阳光电源 SUNGROW

Sungrow Power Supply Co., Ltd.

EPD ITALY

ENVIRONMENTAL PRODUCT DECLARATION

Product Name: **Central Power Inverter**

SG1100UD, SG2200UD, SG3300UD
SG4400UD

Site Plant: **Hefei, Anhui Province, China**

in accordance with ISO 14025 and EN 50693: 2019

Program Operator EPDItaly

Publisher EPDItaly

Declaration Number *SG-EPD02*

Registration Number EPDITALY0459

Issue Date 2024/05/12

Valid to 2029/05/12

1. GENERAL INFORMATION

EPD Owner:	Sungrow Power Supply Co., Ltd. Address: No.1699, Xiyou Road, New & High Technology Industrial Development Zone, HeFei City, Anhui Province,P.R.China
Product Name:	Central Power Inverter SG1100UD, SG2200UD, SG3300UD SG4400UD
Production site:	No. 608, Changning Avenue, New & High Technology Industrial Development Zone, HeFei City, Anhui Province, P.R.China
Field of application:	DC/AC power conversion
Program Operator:	EPDITALY (www.epditaly.it) Add: via Gaetano De Castillia n° 10 - 20124 Milano, Italy
CPC Code:	4612 "Electrical transformers, static converters and inductors"
Company Contact:	Bai Rongfang Email: bairongfang@sungrowpower.com
External Audit:	This declaration has been developed referring to EPDItaly, following the General Program Instruction; further information and the document itself are available at: www.epditaly.it. Independent verification of the declaration and data, according to EN ISO 14025:2010. ☐ INTERNAL ☒ EXTERNAL Third party verifier: ICMQ SpA - Via Gaetano De Castillia, 10 - 20124 – Milano/Italy
LCA Consultant:	This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by: TÜV SÜD (www.tuvsud.cn)
Reference PCR and version number:	Core PCR: EPDItaly007 – PCR for Electronic and Electrical Products and Systems, Rev. 3, 2023/01/13. Sub PCR: EPDItaly032 - Power Inverter, Rev. 0, 2022/12/22.
Other reference documents:	Regulations of the EPDItaly Program rev. 5.2 published on 2022/02/16. EN 50693:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems.
Comparability:	EPDs relating to the same category of products but belonging to different programmes may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.
Liability:	The owner of the declaration will be responsible for the information and supporting evidence. EPDItaly disclaims any liability regarding the manufacturer's information data.
Reference document:	This declaration is based on the EPDItaly regulation, available on the website www.epditaly.com

2. COMPANY INTRODUCTION

As a key high-tech enterprise in China, Sungrow Power Supply Co., Ltd. (Stock code: 300274) specializes in R&D, production, sales and services of new energy equipment, such as solar energy, wind energy, energy storage, hydrogen energy, electric vehicles, mainly provides photovoltaic inverters, wind energy converters, energy storage system, floating PV system, new energy automotive driving system, EV charging station, renewable hydrogen production system, smart operation and maintenance, and commits itself to providing first-class life cycle solutions of clean energy.

Since the establishment in 1997, the Company has been concentrating on the field of new energy power generation, adhering to market demand orientation, and taking technological innovation as the propellant for development. The Company has cultivated a professional R&D team with solid R&D experiences and strong capabilities of independent innovation. Sungrow has successively undertaken more than 20 national key science and technology programs, led the drafting of multiple national standards, and is one of the few companies in the industry that have mastered a number of independent core technologies.

Photovoltaic inverters, Sungrow's core products, have been accredited by TÜV, CSA, SGS, and other international authorities, and sold to 170 countries and regions in the world. Sungrow's cumulative installed capacity of Inverter & converter equipment across the world has been above 405GW by the end of June 2023.

The Company has successively won the awards of China Grand Awards for Industry, National Manufacturing Single Champion Demonstration Enterprise, Top 50 Innovative Chinese Companies, National Intellectual Property Demonstration Enterprise, Global Top 500 New Energy Enterprises, and Best Companies to Work for in Asia. Sungrow is a company with state-level post-doctoral research workstation, a national high-tech industrialization demonstration base, a national enterprise technology center, a national industrial design center, a national green factory, and ranks among the best in the global new energy power generation industry in terms of comprehensive strength.

In the future, Sungrow will adhere to its mission of "Clean power for all", accelerate the development of clean energy power generation system integration based on the new energy equipment business, innovate and expand new business in the field of clean power conversion technology, keep in close contact with the customers, actively participate in global competition, and strive to build itself into a trusted world-class company.

3. SCOPE AND TYPE OF EPD

3.1. Scope of EPD

The system boundary of this study on Sungrow's power inverters encompasses the entire life cycle of the product, from cradle to grave, including the manufacturing, distribution, installation, use, and end-of-life stage, as defined in the PCR.

