山东泰开隔离开关有限公司
SHANDONG TAIKAI DISCONNECTOR CO., LTD.

Shandong Taikai Disconnector Co., Ltd.

ENVIRONMENTAL PRODUCT DECLARATION

Product Name: Disconnect Switches (GW4-40.5DW, GW4-72.5DW, GW4-126DW, GW4-145DW, GW4-170DW, GW4-252DW)

Site Plant: Taian, Shangdong Province, China

in accordance with ISO 14025 and EN 50693: 2019

Program Operator	EPDItaly
Publisher	EPDItaly
Declaration Number	Taikai-00002
Registration Number	EPDITALY0567
Issue Date	29 / 05 / 2024
Valid to	29 / 05 / 2029

1. GENERAL INFORMATION

EPD Owner:	Shandong Taikai Disconnector Co., Ltd. Address: No. 58 Longtan South Road, Taikai South Industrial Zone, Tai'an High-Tech Development Zone, Tai'an City Shandong Province (China)
Product Name:	Disconnect Switches
Production site:	No. 58 Longtan South Road, Taikai South Industrial Zone, Tai'an High-Tech Development Zone, Tai'an City Shandong Province (China)
Field of application:	High voltage substation
Program Operator:	EPDItaly (www.epditaly.it) Add: via Gaetano De Castillia n° 10 - 20124 Milano, Italy
CPC Code:	46211 – "Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits, for a voltage exceeding 1000 V"
Company Contact:	Wang Lishan (E-mail: tkgl2005@163.com)
External Audit:	This declaration has been developed referring to EPDItaly, following the Regulation; 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 verification carried out by: ICMQ S.p.A., via Gaetano De Castillia n ° 10 - 20124 Milan, Italy. Accredited by Accredia
LCA Consultant:	This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by: Ecovane Environmental Co., Ltd (www.1mi1.org/www.ecovane.cc)
Reference PCR and version number:	Core PCR: EPDItaly007 – PCR for Electronic and Electrical Products and Systems, Rev. 3, 2020/10/21(revision on 2023/01/13) Sub PCR: EPDItaly012: Electronic and electrical products and systems – Switches (March 2020, Revision REV.0)
Other reference documents:	Regulation of the EPDItaly Program rev. 6.0 published on 2023/10/30. 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

Shandong Taikai Disconnector Co., Ltd. has a registered capital of 200 million yuan and total assets of 800 million yuan. It specializes in the research and development, complete engineering design, manufacture, sales and installation of high-voltage switches, isolation switches and grounding switches, high-voltage fuse products, intelligent operating mechanisms and transformer neutral point protection devices for power systems and new energy sources such as wind power, hydropower and nuclear power. It is a wholly-owned subsidiary of Taikai Group and ranks first in the country with a market share of 17.6% in the same industry in 2022.

The company has won 11 national and provincial awards and formulated 2 national and industry standards. It has undertaken 24 provincial-level scientific research projects and 1 major municipal-level project. It has a number of provincial and municipal innovation platforms such as Shandong Provincial Enterprise Technology Centre, Industrial Design Centre, Taian Industrial Design Centre and Municipal Key Laboratory.

3. SCOPE AND TYPE OF EPD

3.1. Scope of EPD

The entire life cycle stages of the product (type of EPD: « cradle-to-grave ») are considered in the LCA study, which include all stages from extraction of raw materials, manufacturing, transportation and installation, maintenance and end-of-life.

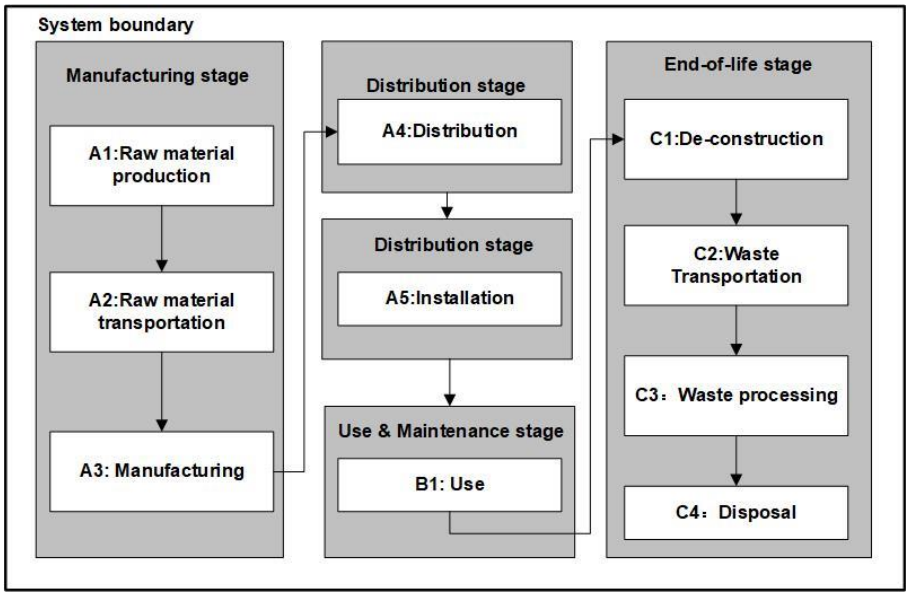

Figure 3-1 System boundary of Taikai switch products

3.2. Type of EPD

This EPD is a product specific EPD. The declaration covers in total 6 series of disconnect switches.

