PRODUCT ENVIRONMENTAL PROFILE

Environmental Product Declaration

Emax2 E2.2 E9 IEC Air Circuit Breaker

February 2025

REGISTRATION NUMBER ABBG-00413-V01.01-EN	IN COMPLIANCE WITH PCR-ED4-EN-2021 09 06 SUPPLEMENTED BY PSR-0005-ED3.1-EN-2023 12 08
VERIFIER ACCREDITATION NUMBER VH50	INFORMATION AND REFERENCE DOCUMENTS www.pep-ecopassport.org
DATE OF ISSUE 02-2025	VALIDITY PERIOD 5 years
INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, IN COMPLIANCE WITH ISO 14025: 2006	
INTERNAL ☐	EXTERNAL ☒
THE PCR REVIEW WAS CONDUCTED BY A PANEL OF EXPERTS CHAIRED BY JULIE ORGELET (DDEMAIN)	
PEP ARE COMPLIANT WITH XP C08-100-1 :2016 OR EN 50693:2019 OR NF E38-500:2022 THE ELEMENTS OF THE PRESENT PEP CANNOT BE COMPARED WITH ELEMENTS FROM ANOTHER PROGRAM.	
DOCUMENT IN COMPLIANCE WITH ISO 14025: 2006 « ENVIRONMENTAL LABELS AND DECLARATIONS. TYPE III ENVIRONMENTAL DECLARATIONS »	

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Manufacturer name and address	ABB S.p.A. Via E. Fermi 40 - 03100 Frosinone (FR) - Italy
Company contacts	EPD_ELSP@in.abb.com
Reference product	Emax 2 E2.2 E9 circuit breaker IEC type withdrawable version equipped with Ekip Touch electronic trip unit
Description of the product	Emax air circuit breaker is a multifunctional platform able to manage the next generation of electrical plants such as microgrids, evolving into a true Power Manager. Emax is the first air circuit breaker that matches all the new grid requirements. It enables a direct communication to the new energy management cloud-computing platform ABB Ability™. Energy and Asset Manager
Functional unit	The functional unit to this study is a single circuit breaker (including its packaging and accessories), to protect during 20 years the installation against overloads and short-circuits in circuit with assigned volt-age U and rated current. This protection is ensured in accordance with the parameters for use in commercial or industrial application area. IEC Type Rated voltage [V]: 690 Rated current [A]: 2500 Rated breaking capacity [kA]: 100 Number of poles: 3/4 Tripping Curve: L, S, I
Other products covered	Emax2 E2.2 Withdrawable Circuit Breakers of types [IEC] B/N/S/H and ratings 1250A to 2500A / 3poles /4poles
Reference lifetime	20 years
Product category	Electrical, Electronic and HVAC-R Products “Circuit Breaker”
Use Scenario	The use phase has been modeled based on the sales mix data (2023), and the corresponding low voltage electricity countries mix
Geographical representativeness	Raw materials & Manufacturing: [Europe / Global] Assembly: [Italy] Distribution / Use: [Global] specific sales mix EoL: [Global]
Technological representativeness	Materials and processes data are specific for the production of Emax Air circuit breaker
LCA Study	This study is based on the LCA study described in the LCA report 1SDH002181A1001
EPD type	Products family declaration
EPD scope	“Cradle to grave”
Year of reported primary data	2023
LCA software	SimaPro 9.6.0.1 (2024)
LCI database	Ecoinvent v3.10 (2023)
LCIA methodology	EN 15804:2012+A2:2019/ EF3.1

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ABB Purpose & Embedding Sustainability

ABB is a leading global technology company that energizes the transformation of society and industry to achieve a more productive, sustainable future. By connecting software to its electrification, robotics, automation and motion portfolio, ABB pushes the boundaries of technology to drive performance to new levels. With a history of excellence stretching back more than 130 years, ABB's success is driven by about 105 thousand talented employees in over 100 countries.
ABB's Electrification business offers a wide-ranging portfolio of products, digital solutions and services, from substation to socket, enabling safe, smart and sustainable electrification. Offerings encompass digital and connected innovations for low voltage and medium voltage, including EV infrastructure, solar inverters, modular substations, distribution automation, power protection, wiring accessories, switchgear, enclosures, cabling, sensing and control.
ABB is committed to continually promoting and embedding sustainability across its operations and value chain, aspiring to become a role model for others to follow. With its ABB Purpose, ABB is focusing on reducing harmful emissions, preserving natural resources and championing ethical and humane behavior.

