.78E-03	1.09E-02	2.80E-05
PENRM	MJ	6.77E-03	5.00E-03	0.00E+00	1.77E-03	0.00E+00
PERM	MJ	8.46E-04	8.46E-04	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.77E-01	8.32E-02	1.41E-02	7.95E-02	2.45E-04
PERT	MJ	3.25E-02	1.97E-02	1.78E-03	1.09E-02	2.80E-05
FW	m^3	3.95E-04	2.81E-04	4.43E-05	6.90E-05	1.29E-07
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 14: Waste deposed results for JKMXXXN-78HL4-BDV(Haining)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
HWD	kg	1.79E-07	1.67E-07	0.00E+00	1.16E-08	0.00E+00
NHWD	kg	3.56E-04	4.60E-09	2.89E-05	0.00E+00	3.27E-04
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	2.19E-03	9.94E-05	1.64E-04	7.73E-05	1.85E-03
CRU	kg	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

JKMXXXM-72HL4-BDVP(CHUZHOU)

Table 15: LCIA results for JKMXXXM-72HL4-BDVP(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
GWP, t	kg CO2 eq	1.59E-02	7.47E-03	1.08E-03	7.28E-03	2.21E-05
GWP, f	kg CO2 eq	1.57E-02	7.42E-03	1.07E-03	7.15E-03	2.21E-05
GWP, b	kg CO2 eq	1.69E-04	3.64E-05	1.01E-05	1.23E-04	8.52E-09
GWP, luluc	kg CO2 eq	2.48E-05	1.36E-05	3.48E-06	7.63E-06	3.95E-08
ODP	kg CFC-11 eq	1.25E-09	7.10E-10	8.43E-11	4.52E-10	1.19E-12
AP	mole H+ eq	1.45E-04	5.26E-05	1.58E-05	7.64E-05	1.27E-07
EP	kg P eq	1.15E-05	4.76E-06	1.21E-06	5.52E-06	1.05E-08
POCP	kg NMVOC eq	6.63E-05	2.80E-05	5.94E-06	3.23E-05	6.86E-08
ADP, m	kg Sb eq	2.57E-06	1.14E-06	2.93E-07	1.14E-06	3.27E-10
ADP, f	MJ	1.88E-01	9.28E-02	1.29E-02	8.20E-02	3.00E-04
WDP	m3 water eq	1.39E-02	9.84E-03	1.73E-03	2.30E-03	4.95E-06

Table 15: Resource consumption results for JKMXXXM-72HL4-BDVP(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
PENRE	MJ	1.82E-01	8.91E-02	1.29E-02	8.01E-02	3.00E-04

PERE	MJ	3.40E-02	2.18E-02	1.42E-03	1.07E-02	3.46E-05
PENRM	MJ	5.68E-03	3.78E-03	0.00E+00	1.90E-03	0.00E+00
PERM	MJ	1.00E-03	1.00E-03	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.88E-01	9.29E-02	1.29E-02	8.20E-02	3.00E-04
PERT	MJ	3.50E-02	2.28E-02	1.42E-03	1.07E-02	3.46E-05
FW	m^3	4.27E-04	3.27E-04	4.03E-05	5.95E-05	1.57E-07
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 15: Waste deposed results for JKMXXXM-72HL4-BDVP(Chuzhou)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
HWD	kg	4.88E-05	4.88E-05	0.00E+00	3.15E-10	0.00E+00
NHWD	kg	4.38E-04	3.23E-05	3.13E-05	0.00E+00	3.75E-04
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	2.95E-03	5.72E-04	1.77E-04	8.14E-05	2.12E-03
CRU	kg	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

JKMXXXM-72HL4-BDVP(YIWU)