3.3. Geographical scope

The disconnect switches analysed within this study are manufactured in one factory located in Taian, Shandong Province, China. The geographical coverage of the product is global, a reference market in Italy is used for assessment in this study.

3.4. Time representativeness

January 2021 to December 2021.

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 LCI-database Ecoinvent 3.9. LCA-software SimaPro 9.5 was used for modelling and calculation.

4. DETAILED PRODUCT DESCRIPTION

4.1. Description of the Product

The isolation switch produced by Shandong Taikai has the characteristics of good through-flow performance, high strength and good transmission, light weight, strong weather resistance, high corrosion resistance and strong impact resistance.

The switch conductive system adopts high quality aluminium alloy tube and high quality graphite silver-plated contacts and fingers. The conductive meshing part has the ability to self-clean the contact surface during product division and closing, reducing the wear and tear of the contact surface, high reliable clamping force, reducing contact resistance and avoiding contact surface heating. The insulator has high strength, good resistance to bending and twisting, the body and drive system are made of high quality steel, high strength stainless steel shaft pins, etc. Double seal design structure, strong weather resistance, to ensure long-term rotation flexible and light, no failure.

4.2. Technical parameters

Table 4-1 technical parameters of different disconnect switches

Disconnect switch	Nominal voltage/kV	Nominal current/A	Number of poles of the switch, P	Rated peak withstands current (kA)
GW4-40.5DW	40.5	2000	3	40
GW4-72.5DW	72.5	2000	3	40
GW4-126DW	126	3150	3	50
GW4-145DW	145	3150	3	50
GW4-170DW	170	3150	3	50
GW4-252DW	252	3150	3	50

4.3. Materials compositions

Table 4-2 Materials compositions of different disconnect switches

Item	IEC62474 Code	GW4-40.5DW	GW4-72.5DW	GW4-126DW	GW4-145DW	GW4-170DW	GW4-252DW
Other ferrous alloys, non-stainless steels	M-119	67.80%	61.30%	54.40%	49.40%	53.30%	61.00%
Aluminium alloy	M-120	7.30%	6.10%	9.40%	7.90%	7.60%	5.10%
Copper and its alloys	M-121	2.00%	1.50%	1.30%	1.00%	0.90%	0.90%
Polyamide	M-258	0.80%	0.60%	0.50%	0.40%	0.30%	0.20%
Stainless steel	M-100	4.80%	3.60%	2.70%	2.10%	1.90%	1.10%
Glass	M-161	8.60%	16.70%	21.00%	30.30%	0.00%	0.00%
Silicone	M-321	3.40%	5.10%	6.30%	5.60%	0.00%	0.00%
Ceramic	M-160	5.20%	5.10%	4.40%	3.40%	0.00%	0.00%
Cast and sintered irons	M-101	0.00%	0.00%	0.00%	0.00%	31.40%	25.20%

4.4. Description of the production process

Figure 4-1 is the flowchart depicting the production process of disconnect switch. The manufacturing of disconnect switch takes place in three workshops, (1) the processing workshop, where the metal raw materials are processed into different components, (2) the spare part workshop, and the (3) final assembly workshop, where all the components and shell are assembled into the final products.

Processing workshop

The production process in the processing workshop mainly contains three steps:

Step1: Cutting

This process cuts all the raw metal materials into a desired shape and size.

Step2: Processing

This process mainly carries out the production of metal raw materials into the components of the products.

Step3: Cleaning and post-processing

This process is to clean the processed components and to further processing.

Assembly workshop

The finished components and parts will be assembled in this workshop to produce the disconnect switches.