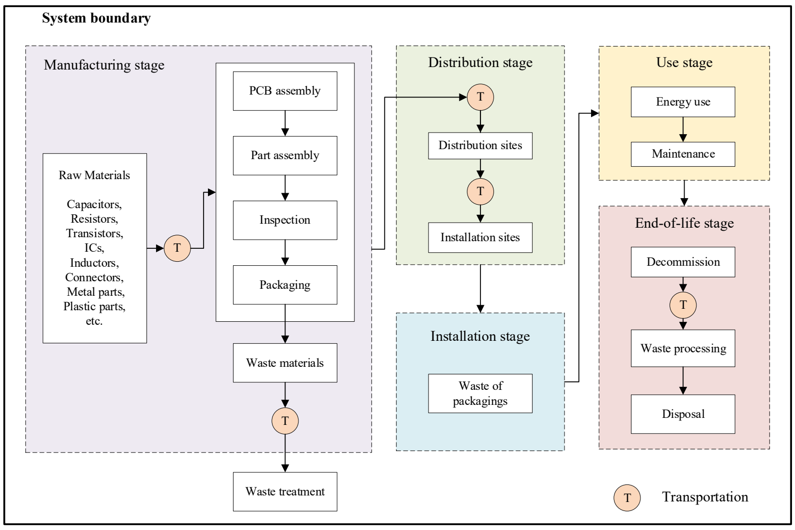

Figure 3-1 System boundary

3.2. Type of EPD

This EPD is a product specific EPD. The declaration covers in total 4 series of inverters, including SG1100UD, SG2200UD, SG3300UD SG4400UD.

3.3. Geographical scope

The geographical boundary for this LCA study is defined with manufacturing of power inverters taking place in mainland China, while use phase and end-of-life treatment stage will be modelled with a case study taken place in Italy. It is noted that the inverter products can be installed and operated worldwide. Therefore, when interpretating the LCA results, the location where the products is installed and operated shall be considered.

3.4. Time representativeness

All manufacturing data has been collected by Sungrow based on their production inventory in the reference period from May 2022 to April 2023. Datasets have been selected according to the actual processes used by the manufacturer. For generic products where no upstream data was available, such as packaging, manufacturing has been modelled according to current industry practices.

3.5. Database and LCA software used

In this study, generic data for materials, energy as well as waste disposal and transportation were taken from the database Ecoinvent 3.9. LCA-software SimaPro 9.5 was used for the modeling and calculation.

4. DETAILED PRODUCT DESCRIPTION

4.1. Description of the Product

An inverter converts current from direct current (DC) to alternating current (AC), it is sometimes referred to as a DC/AC converter. Sungrow offers a wide range of products for residential, commercial, and utility-scale applications. For commercial and utility-scale applications, Sungrow offers string inverters and central inverters that are designed to be highly efficient and reliable, while also being easy to install and maintain. These products are suitable for use in large-scale solar power plants, as well as commercial and industrial buildings. Similar to string inverters, central inverters convert DC into AC that can be fed into the electrical grid. The difference is the size. Central inverters are exclusively meant for utility-scale applications such as industrial facilities, large buildings, and very large field arrays or even floating installations. Sungrow central inverters come in a standard 10 or 20-foot container size, start at 500 kW and are available with up to 6.8 MW power output.

Within this project, there are four central inverters being analyzed, SG1100UD, SG2200UD, SG3300UD, SG4400UD. The product general and technical information are listed below.

4.2. Technical parameters

Table 4-1 technical parameters of different power inverters.

Series	**SG1100UD**	**SG2200UD**	**SG3300UD**	**SG4400UD**
Nominal PV input voltage (V)	1500	1500	1500	1500
Nominal AC voltage (V)	630	630	630	630
Max AC current (A)	1160	2*1160	3*1160	4*1160

Topology	3 phases	3 phases	3 phases	3 phases
Dimension (mm)	700*2290*1525	1415*2235*1690	2340*2300*1550	2900*2300*1550
Weight (kg)*	900	1800	2500	3300
Efficiency (Max/EU)	99.0%/98.8%	99.0%/98.8%	99.0%/98.8%	99.0%/98.8%
AC power	1100 @ 45 °C 1133 @ 40 °C 1265 @ 22.5 °C	2200 @ 45 °C 2266 @ 40 °C 2530 @ 22.5 °C	3300 @ 45 °C 3399 @ 40 °C 3795 @ 22.5 °C	4400 @ 45 °C 4532 @ 40 °C 5060 @ 22.5 °C
Standby power (W)	200	200	200	200

*The actual weight of the product fluctuates within a very small range. In this study, the following weights have been considered for the analysis: SG1100UD 902kg, SG2200UD 1786kg, SG3300UD 2616kg, SG4400UD 3446kg.