General Information

ABB's Frosinone factory represents a centre of excellence in ABB for the development and manufacture of low-voltage circuit breakers. The 150,000 square-meter facility with 800 employees is highly automated and produces more than three million circuit breakers every year. A Lighthouse Plant, selected by the Italian government as a model for digital transformation and Industry 4.0 strategies, Frosinone promotes smart, digitalized, and connected operations, increasing efficiency across the full value chain. Achieving zero production waste to landfill was a whole-factory program. Flexibility, lean production processes, capacity to efficiently and rapidly meet market demands, and process innovation are some of the most significant characteristics of this site

ABB IT-ELSP adopts and implements for its own activities an integrated Quality/Environmental/Health Management System in compliance with the following standards:

- UNI EN ISO 9001:2015 - Quality Management Systems – Requirements
- UNI EN ISO 14001:2015 - Environmental management systems – Specification with guidance for use
- UNI EN ISO 45001:2018 - Occupational Health and Safety Assessment Series – Requirements
- SA 8000:2014 - Social Accountability 8000 – SA 8000

ABB offers a wide range of low voltage Air Circuit Breakers & Molded Case Circuit Breakers for different applications. The primary scope of Low Voltage Circuit Breakers is to isolate parts of an electrical distribution system in the event of abnormal conditions. Abnormal conditions are generally caused by faults on a system which can lead to dangerous situations for both people and the system itself. In addition to providing system protection, circuit breakers enable parts of the electrical distribution to be isolated for operation and maintenance. In the factory, the different components and subassemblies are assembled on the manufacturing line. All components and subassemblies are produced by ABB's suppliers and are only assembled in the factory.

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Emax 2.2 product cluster

Emax 2 air circuit breaker is a multifunctional platform able to manage the next generation of electrical plants such as microgrids, evolving into a true Power Manager. Emax 2 is the first air circuit breaker that matches all the new grid requirements. It enables a direct communication to the new energy management cloud-computing platform ABB Ability™. Energy and Asset Manager

Circuit brakers are used for to allow opening the circuit of EMAX 2 E 2.2 IEC type circuit breakers and EMAX 2 E2.2 air circuit breakers UL type over a 20-year period, with a nominal voltage of 900 Vac

Product cluster Emax2 analyzed in this LCA includes E2.2 both IEC and UL types of the withdrawable circuit breaker, consisting of a fixed and moving part (which is inserted and removed via dedicated guide rails).
Based on the frame size and functionality, the circuit brakers have been categorized into two groups. Along the whole Circuit braker product cluster (IEC/UL) a set of different build configurations have been covered by this analysis. The SimaPro LCA model has been fully parametrized to include different configurations.

Official declarations 1SDL000282R1377 [13] and 1SDL000282R1378 [14] states compliance of ABB molded case circuit breakers and air circuit breakers respectively to RoHS II and REACH regulations; annex 1SDL000571R0 Ver 01 [15] provides exemptions considered for RoHS II.

Emax2 E2.2 IEC

Circuit breaker	E2.2
Rated voltage U [V]	900
Rated current In [A]	1250-2500
Rated short circuit breaking current Icu [kA]	100
Number of poles	3/4

Table 1: Technical characteristics of E2.2 S IEC 3P E9 Emax circuit breakers (Refer Technical catalogue for complete details).

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Constituent Materials

E2.2 S IEC 3P E9

The representative product is E2.2 S IEC 3P E9 Circuit Breaker which weighs 119.15kg including its installed accessories, paper documentation and packaging.

Materials	Name	IEC 62474 MC	[g]	Weight %
Metals	Steel	M-119	41234.2	34.6%
	Cu and Cu Alloys	M-121	26797.0	22.5%
	Stainless Steel	M-100	2065.1	1.7%
	Aluminium	M-120	684.2	0.6%
	Precious Metals	M-159	43.0	<0.1%
Plastics	Unsaturated Polyester	M-301	13266.7	11.1%
	Polyamide	M-258	2682.6	2.3%
	Polycarbonate	M-254	1463.8	1.2%
	Polypropylene	M-252	351.4	0.3%
	PolyEthyleneTerephthalate	M-259	287.4	0.2%
	Polyethylene	M-251	199.3	0.2%
	Elastomer	M-320	150.3	0.1%
	ABS	M-256	145.6	0.1%
	Polyarylamide	M-272	26.2	<0.1%
	PolyButyleneTerephthalate	M-261	2.2	<0.1%
	PolyVinylChloride	M-250	1.5	<0.1%
Other	Wood	M-340	28200.0	23.7%
	Paper/Cardboard	M-341	1272.8	1.1%
	Others	N/A	280.5	0.2%
Total			119153.7	100.0%