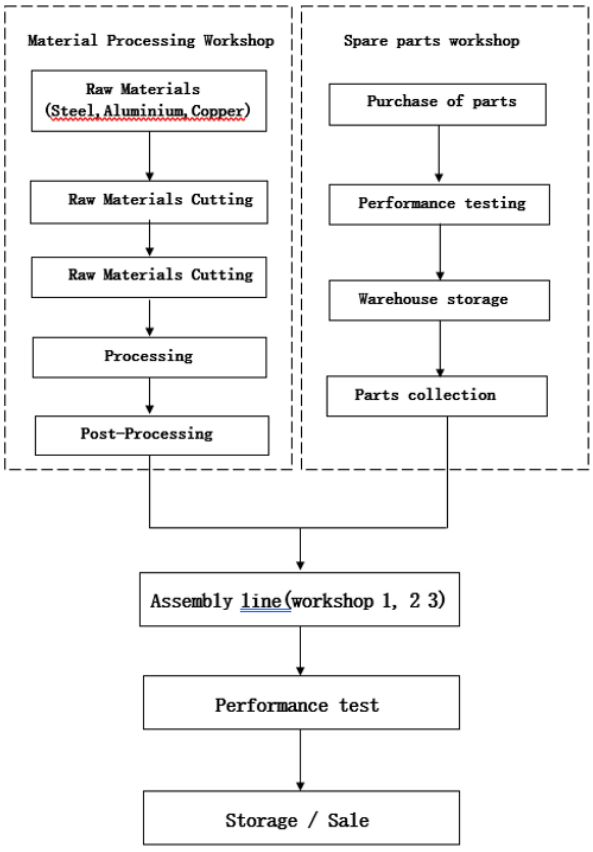

Figure 4-1 Manufacturing process flow diagram of disconnect switch

5. LCA RESULTS

5.1. Environmental performance

Table 5-1 Environmental impacts - GW4-40.5DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	4.74E+03	1.74E+02	2.05E+01	3.41E+02	7.16E+01	5.35E+03
GWP-fossil	kg CO2 eq	4.65E+03	1.74E+02	2.03E+01	3.37E+02	7.12E+01	5.25E+03
GWP-biogenic	kg CO2 eq	8.76E+01	3.95E-02	2.42E-01	3.91E+00	3.35E-01	9.22E+01
GWP-luluc	kg CO2 eq	5.81E+00	1.12E-01	3.19E-03	7.47E-02	8.19E-02	6.08E+00
ODP	kg CFC11 eq	6.78E-05	2.88E-06	4.54E-07	8.03E-06	1.02E-06	8.02E-05
AP	mol H+ eq	3.52E+01	2.79E+00	7.33E-02	1.45E+00	3.04E-01	3.98E+01
EP-Freshwater	kg P eq	2.57E-01	1.13E-03	3.82E-04	7.64E-03	2.30E-03	2.69E-01
EP-Marine	kg N eq	4.75E+00	6.95E-01	1.18E-02	2.09E-01	5.45E-02	5.72E+00
EP-Terrestrial	mol N eq	5.39E+01	7.67E+00	1.42E-01	2.54E+00	6.35E-01	6.49E+01
POCP	kg NMVOC eq	1.99E+01	2.22E+00	6.10E-02	1.06E+00	2.25E-01	2.35E+01
ADP- M&M*	kg Sb eq	2.35E-01	3.68E-04	3.61E-05	3.89E-03	4.03E-04	2.39E-01
ADP-fossil*	MJ	5.16E+04	2.30E+03	3.19E+02	5.26E+03	9.76E+02	6.04E+04
WDP*	m3 depriv.	6.94E+02	7.73E+00	1.28E+01	2.16E+02	2.02E+01	9.51E+02

*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

Table 5-2 Environmental impacts - GW4-72.5DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	6.07E+03	2.41E+02	2.05E+01	3.41E+02	8.97E+01	6.76E+03
GWP-fossil	kg CO2 eq	5.95E+03	2.41E+02	2.03E+01	3.37E+02	8.92E+01	6.63E+03
GWP-biogenic	kg CO2 eq	1.12E+02	5.47E-02	2.42E-01	3.91E+00	3.70E-01	1.17E+02
GWP-luluc	kg CO2 eq	7.28E+00	1.55E-01	3.19E-03	7.47E-02	1.10E-01	7.62E+00
ODP	kg CFC11 eq	9.12E-05	3.98E-06	4.54E-07	8.03E-06	1.23E-06	1.05E-04
AP	mol H+ eq	4.22E+01	3.86E+00	7.33E-02	1.45E+00	3.91E-01	4.79E+01
EP-Freshwater	kg P eq	3.20E-01	1.56E-03	3.82E-04	7.64E-03	2.98E-03	3.33E-01
EP-Marine	kg N eq	6.02E+00	9.62E-01	1.18E-02	2.09E-01	7.18E-02	7.28E+00
EP-Terrestrial	mol N eq	6.82E+01	1.06E+01	1.42E-01	2.54E+00	8.33E-01	8.23E+01
POCP	kg NMVOC eq	2.52E+01	3.07E+00	6.10E-02	1.06E+00	2.92E-01	2.97E+01
ADP- M&M*	kg Sb eq	2.52E-01	5.09E-04	3.61E-05	3.89E-03	5.32E-04	2.57E-01
ADP-fossil*	MJ	6.62E+04	3.18E+03	3.19E+02	5.26E+03	1.22E+03	7.62E+04
WDP*	m3 depriv.	8.75E+02	1.07E+01	1.28E+01	2.16E+02	2.38E+01	1.14E+03