4.3. Materials compositions

Table 4-2 Materials compositions (Mass ratio)

Materials classes	**IEC62474 Code**	**SG1100UD**	**SG2200UD**	**SG3300UD**	**SG4400UD**
Main body of the inverter					
Aluminium and its alloys	M-120	10.3%	10.4%	10.7%	10.8%
Stainless steel	M-100	0.7%	0.7%	0.7%	0.7%
Other ferrous alloys, non-stainless steels	M-119	52.0%	52.6%	53.8%	54.5%
Copper and its alloys	M-121	8.4%	8.5%	8.7%	8.8%
Plastics and rubber (PC, PA, PE, PET, PVC, PU, Rubber)	M-204, M-208, M-201, M-209, M-200, M-300, M-323	12.9%	13.0%	13.3%	13.5%
Other non-ferrous metals and alloys	M-149	0.3%	0.3%	0.3%	0.3%
Other organic materials	M-399	0.9%	0.9%	0.9%	0.9%
Other inorganic materials	M-199	0.5%	0.5%	0.5%	0.5%
Packaging materials					
Wood	M-340	13.2%	11.1%	9.6%	7.8%
TPE (Thermo-plastic elastomer)	M-327	0.8%	0.3%	0.3%	0.3%
Silicone	M-321	0.1%	0.0%	0.0%	0.0%
Other ferrous alloys, non-stainless steels	M-119	0.0%	1.8%	1.3%	1.9%
Stainless steel	M-100	0.0%	6E-3%	4E-3%	3E-3%
PE (Polyethylene)	M-201	2E-3%	1E-3%	1E-3%	1E-3%

4.4. Description of the production process

Figure 4-1 describes the production processes of Sungrow inverter products. A central inverter is manufactured through pre-processing (i.e. module assembly), final assembly, aging test, and packaging, with several quality checks and commissioning stages being integrated.

Module assembly

Module assembly involves spreading the silicone grease, soldering, and installing subparts. There are both manual and automatic spreading of the silicone grease, depending on the characteristics of the modules. For each module, a stencil will be custom-built based on the silicone grease configuration in the specification. Performance parameters of the stencil, such as dimension, surface tension, and friction coefficient must pass the quality inspection, visual inspection, and technical process inspection, before the stencil goes into production. The soldering process adopts wave-soldering, to prevent soldering defects such as positional offset.

Final assembly

The finished components, including PCBA, electric reactors, relays, transformers, heat radiators, and modules, will be assembled in this workshop to produce the inverter.

Aging test

Aging test applies continuous environmental stress to components at a certain temperature for a long time, including high temperature stress and other types of stress like temperature cycling and random vibration. The goal is to accelerate physical and chemical reactions and expose potential defects early, eliminating early failures of products.

Packaging and warehousing

Packing finished components in specified quantity for easy transportation and sale and put the packed components into the warehouse procedure.

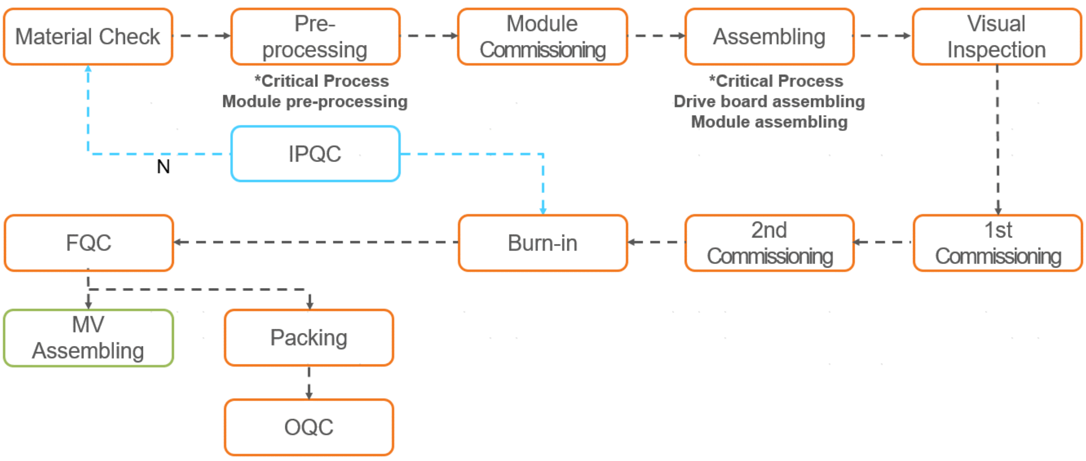

Figure 4-1 Manufacturing process flow diagram of power inverter

5. LCA RESULTS

The LCA results show the environmental impacts and resource input and output flows calculated according to EN 50693. The results are shown per functional unit (1 pcs of inverter). The LCA results have been calculated using the LCA software SimaPro 9.5.