Table 16: LCIA results for JKMXXXM-72HL4-BDVP(Yiwu)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
GWP, t	kg CO2 eq	1.59E-02	7.47E-03	1.08E-03	7.37E-03	2.21E-05
GWP, f	kg CO2 eq	1.57E-02	7.42E-03	1.07E-03	7.24E-03	2.21E-05
GWP, b	kg CO2 eq	1.69E-04	3.64E-05	1.01E-05	1.23E-04	8.52E-09
GWP, luluc	kg CO2 eq	2.49E-05	1.36E-05	3.48E-06	7.71E-06	3.95E-08
ODP	kg CFC-11 eq	1.27E-09	7.10E-10	8.43E-11	4.76E-10	1.19E-12
AP	mole H+ eq	1.46E-04	5.26E-05	1.58E-05	7.71E-05	1.27E-07
EP	kg P eq	1.15E-05	4.76E-06	1.21E-06	5.53E-06	1.05E-08
POCP	kg NMVOC eq	6.68E-05	2.80E-05	5.94E-06	3.28E-05	6.86E-08
ADP, m	kg Sb eq	2.57E-06	1.14E-06	2.93E-07	1.14E-06	3.27E-10
ADP, f	MJ	1.90E-01	9.28E-02	1.29E-02	8.39E-02	3.00E-04
WDP	m3 water eq	1.39E-02	9.84E-03	1.73E-03	2.31E-03	4.95E-06

Table 16: Resource consumption results for JKMXXXM-72HL4-BDVP(Yiwu)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
PENRE	MJ	1.84E-01	8.91E-02	1.29E-02	8.20E-02	3.00E-04
PERE	MJ	3.41E-02	2.18E-02	1.42E-03	1.08E-02	3.46E-05
PENRM	MJ	5.68E-03	3.78E-03	0.00E+00	1.90E-03	0.00E+00
PERM	MJ	1.00E-03	1.00E-03	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.90E-01	9.29E-02	1.29E-02	8.39E-02	3.00E-04
PERT	MJ	3.51E-02	2.28E-02	1.42E-03	1.08E-02	3.46E-05
FW	m^3	4.27E-04	3.27E-04	4.03E-05	5.96E-05	1.57E-07

SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 16: Waste deposed results for JKMXXXM-72HL4-BDVP(Yiwu)

Categories	Unit	Total	Upstream	Core-process	Core-infrastructure	Downstream
HWD	kg	4.88E-05	4.88E-05	0.00E+00	4.94E-14	0.00E+00
NHWD	kg	4.38E-04	3.23E-05	3.13E-05	0.00E+00	3.75E-04
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	2.95E-03	5.72E-04	1.77E-04	8.14E-05	2.12E-03
CRU	kg	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
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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.

$$RoE = \frac{E_{invested}}{E_{produced,annual}}$$

Where $E_{invested} = PENRT + PERT$. $E_{produced,annual}$ is the electricity generated on the yearly basis.

Table 17: RoE for different PV modules

	JKMXXXN-72HL4-V(Chuzhou)	JKMXXXN-72HL4-BDV(Haining)	JKMXXXN-78HL4-BDV(Haining)	JKMXXXM-72HL4-BDVP(Chuzhou)	JKMXXXM-72HL4-BDVP(Yiwu)
$E_{produced,annual}$	877.28	884.97	946.52	774.97	774.97
$E_{invested}$	1475	1535	1651	1438	1453
RoE	1.68	1.74	1.74	1.86	1.88

REFERENCES

- ISO 14025:2006, Environmental labels and declarations — Type III environmental declarations — Principles and procedures.
- ISO 14040:2006/Amd 1:2020Environmental management — Life cycle assessment — Principles and framework — Amendment 1
- ISO 14044:2006/Amd 2:2020Environmental management — Life cycle assessment — Requirements and guidelines — Amendment 2
- EN 50693:2019 - Product category rules for life cycle assessments of electronicand electrical products and systems
- EN 15804:2012+A2:2019, Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products
- PCR EPDItaly 014: Electricity Produced by Photovoltaic Modules.
- Ecoinvent, 2021. Swiss Centre for Life Cycle Assessment, v3.8 (www.ecoinvent.ch).

- PRé Consultants, 2021. Software SimaPro versione 9.3.0.2 (www.pre.nl).
- https://www.isprambiente.gov.it/it
- https://www.mise.gov.it/index.php/it/
- EPDItaly regulations rev. 5.2
- WEEE Directive(2012/19/EU)
- LCA background report, Life cycle assessment of solar photovoltaic module, prepared for the Jinko Co. Ltd.