*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

Table 5-3 Environmental impacts - GW4-126DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	7.80E+03	3.11E+02	2.05E+01	3.41E+02	1.12E+02	8.59E+03

GWP-fossil	kg CO2 eq	7.66E+03	3.10E+02	2.03E+01	3.37E+02	1.11E+02	8.44E+03
GWP-biogenic	kg CO2 eq	1.37E+02	7.05E-02	2.42E-01	3.91E+00	4.12E-01	1.42E+02
GWP-luluc	kg CO2 eq	9.89E+00	2.00E-01	3.19E-03	7.47E-02	1.44E-01	1.03E+01
ODP	kg CFC11 eq	1.20E-04	5.13E-06	4.54E-07	8.03E-06	1.50E-06	1.35E-04
AP	mol H+ eq	5.36E+01	4.98E+00	7.33E-02	1.45E+00	4.96E-01	6.06E+01
EP-Freshwater	kg P eq	3.99E-01	2.02E-03	3.82E-04	7.64E-03	3.81E-03	4.13E-01
EP-Marine	kg N eq	7.78E+00	1.24E+00	1.18E-02	2.09E-01	9.26E-02	9.33E+00
EP-Terrestrial	mol N eq	8.81E+01	1.37E+01	1.42E-01	2.54E+00	1.07E+00	1.05E+02
POCP	kg NMVOC eq	3.21E+01	3.96E+00	6.10E-02	1.06E+00	3.71E-01	3.76E+01
ADP- M&M*	kg Sb eq	2.98E-01	6.57E-04	3.61E-05	3.89E-03	6.89E-04	3.03E-01
ADP-fossil*	MJ	8.51E+04	4.10E+03	3.19E+02	5.26E+03	1.52E+03	9.63E+04
WDP*	m3 depriv.	1.14E+03	1.38E+01	1.28E+01	2.16E+02	2.81E+01	1.41E+03

*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

Table 5-4 Environmental impacts - GW4-145DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	9.13E+03	4.02E+02	2.05E+01	3.41E+02	1.40E+02	1.00E+04
GWP-fossil	kg CO2 eq	8.96E+03	4.01E+02	2.03E+01	3.37E+02	1.39E+02	9.85E+03
GWP-biogenic	kg CO2 eq	1.62E+02	9.11E-02	2.42E-01	3.91E+00	4.68E-01	1.67E+02
GWP-luluc	kg CO2 eq	1.11E+01	2.58E-01	3.19E-03	7.47E-02	1.88E-01	1.16E+01
ODP	kg CFC11 eq	1.41E-04	6.64E-06	4.54E-07	8.03E-06	1.85E-06	1.58E-04
AP	mol H+ eq	6.08E+01	6.44E+00	7.33E-02	1.45E+00	6.35E-01	6.94E+01
EP-Freshwater	kg P eq	4.57E-01	2.61E-03	3.82E-04	7.64E-03	4.87E-03	4.72E-01
EP-Marine	kg N eq	9.12E+00	1.60E+00	1.18E-02	2.09E-01	1.21E-01	1.11E+01
EP-Terrestrial	mol N eq	1.03E+02	1.77E+01	1.42E-01	2.54E+00	1.40E+00	1.25E+02
POCP	kg NMVOC eq	3.77E+01	5.12E+00	6.10E-02	1.06E+00	4.80E-01	4.44E+01
ADP- M&M*	kg Sb eq	3.06E-01	8.49E-04	3.61E-05	3.89E-03	8.90E-04	3.12E-01
ADP-fossil*	MJ	9.94E+04	5.29E+03	3.19E+02	5.26E+03	1.92E+03	1.12E+05
WDP*	m3 depriv.	1.28E+03	1.78E+01	1.28E+01	2.16E+02	3.43E+01	1.56E+03

*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

Table 5-5 Environmental impacts- GW4-170DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	9.11E+03	4.23E+02	2.05E+01	3.41E+02	1.52E+02	1.01E+04
GWP-fossil	kg CO2 eq	8.94E+03	4.23E+02	2.03E+01	3.37E+02	1.52E+02	9.87E+03
GWP-biogenic	kg CO2 eq	1.64E+02	9.60E-02	2.42E-01	3.91E+00	4.91E-01	1.69E+02
GWP-luluc	kg CO2 eq	1.09E+01	2.72E-01	3.19E-03	7.47E-02	2.07E-01	1.14E+01
ODP	kg CFC11 eq	1.25E-04	6.99E-06	4.54E-07	8.03E-06	1.98E-06	1.43E-04
AP	mol H+ eq	5.90E+01	6.78E+00	7.33E-02	1.45E+00	6.91E-01	6.80E+01