System boundaries (X = included, MND = module not declared, MNR = module not relavant)						
Phases	**Manufacturing Stage**	**Distribution stage**	**Installation Stage**	**Use & Maintenance Stage**	**End-of-life stage De-Installation**	**Beyond the system boundaries**
Phases declared	X	X	X	X	X	MND

5.1. Environmental impacts

Table 5-1 Environmental impacts – SG1100UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO_2 eq	1.29E+04	2.96E+02	1.89E+02	6.21E+04	1.76E+02	7.56E+04
GWP-fossil	kg CO_2 eq	1.29E+04	2.96E+02	1.97E+01	6.05E+04	1.76E+02	7.39E+04
GWP-biogenic	kg CO_2 eq	-2.41E+01	4.94E-02	1.69E+02	1.41E+03	4.82E-02	1.55E+03
GWP-luluc	kg CO_2 eq	2.46E+01	1.91E-01	1.33E-03	9.51E+01	8.57E-02	1.20E+02
ODP	kg CFC11 eq	3.22E-04	4.87E-06	8.36E-08	3.82E-03	9.81E-07	4.14E-03
AP	mol H+ eq	1.30E+02	4.78E+00	1.80E-02	3.36E+02	2.91E-01	4.71E+02
EP-Freshwater	kg P eq	9.42E-01	1.92E-03	2.78E-05	3.32E+00	2.14E-03	4.26E+00
EP-Marine	kg N eq	1.42E+01	1.19E+00	7.40E-03	5.62E+01	6.03E-02	7.16E+01
EP-Terrestrial	mol N eq	1.63E+02	1.31E+01	8.13E-02	6.51E+02	6.57E-01	8.28E+02
POCP	kg NMVOC eq	8.35E+01	3.80E+00	2.57E-02	2.40E+02	2.19E-01	3.27E+02
ADP- M&M*	kg Sb eq	1.66E+05	3.90E+03	3.85E+01	7.89E+05	8.39E+02	9.60E+05
ADP-fossil*	MJ	1.26E+00	6.24E-04	8.95E-06	1.74E+00	4.00E-04	3.01E+00
WDP	m^3 depriv.	3.08E+03	1.31E+01	3.04E-01	5.35E+04	9.04E+00	5.66E+04

Table 5-2 Environmental impacts – SG2200UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO_2 eq	2.58E+04	5.87E+02	2.97E+02	1.10E+05	3.51E+02	1.37E+05
GWP-fossil	kg CO_2 eq	2.57E+04	5.86E+02	1.65E+01	1.08E+05	3.51E+02	1.34E+05
GWP-biogenic	kg CO_2 eq	9.04E+00	9.77E-02	2.80E+02	1.60E+03	9.63E-02	1.88E+03
GWP-luluc	kg CO_2 eq	4.91E+01	3.78E-01	2.07E-03	1.88E+02	1.71E-01	2.38E+02
ODP	kg CFC11 eq	6.44E-04	9.65E-06	1.18E-07	7.33E-03	1.96E-06	7.99E-03
AP	mol H+ eq	2.59E+02	9.46E+00	2.61E-02	6.24E+02	5.82E-01	8.93E+02
EP-Freshwater	kg P eq	1.88E+00	3.81E-03	4.18E-05	6.38E+00	4.27E-03	8.27E+00
EP-Marine	kg N eq	2.82E+01	2.36E+00	1.05E-02	1.05E+02	1.21E-01	1.35E+02
EP-Terrestrial	mol N eq	3.24E+02	2.60E+01	1.17E-01	1.21E+03	1.31E+00	1.56E+03

POCP	kg NMVOC eq	1.67E+02	7.52E+00	3.78E-02	4.39E+02	4.38E-01	6.14E+02
ADP- M&M*	kg Sb eq	3.30E+05	7.73E+03	5.96E+01	1.37E+06	1.68E+03	1.71E+06
ADP-fossil*	MJ	2.53E+00	1.24E-03	1.38E-05	3.46E+00	7.99E-04	5.99E+00
WDP	m^3 depriv.	6.11E+03	2.60E+01	4.11E-01	9.86E+04	1.81E+01	1.05E+05

Table 5-3 Environmental impacts – SG3300UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO_2 eq	3.86E+04	8.59E+02	3.77E+02	1.57E+05	5.27E+02	1.97E+05
GWP-fossil	kg CO_2 eq	3.84E+04	8.59E+02	2.22E+01	1.55E+05	5.27E+02	1.95E+05
GWP-biogenic	kg CO_2 eq	7.77E+01	1.43E-01	3.54E+02	1.78E+03	1.44E-01	2.21E+03
GWP-luluc	kg CO_2 eq	7.34E+01	5.53E-01	2.62E-03	2.81E+02	2.57E-01	3.55E+02
ODP	kg CFC11 eq	9.65E-04	1.41E-05	1.51E-07	1.08E-02	2.94E-06	1.18E-02
AP	mol H+ eq	3.88E+02	1.39E+01	3.33E-02	9.11E+02	8.72E-01	1.31E+03
EP-Freshwater	kg P eq	2.82E+00	5.57E-03	5.32E-05	9.45E+00	6.41E-03	1.23E+01
EP-Marine	kg N eq	4.22E+01	3.45E+00	1.34E-02	1.53E+02	1.81E-01	1.99E+02
EP-Terrestrial	mol N eq	4.85E+02	3.80E+01	1.49E-01	1.77E+03	1.97E+00	2.29E+03
POCP	kg NMVOC eq	2.49E+02	1.10E+01	4.82E-02	6.38E+02	6.58E-01	8.99E+02
ADP- M&M*	kg Sb eq	4.94E+05	1.13E+04	7.57E+01	1.95E+06	2.52E+03	2.45E+06
ADP-fossil*	MJ	3.79E+00	1.81E-03	1.75E-05	5.18E+00	1.20E-03	8.98E+00
WDP	m^3 depriv.	9.12E+03	3.81E+01	5.28E-01	1.44E+05	2.71E+01	1.53E+05