EP-Freshwater	kg P eq	4.82E-01	2.74E-03	3.82E-04	7.64E-03	5.35E-03	4.98E-01
EP-Marine	kg N eq	8.76E+00	1.69E+00	1.18E-02	2.09E-01	1.31E-01	1.08E+01
EP-Terrestrial	mol N eq	9.92E+01	1.86E+01	1.42E-01	2.54E+00	1.51E+00	1.22E+02
POCP	kg NMVOC eq	3.73E+01	5.40E+00	6.10E-02	1.06E+00	5.18E-01	4.43E+01
ADP- M&M*	kg Sb eq	3.48E-01	8.94E-04	3.61E-05	3.89E-03	9.83E-04	3.54E-01
ADP-fossil*	MJ	9.97E+04	5.58E+03	3.19E+02	5.26E+03	2.08E+03	1.13E+05
WDP*	m3 depriv.	1.35E+03	1.88E+01	1.28E+01	2.16E+02	3.58E+01	1.64E+03

*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

Table 5-6 Environmental impacts - GW4-252DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
GWP-total	kg CO2 eq	1.47E+04	6.88E+02	2.05E+01	5.18E+02	2.38E+02	1.62E+04
GWP-fossil	kg CO2 eq	1.44E+04	6.87E+02	2.03E+01	5.12E+02	2.37E+02	1.59E+04
GWP-biogenic	kg CO2 eq	2.76E+02	1.56E-01	2.42E-01	5.94E+00	6.54E-01	2.83E+02
GWP-luluc	kg CO2 eq	1.62E+01	4.42E-01	3.19E-03	1.13E-01	3.44E-01	1.71E+01
ODP	kg CFC11 eq	2.04E-04	1.14E-05	4.54E-07	1.22E-05	2.96E-06	2.31E-04
AP	mol H+ eq	9.33E+01	1.10E+01	7.33E-02	2.21E+00	1.09E+00	1.08E+02
EP-Freshwater	kg P eq	7.89E-01	4.46E-03	3.82E-04	1.16E-02	8.69E-03	8.14E-01
EP-Marine	kg N eq	1.40E+01	2.74E+00	1.18E-02	3.18E-01	2.06E-01	1.73E+01
EP-Terrestrial	mol N eq	1.59E+02	3.03E+01	1.42E-01	3.86E+00	2.37E+00	1.95E+02
POCP	kg NMVOC eq	6.07E+01	8.77E+00	6.10E-02	1.61E+00	8.07E-01	7.20E+01
ADP- M&M*	kg Sb eq	5.48E-01	1.45E-03	3.61E-05	5.91E-03	1.62E-03	5.57E-01
ADP-fossil*	MJ	1.61E+05	9.06E+03	3.19E+02	8.00E+03	3.23E+03	1.81E+05
WDP*	m3 depriv.	2.03E+03	3.05E+01	1.28E+01	3.28E+02	4.92E+01	2.45E+03

*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

Caption: 1E+01 is equal to 1×10^1

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; **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 and waste generation

Table 5-7 Resource use/waste production - GW4-40.5DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	5.23E+03	2.47E+01	9.99E+01	1.75E+03	1.44E+02	7.25E+03
PERM	MJ	1.91E+01	0.00E+00	-1.91E+01	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	5.25E+03	2.47E+01	8.08E+01	1.75E+03	1.44E+02	7.25E+03
PENRE	MJ	5.14E+04	2.30E+03	3.22E+02	5.26E+03	1.17E+03	6.04E+04
PENRM	MJ	2.00E+02	0.00E+00	-3.54E+00	0.00E+00	-1.96E+02	0.00E+00
PENRT	MJ	5.16E+04	2.30E+03	3.19E+02	5.26E+03	9.76E+02	6.04E+04
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	2.50E+01	2.63E-01	3.44E-01	5.88E+00	6.31E-01	3.21E+01
HWD	kg	4.72E-01	1.32E-02	1.07E-03	2.31E-02	3.27E-03	5.13E-01
NHWD	kg	1.33E+03	6.37E+01	9.51E-01	2.53E+01	9.89E+01	1.52E+03
RWD	kg	4.95E-02	4.24E-04	6.89E-04	1.13E-02	1.92E-03	6.38E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	2.61E-01	0.00E+00	1.51E+02	0.00E+00	5.48E+02	6.99E+02
MER	kg	1.46E-01	0.00E+00	0.00E+00	0.00E+00	5.85E-01	7.31E-01
ETE	MJ	0.00E+00	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	0.00E+00