Table 5-4 Environmental impacts- SG4400UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO_2 eq	5.15E+04	1.13E+03	4.11E+02	2.04E+05	7.03E+02	2.58E+05
GWP-fossil	kg CO_2 eq	5.12E+04	1.13E+03	2.81E+01	2.02E+05	7.02E+02	2.55E+05
GWP-biogenic	kg CO_2 eq	1.91E+02	1.89E-01	3.83E+02	1.97E+03	1.93E-01	2.54E+03
GWP-luluc	kg CO_2 eq	9.77E+01	7.29E-01	2.87E-03	3.74E+02	3.43E-01	4.73E+02
ODP	kg CFC11 eq	1.29E-03	1.86E-05	1.68E-07	1.44E-02	3.92E-06	1.57E-02
AP	mol H+ eq	5.17E+02	1.83E+01	3.69E-02	1.20E+03	1.16E+00	1.74E+03
EP-Freshwater	kg P eq	3.75E+00	7.34E-03	5.85E-05	1.25E+01	8.54E-03	1.63E+01
EP-Marine	kg N eq	5.61E+01	4.54E+00	1.49E-02	2.01E+02	2.41E-01	2.62E+02
EP-Terrestrial	mol N eq	6.44E+02	5.01E+01	1.65E-01	2.32E+03	2.63E+00	3.02E+03
POCP	kg NMVOC eq	3.32E+02	1.45E+01	5.33E-02	8.38E+02	8.77E-01	1.18E+03
ADP- M&M*	kg Sb eq	6.58E+05	1.49E+04	8.28E+01	2.52E+06	3.36E+03	3.20E+06
ADP-fossil*	MJ	5.05E+00	2.39E-03	1.92E-05	6.90E+00	1.60E-03	1.20E+01
WDP	m^3 depriv.	1.21E+04	5.02E+01	5.93E-01	1.89E+05	3.62E+01	2.01E+05

*The result of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator. The additional environmental impact indicators have been calculated for all the products, but not reported in the EPD.

Caption:

1E+01 is equal to 1 x 10^1

GWP-total: Global Warming Potential; **GWP-fossil**: Global Warming Potential fossil fuels; **GWP-biogenic**: Global Warming Potential biogenic; **GWP-luluc**: Global Warming Potential land use and land use change; **ODP**: Depletion potential of the stratospheric ozone layer; **AP**: Acidification potential, Accumulated Exceedance; **EP-Freshwater**: Eutrophication potential, fraction of nutrients reaching freshwater and compartment; See "additional Norwegian requirements" for indicator given as PO4 eq. **EP-Marine**: Eutrophication potential, fraction of nutrients reaching freshwater end compartment; **EP-Terrestrial**: Eutrophication potential, Accumulated Exceedance; **POCP**: Formation potential of tropospheric ozone; **ADP-M&M**: Abiotic depletion potential for non-fossil resources (minerals and metals); **ADP-fossil**: Abiotic depletion potential for fossil resources; **WDP**: Water deprivation potential, deprivation weighted water consumption

5.2. Resources uses

Table 5-5 Resource use – SG1100UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	2.06E+04	4.18E+01	1.70E+03	2.70E+06	7.15E+01	2.73E+06
PERM	MJ	1.70E+03	0.00E+00	-1.70E+03	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.23E+04	4.18E+01	7.97E-01	2.70E+06	7.15E+01	2.73E+06
PENRE	MJ	1.60E+05	0.00E+00	3.42E+02	0.00E+00	3.83E+03	1.64E+05
PENRM	MJ	3.89E+03	0.00E+00	-3.03E+02	0.00E+00	-3.59E+03	0.00E+00
PENRT	MJ	1.66E+05	3.90E+03	3.85E+01	7.89E+05	8.39E+02	9.60E+05
SM	kg	0.00E+00	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	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	1.04E+02	4.46E-01	3.89E-02	1.90E+03	4.81E-01	2.00E+03