Table 5-8 Resource use/waste production - GW4-72.5DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	9.74E+01	3.42E+01	1.12E+02	1.75E+03	1.66E+02	2.16E+03
PERM	MJ	3.11E+01	0.00E+00	-3.11E+01	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.28E+02	3.42E+01	8.08E+01	1.75E+03	1.66E+02	2.16E+03
PENRE	MJ	1.69E+03	3.18E+03	3.25E+02	5.26E+03	1.43E+03	1.19E+04
PENRM	MJ	2.12E+02	0.00E+00	-5.74E+00	0.00E+00	-2.06E+02	0.00E+00
PENRT	MJ	1.91E+03	3.18E+03	3.19E+02	5.26E+03	1.22E+03	1.19E+04
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	6.02E-01	3.64E-01	3.44E-01	5.88E+00	7.55E-01	7.94E+00
HWD	kg	3.09E-03	1.82E-02	1.07E-03	2.31E-02	4.14E-03	4.96E-02
NHWD	kg	2.61E+01	8.81E+01	9.51E-01	2.53E+01	2.24E+02	3.64E+02
RWD	kg	1.93E-03	5.87E-04	6.89E-04	1.13E-02	2.35E-03	1.69E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	2.96E-01	0.00E+00	2.35E+02	0.00E+00	6.50E+02	8.85E+02
MER	kg	1.66E-01	0.00E+00	0.00E+00	0.00E+00	5.85E-01	7.51E-01
ETE	MJ	0.00E+00	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	0.00E+00

Table 5-9 Resource use/waste production - GW4-126DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	1.36E+02	4.41E+01	1.21E+02	1.75E+03	1.93E+02	2.24E+03
PERM	MJ	4.04E+01	0.00E+00	-4.04E+01	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.76E+02	4.41E+01	8.08E+01	1.75E+03	1.93E+02	2.24E+03
PENRE	MJ	2.47E+03	4.10E+03	3.26E+02	5.26E+03	1.74E+03	1.39E+04
PENRM	MJ	2.21E+02	0.00E+00	-7.46E+00	0.00E+00	-2.14E+02	0.00E+00
PENRT	MJ	2.69E+03	4.10E+03	3.19E+02	5.26E+03	1.52E+03	1.39E+04
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	8.32E-01	4.69E-01	3.44E-01	5.88E+00	9.02E-01	8.43E+00
HWD	kg	4.20E-03	2.35E-02	1.07E-03	2.31E-02	5.18E-03	5.71E-02
NHWD	kg	3.63E+01	1.14E+02	9.51E-01	2.53E+01	3.62E+02	5.38E+02
RWD	kg	2.59E-03	7.57E-04	6.89E-04	1.13E-02	2.87E-03	1.82E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	4.37E-01	0.00E+00	2.81E+02	0.00E+00	7.98E+02	1.08E+03
MER	kg	2.45E-01	0.00E+00	0.00E+00	0.00E+00	5.85E-01	8.30E-01
ETE	MJ	0.00E+00	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	0.00E+00

Table 5-10 Resource use/waste production - GW4-145DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	1.74E+02	5.69E+01	1.22E+02	1.75E+03	2.28E+02	2.33E+03
PERM	MJ	4.08E+01	0.00E+00	-4.08E+01	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.15E+02	5.69E+01	8.08E+01	1.75E+03	2.28E+02	2.33E+03
PENRE	MJ	2.92E+03	5.29E+03	3.26E+02	5.26E+03	2.14E+03	1.59E+04
PENRM	MJ	2.22E+02	0.00E+00	-7.54E+00	0.00E+00	-2.14E+02	0.00E+00
PENRT	MJ	3.14E+03	5.29E+03	3.19E+02	5.26E+03	1.92E+03	1.59E+04
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	1.00E+00	6.06E-01	3.44E-01	5.88E+00	1.11E+00	8.94E+00
HWD	kg	5.32E-03	3.04E-02	1.07E-03	2.31E-02	6.59E-03	6.65E-02
NHWD	kg	4.41E+01	1.47E+02	9.51E-01	2.53E+01	6.10E+02	8.27E+02
RWD	kg	3.26E-03	9.79E-04	6.89E-04	1.13E-02	3.54E-03	1.98E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	4.70E-01	0.00E+00	3.51E+02	0.00E+00	9.25E+02	1.28E+03
MER	kg	2.63E-01	0.00E+00	0.00E+00	0.00E+00	5.85E-01	8.48E-01
ETE	MJ	0.00E+00	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	0.00E+00