Table 5-6 Resource use – SG2200UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	4.05E+04	8.27E+01	2.81E+03	5.36E+06	1.43E+02	5.40E+06
PERM	MJ	2.81E+03	0.00E+00	-2.81E+03	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	4.33E+04	8.27E+01	1.15E+00	5.36E+06	1.43E+02	5.40E+06
PENRE	MJ	3.19E+05	0.00E+00	2.86E+02	0.00E+00	7.65E+03	3.27E+05
PENRM	MJ	7.40E+03	0.00E+00	-2.27E+02	0.00E+00	-7.17E+03	0.00E+00
PENRT	MJ	3.30E+05	7.73E+03	5.96E+01	1.37E+06	1.68E+03	1.71E+06
SM	kg	0.00E+00	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	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	2.06E+02	8.84E-01	4.56E-02	3.57E+03	9.62E-01	3.77E+03

Table 5-7 Resource use- SG3300UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	5.97E+04	1.21E+02	3.55E+03	8.01E+06	2.15E+02	8.07E+06
PERM	MJ	3.55E+03	0.00E+00	-3.55E+03	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	6.33E+04	1.21E+02	1.47E+00	8.01E+06	2.15E+02	8.07E+06
PENRE	MJ	4.78E+05	0.00E+00	3.87E+02	0.00E+00	1.15E+04	4.90E+05
PENRM	MJ	1.11E+04	0.00E+00	-3.12E+02	0.00E+00	-1.08E+04	0.00E+00
PENRT	MJ	4.94E+05	1.13E+04	7.57E+01	1.95E+06	2.52E+03	2.45E+06
SM	kg	0.00E+00	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	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	3.08E+02	1.29E+00	5.93E-02	5.24E+03	1.44E+00	5.55E+03

Table 5-8 Resource use-SG4400UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	7.85E+04	1.60E+02	3.83E+03	1.07E+07	2.86E+02	1.07E+07
PERM	MJ	3.83E+03	0.00E+00	-3.83E+03	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	8.23E+04	1.60E+02	1.63E+00	1.07E+07	2.86E+02	1.07E+07
PENRE	MJ	6.37E+05	0.00E+00	4.94E+02	0.00E+00	1.53E+04	6.53E+05
PENRM	MJ	1.48E+04	0.00E+00	-4.11E+02	0.00E+00	-1.43E+04	0.00E+00
PENRT	MJ	6.58E+05	1.49E+04	8.28E+01	2.52E+06	3.36E+03	3.20E+06
SM	kg	0.00E+00	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	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m3	4.09E+02	1.70E+00	6.87E-02	6.90E+03	1.92E+00	7.32E+03

Caption:

1E+01 is equal to 1 x 10^1

PENRE: Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; **PERE**: Use of renewable primary energy excluding renewable primary energy resources used as raw materials; **PENRM**: Use of non-renewable primary energy resources used as raw materials; **PERM**: Use of renewable primary energy resources used as raw materials; **PERT**: Total use of renewable primary energy resources; **PENRT**: Total use of non-renewable primary energy resources; **SM**: Use of secondary materials; **RSF**: Use of renewable secondary fuels**;** **NRSF**: Use of non-renewable secondary fuels; **FW**: Use of net fresh water

5.3. End-of-life-Waste

Table 5-9 Waste- SG1100UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
HWD	kg	9.21E-01	2.24E-02	2.70E-04	3.44E+01	3.31E-03	3.54E+01
NHWD	kg	2.00E+03	1.08E+02	2.09E+00	9.02E+03	8.70E+02	1.20E+04
RWD	kg	3.21E-01	7.14E-04	1.50E-05	1.39E+00	1.39E-03	1.72E+00

Table 5-10 Waste- SG2200UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
HWD	kg	1.85E+00	4.44E-02	3.95E-04	6.82E+01	6.63E-03	7.01E+01
NHWD	kg	4.01E+03	2.13E+02	3.14E+00	1.74E+04	1.74E+03	2.34E+04
RWD	kg	6.38E-01	1.41E-03	2.23E-05	2.33E+00	2.78E-03	2.97E+00

Table 5-11 Waste- SG3300UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
HWD	kg	2.76E+00	6.50E-02	5.04E-04	1.02E+02	9.94E-03	1.05E+02
NHWD	kg	5.99E+03	3.12E+02	4.00E+00	2.58E+04	2.37E+03	3.45E+04
RWD	kg	9.54E-01	2.07E-03	2.84E-05	3.27E+00	4.17E-03	4.23E+00

Table 5-12 Waste- SG4400UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
HWD	kg	3.69E+00	8.57E-02	5.57E-04	1.36E+02	1.33E-02	1.39E+02
NHWD	kg	7.99E+03	4.11E+02	4.40E+00	3.42E+04	3.48E+03	4.61E+04
RWD	kg	1.27E+00	2.73E-03	3.13E-05	4.21E+00	5.55E-03	5.49E+00

Caption:
1E+01 is equal to 1 x 10^1
HWD = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed

5.4. End-of-life-Output flows

Table 5-13 Output flows- SG1100UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.28E+01	0.00E+00	8.96E+01	0.00E+00	6.42E+02	7.45E+02
MER	kg	0.00E+00	0.00E+00	6.42E+02	0.00E+00	5.01E+01	6.92E+02
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.54E+02	4.54E+02
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E+02	1.74E+02

Table 5-14 Output flows- SG2200UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.58E+01	0.00E+00	1.48E+02	0.00E+00	1.28E+03	1.45E+03
MER	kg	0.00E+00	0.00E+00	5.64E+01	0.00E+00	1.00E+02	1.57E+02
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.07E+02	9.07E+02
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E+02	3.47E+02

Table 5-15 Output flows- SG3300UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.80E+01	0.00E+00	1.87E+02	0.00E+00	1.93E+03	2.13E+03
MER	kg	0.00E+00	0.00E+00	6.94E+01	0.00E+00	1.50E+02	2.20E+02
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E+03	1.36E+03
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.21E+02	5.21E+02

Table 5-16 Output flows- SG4400UD

Category	Unit	Manufacturing	Distribution	Installation	Use & Maintenance	End-of-life	Total
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.95E+01	0.00E+00	2.02E+02	0.00E+00	2.57E+03	2.79E+03
MER	kg	0.00E+00	0.00E+00	7.44E+01	0.00E+00	2.00E+02	2.75E+02
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E+03	1.81E+03
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E+02	6.95E+02

CRU = Components for re-use; **MFR** = Materials for recycling; **MER** = Materials for energy recovery; **EEE** = Exported electrical energy; **ETE** = Exported thermal energy

6. Calculation rules

6.1. Declared or functional unit

A single power inverter unit intended for DC/AC voltage transformation.

6.2. Reference Service Life

The reference service life of the studied product is 25 years.

6.3. Assumptions

Table 6-1 List of assumptions.

Categories	Items	Assumptions
Transportation stage	Transportation vehicle type	For the vehicle used for raw materials and product transportation, EURO 6 type vehicle with 16-32 ton capacity was assumed for modelling
Installation stage	Electricity and materials use	No electricity and materials used for installation as it can be done manually
Use & Maintenance	Replacement	No replacement for the module as the module has an RSL>25 years
End-of-life	De-construction	The de-construction of inverter was assumed to be done manually, no electricity and materials use in this stage
	Waste transportation	Waste transportation distance from the de-installation plant to the waste treatment facilities was assumed to be 50 km for simplification purposes
	Waste processing	The Ecoinvent waste processing data "waste electric and electronic equipment, treatment of, shredding" was applied
	Disposal	The disposal scenario follows the WEEE standards and disposal scenario of Huawei inverter carbon footprint report (Huawei, 2020)

6.4. Cut-off rules

For the processes within the system boundary, all available energy and material flow data have been included in the model. The cut-off criteria were set to 2% in this study according to PCR.

Table 6-2 Cut-off flows.

Flow name	Process stage	Mass %	Criteria to cut-off
Devices external to the inverter itself required for installation	Installation stage	N/A	Cut-off due to small impact according to PCR
Any extraordinary maintenance done on the switch	Use & Maintenance	N/A	Specified in PCR
Total cut-off mass % estimated			<2%

6.5. Data quality

Primary data (such as materials or energy flows that enter and leave the production system) is from Sungrow manufacturing facilities in a reference period from May 2022 to April 2023 (annual average). Generic data related to the life cycle impacts of the material or energy flows that enter and leave the production system is sourced from Ecoinvent 3.9 "allocation, cut-off by allocation - unit" database.

6.6. Allocations

The allocation is made in accordance with the provisions of EN 50693. Allocation refers to the partitioning of input or output flows of a process or a product system between the product systems under study and one or more other product systems. In this study, there are three types of allocation procedures considered:

Multi-input allocation

For data sets in this study, raw materials as well as packaging materials of different inverters are based on the BOM from Sungrow, no allocation is used at the stage. As for the manufacturing process, the energy consumption and emission are allocated based on working hours of different inverter, i.e., the electricity consumption and the emissions are calculated based on the amount of time spent producing each type of inverter.

Multi-output allocation

No other by-products are produced from the production, hence there is no production of by-products that need to be used to allocate the situation.

End-of-life allocation

For end-of-life allocation of background data (energy and materials), the model "allocation cut-off by classification (ISO standard) is used. The underlying philosophy of this approach is that primary (first) production of materials is always allocated to the primary user of a material. If material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials. Consequently, recyclable materials are available burden-free for recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes.

For end-of-life stage of the inverter products, the polluter pays principle (PPP) is followed in this report. This means that the waste transportation to the treatment site and the waste processing (mainly shredding) is considered in this report, while the benefit, the load from waste treatment for recycling purposes such as de-pollution and crushing, etc., is allocated to the next life cycle of substituted products, but not the primary producers, hence no burden or benefit will be allocated to the primary producer of the electric products (cut-off approach).