Table 5-11 Resource use/waste production - GW4-170DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	1.61E+02	6.00E+01	1.66E+02	1.75E+03	2.44E+02	2.38E+03
PERM	MJ	8.50E+01	0.00E+00	-8.50E+01	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.46E+02	6.00E+01	8.08E+01	1.75E+03	2.44E+02	2.38E+03
PENRE	MJ	3.86E+03	5.58E+03	3.35E+02	5.26E+03	2.33E+03	1.74E+04
PENRM	MJ	2.66E+02	0.00E+00	-1.57E+01	0.00E+00	-2.50E+02	0.00E+00
PENRT	MJ	4.13E+03	5.58E+03	3.19E+02	5.26E+03	2.08E+03	1.74E+04
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	1.20E+00	6.38E-01	3.44E-01	5.88E+00	1.17E+00	9.24E+00
HWD	kg	1.02E-02	3.20E-02	1.07E-03	2.31E-02	7.11E-03	7.35E-02
NHWD	kg	8.17E+01	1.55E+02	9.51E-01	2.53E+01	5.98E+02	8.60E+02
RWD	kg	3.75E-03	1.03E-03	6.89E-04	1.13E-02	3.85E-03	2.06E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	5.13E-01	0.00E+00	2.81E+02	0.00E+00	1.08E+03	1.36E+03
MER	kg	2.87E-01	0.00E+00	0.00E+00	0.00E+00	5.85E-01	8.72E-01
ETE	MJ	0.00E+00	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	0.00E+00

Table 5-12 Resource use/waste production - GW4-252DW

Category	Unit	Manufacturing stage	Distribution	Installation	Use & Maintenance	End-of-life	Total
PERE	MJ	3.04E+02	9.75E+01	2.12E+02	2.66E+03	3.53E+02	3.63E+03
PERM	MJ	1.31E+02	0.00E+00	-1.31E+02	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	4.35E+02	9.75E+01	8.08E+01	2.66E+03	3.53E+02	3.63E+03
PENRE	MJ	6.98E+03	9.06E+03	-2.42E+01	0.00E+00	-3.06E+02	0.00E+00
PENRM	MJ	3.31E+02	0.00E+00	3.19E+02	8.00E+03	3.23E+03	2.79E+04
PENRT	MJ	7.31E+03	9.06E+03	3.19E+02	8.00E+03	3.23E+03	2.79E+04
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	2.12E+00	1.04E+00	3.44E-01	8.93E+00	1.68E+00	1.41E+01
HWD	kg	1.59E-02	5.21E-02	1.07E-03	3.51E-02	1.10E-02	1.15E-01
NHWD	kg	1.31E+02	2.51E+02	9.51E-01	3.84E+01	8.16E+02	1.24E+03
RWD	kg	6.43E-03	1.68E-03	6.89E-04	1.72E-02	5.98E-03	3.19E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.03E+00	0.00E+00	3.71E+02	0.00E+00	1.94E+03	2.31E+03
MER	kg	5.77E-01	0.00E+00	0.00E+00	0.00E+00	6.45E-01	1.22E+00
ETE	MJ	0.00E+00	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	0.00E+00

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

HWD = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed

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

6. CALCULATION RULES

6.1. Declared or functional unit

A single piece of the disconnect switch operating for 20 years.

6.2. Reference Service Life

According to the PCR, the RSL for disconnect switch is defined as 20 years.

6.3. Assumptions

The key assumptions of this LCA study are as follows**:**

- For missing background data, the substitution of missing data using a similar background data approach was taken to shorten the gap;
- Disconnect switch contain many pieces of components, and the majority of them are made from metals like steel, aluminium alloy, and copper, etc. Thus, the raw materials are categorized and grouped into steel, stainless steel, aluminium alloy, copper, and plastic based on its main constituents;
- During the installation stage, since there is no primary data for energy consumption, an assumption is made by assuming that the high voltage electric equipment is installed by a crane with the power of 50kW for 1 hour, thus the power consumption is 50kWh;
- The power consumption of de-installation (C1) is assumed to be the same as the installation stage (A5), and the dismantling process of the waste processing stage (C3) is modelled by using generic data (Waste electric and electronic equipment {RER}| treatment of, shredding | Cut-off, U) from Ecoinvent database;
- During the end-of-life stage, the transportation of the waste to treatment facilities including recycling, landfill, or incineration center is assumed to be 200 km for simplification purposes.

6.4. Cut-off rules

The following procedures were followed for the inclusion and exclusion of inputs and outputs:

- All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented;

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

Table 6-1 Cut-off flows

Flow name	Process stage	Mass %	Criteria to cut-off
Production, use, and disposal of the packaging of components and semi-finished intermediates;	A3	N/A	Specified in PCR
Devices external to the switch itself (e.g., switchboards) required for installation	A5	N/A	Cut-off due to small impact according to PCR
Any extraordinary maintenance done on the switch	B	N/A	Specified in PCR
Total cut-off mass % estimated			<1%

6.5. Data quality

Primary data system (such materials or energy flows that enter the production system) is from Taikai manufacturing facilities in a reference period from Jan, 2021 to Dec, 2021 (annual average). Generic data related to the life cycle impacts of the material or energy flows that enter the production system is sourced from Ecoinvent 3.9 "allocation, cut-off by allocation - unit" database. SimaPro is one of the world's most widely used LCA software and the data in it comes predominantly from Ecoinvent, the world's most complete and widely used set of data on industrial processes, material production, packaging production, transport, and so on.

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, the allocation of the materials inputs of switch production is generally carried out via the mass. The electricity and emissions during the manufacturing stage of switch are allocated by economic value of different products. The transportation of raw materials is allocated by mass ratio.

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 the allocation of reuse, recycling and recovery, 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

Different electricity mixes are used. For the manufacturing process in China, China's medium-voltage electricity mix is used. As for the downstream module, the high voltage equipment's installation, operation, and end-of-life stage are assumed to take place in Italy, so Italy's average grid medium-voltage electricity mix is used.

7. LCA calculation scenarios

7.1. Distribution

The products are firstly transported from the manufacturing site to Qingdao Port via lorry, the transportation distance is 345km, Then, the products are transported through container ship from Qingdao Port to Italy, Genoa is chosen as the target port. The oceanic transportation distance from Qingdao Port to Genoa is 16458 km. Lastly, the products will be transported from Genoa to the target place, an estimated distance of 200km is assumed in this study.

7.2. Installation

During the installation stage, the products are installed in the substation, where crane is generally assumed for installation, the power output is assumed 50kW, and the installation time is assumed as 1h. Therefore, the electricity consumption during the installation stage is 50kWh. Waste treatment of the products' packaging is considered in this stage, wood pallet is considered as 75% recycling and 25% incineration, while plastic film is considered with 100% incineration. Steel frame is considered as 95% recycling and 5% landfill. Transportation of waste with a distance 200km is assumed in this study.

7.3. Use & Maintenance

The use phase includes the environmental impacts associated to the electricity consumption deriving from the disconnect switch during its operation. The electricity consumption is calculated as follows:

$$\mathrm{E_{use}[kWh]} = \frac{P_{use} * RSL}{1000} \times \frac{\mathrm{T} \times \mathrm{N}}{3600}$$

where T (s) is the time of each switch operation, N is the number of operations per year, P_{use} is the power (W) consumed by the disconnect switch (sum of main and ground mechanism power), RSL is the service life of the product (20 years).

The parameters used for calculation of each product and the electricity consumption are listed in the table below.

Table 7-1 Power consumption of disconnect switches

Disconnect Switches	Main mechanism power	Ground mechanism power	Total number of operations	Operation time	Euse/kWh
GW4-40.5DW	CJTKB/250W	CJTKB/250W	10000	CKTKA: 24s CJTKB: 12s	16.7
GW4-72.5DW	CJTKB/250W	CJTKB/250W			16.7
GW4-126DW	CJTKB/250W	CJTKB/250W			16.7
GW4-145DW	CJTKB/250W	CJTKB/250W			16.7
GW4-170DW	CJTKB/250W	CJTKB/250W			16.7

GW4-252DW	CJTKA/500W	CJTKB/250W			41.7

Besides the operation, a standby energy consumption is also considered by assuming that the stanby power is 1% of the operation power.

Table 7-2 Standby power consumption of disconnect switches

Disconnect Switches	Standby power (W)	$E_{standby}$/kWh
GW4-40.5DW	5	876
GW4-72.5DW	5	876
GW4-126DW	5	876
GW4-145DW	5	876
GW4-170DW	5	876
GW4-252DW	7.5	1314

For the maintenance of the electric products, the Taikai insulation switch products are designed to be free of maintenance during its service life. Therefore, no inputs and outputs are taken place in the maintenance stage in this study.

7.4. End-of-life

For the end-of-life stage, the de-construction (C1) of the electric products during the end-of-life stage is assumed to use only electricity, and the electricity consumption is assumed to be the same as the construction stage (A5). 200km transportation distance from plant site to waste treatment site (C2) is assumed, and waste processing (C3) stage is modelled using general processing data from Ecoinvent database. For the end-of-life disposal process (C4), the existing data of recycling rate and disposal rate for disconnect switches is missing. Thus, the IEC/TR 62635 guidelines are referred. The recycling rate for steel, stainless steel, aluminium, and copper is 95%, 5% of the metal residuals will end up in the incineration treatment. As for porcelain, it is assumed that all of them will end up in landfills as they are inert materials. Following the end-of-life load and benefit allocation approach, the reuse, recovery and/or recycling potentials not declared in this study.

Table 7-3 End-of-life treatment scenarios

Components	Recycling rate	Disposal rate	Treatment
Steel	95%	5%	Incineration without energy recovery
Stainless steel	95%	5%	Incineration without energy recovery
Copper	95%	5%	Incineration without energy recovery
Aluminium alloy	95%	5%	Incineration without energy recovery
Plastic	90%	10%	Incineration without energy recovery
Bushing	0	100%	Land fill

8. REFERENCES

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