6.7. Electricity mix

The manufacturing stage of inverters takes place in Anhui Province, China, note that no residual mix is available at this stage, the Eastern China grid market average electricity mix is used for modelling. The installation and operation of inverters, as well as the end-of-life stage, are assumed taken place in Italy as a case study. Load consumption during the use stage is modelled with DC electricity generated from photovoltaic in Italy, while non-load consumption is modelled using average electricity market mix in Italy.

Table 6-3 Electricity mix used for modelling

Consumption type	Electricity process type
Electricity use in manufacturing stage	Eastern China electricity grid mix (market for electricity, medium voltage, Ecoinvent 3.9)
Electricity use in use stage (load consumption)	Electricity, low voltage {IT}| electricity production, photovoltaic, 570kWp open ground installation (DC output with inverter excluded, Ecoinvent 3.9)
Electricity use in use stage (non-load consumption)	Grid electricity mix in Italy (market for electricity, low voltage, Ecoinvent 3.9)

7. LCA calculation scenarios

7.1. Distribution

Italy is taken as the target market for a case study. The products are firstly transported from the manufacturing site to Shanghai Port. Then, they are transported through container ship from Shanghai Port to Italy, Genoa is chosen as the target port. Lastly, the product will be transported from Genoa to the customer, an estimated distance of 300km is assumed in this study.

7.2. Installation

In the installation stage, the energy use is negligible since the installation process is mainly done manually. According to the product category rules (PCR), only waste generation and treatment of packaging materials are considered in this stage. The waste generated from the product packaging, mainly consisting of waste wood pallets, is accounted for in this stage. The treatment of the waste wood pallets is modeled as 75% recycling and 25% incineration. Other packaging materials, including paper and plastic film, are modeled as 100% incineration.

7.3. Use & Maintenance

According to PCR, the following formula shall be used to calculate the load electricity used during the product's service life:

$$E_{use} = P_{AC} \times I_r \times (1 - eff) \times RSL$$

where:

E_{use} (kWh) is the power losses during the operation of power inverter;

P_{AC} (kW) is the output rated AC active power;

I_r (h) is average local annual sunshine in country where the inverter is installed, in this study Italy is taken as the target country, with annual sunshine hours of 2000 h.

eff (%) is average Energy Efficiency measured or form data sheet

RSL is the service life of the product, 25 years;

While non-load electricity consumption can be calculated using the standby power:

$$E_{\text{standby}} = P_{\text{standby}} \times (8760 - I_r) \times RSL$$

where E_{standby} is the standby electricity consumption of the inverter, P_{standby} (W) is the standby power of the inverter.

Table 7-1 Power consumption of inverter.

Series	Standby power (W)	AC-power*(kW)	Sunshine (h)	Efficiency	RSL (years)	E_{use} (MWh)	$E_{standby}$ (MWh)
SG1100UD	200	1100	2000	98.8%	25	660	33.8
SG2200UD	200	2200	2000	98.8%	25	1320	33.8
SG3300UD	200	3300	2000	98.8%	25	1980	33.8
SG4400UD	200	4400	2000	98.8%	25	2640	33.8

Note: *The AC power outputs selected take 45°C as a representative temperature condition

For the maintenance of the inverter products, the Sungrow inverters are designed to be free of maintenance during its service life. Therefore, no inputs and outputs take place in the maintenance stage in this study.

7.4. End-of-life

For end-of-life (EoL) stage, assumptions are made due to a lack of data. De-installation of power inverters is assumed to be manually done with no energy use. Transportation distance from the plant site to the waste treatment site is assumed to be 50km according to PCR. For waste processing, power inverter is shredded and post-processed. The Ecoinvent waste processing data "waste electric and electronic equipment, treatment of, shredding" was employed here since it effectively represents today's EoL treatment of an inverter. The power inverters disposal and recycling stage involves removing hazardous valuable materials, metal scraps. The most recyclable materials constitute the metal components, printed circuit board (PCBs), and cables. In this study, both carbon footprint report of Huawei inverter (Huawei, 2020) and IEC/TR 62635 guidelines are referred. 90% of metals (steel, aluminium, copper) can be recycled and 10% will be disposed by landfill. 60% of plastics can be recycled and 40% will be disposed with incineration. 65% of electronic components (PCBA and cables) can be recycled and the rest will be disposed with 10% of incineration and 25% of landfill.

Table 7-2 End-of-Life disposal (Huawei, 2020).

Components	Recycling rate	Disposal rate	Disposal Treatment
Metals	90%	10%	Landfill
Plastics	60%	40%	Incineration
PCBA	65%	35%	10% Incineration/25% landfill
Cable	65%	35%	
Rubber	0%	100%	Incineration
Organic oil	0%	100%	Incineration
Inorganics	0%	100%	Landfill

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