Table 2: Weight of materials E2.2 S IEC 3P E9

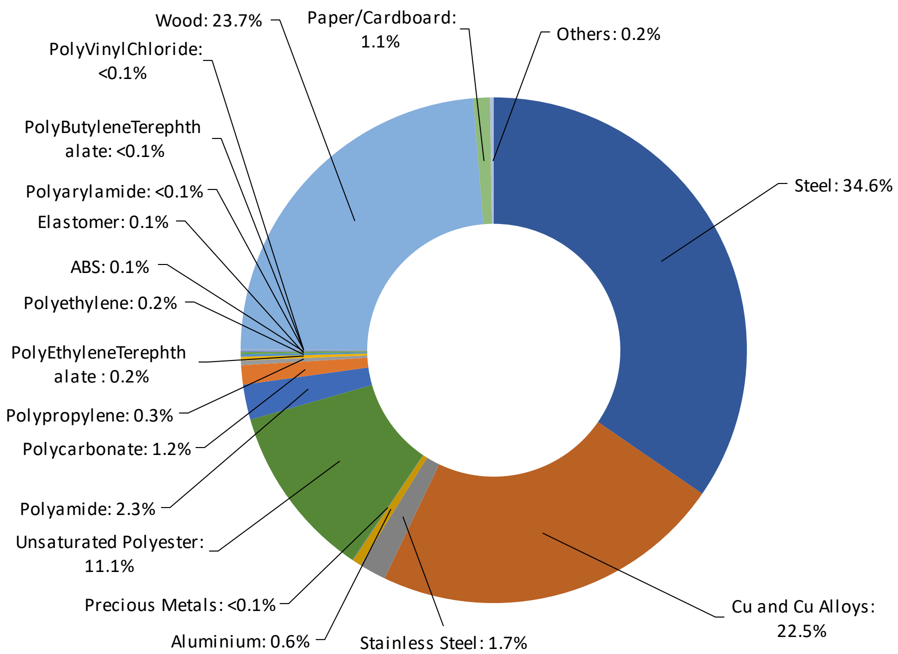

Figure 1: Composition of E2.2 S IEC 3P E9

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Packaging for E2.2 S IEC 3P E9 weigh the following substance composition.

Material weight (g)	E2.2 IEC 3P
Corrugated Cardboard	1120
Wooden Pallet / Plywood	28200
Polyethylene	120
Steel	1200

Table 3: Weight of materials E2.2 S IEC 3P E9 - Packaging

Along the whole Emax E2.2 product cluster (IEC) a set of different build configurations have been covered by this analysis. Main differences consist of the number of poles, trip unit type, and short circuit breaking capacity. The LCA SimaPro model has been fully parametrized to fulfill each different configuration.

LCA background information

Functional unit and Reference Flow

The functional unit is the reference unit used to quantify the performance of the service delivered by a product to the user. The main purpose of the functional unit is to provide a reference to which inputs and outputs are related in the LCA.

The functional unit to this study is a single circuit breaker (including its packaging and accessories), to protect during 20 years the installation against overloads and short-circuits in circuit with assigned voltage U and rated current. This protection is ensured in accordance with the following parameters for use in industrial application area.

	E2.2 IEC 3P
Number of poles	3
Rated breaking capacity [kA]	100
Tripping Curve	L, S, I

The Reference Flow of the study is a single circuit breaker (including its packaging and accessories) with mass described in table 3.

System boundaries and life cycle stages

The life cycle of the Low Voltage Circuit Breaker, an EEPS (Electronic and Electrical Products and Systems), is a "from cradle to grave" analysis and covers the following main life cycle stages: manufacturing, including the relevant acquisition of raw material, preparation of semi-finished goods, etc. and processing steps; distribution; installation, including the relevant steps for the preparation of the product for use; use including the required maintenance steps within the RSL (reference service life of the product) associated to the reference product; end-of-life stage, including the necessary steps until final disposal or recovery of the product system.

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The following table shows the stages of the product life cycle and the information stages according to EN 50693:2019 [3] for the evaluation of electronic and electrical products and systems.

Manufacturing	Distribution	Installation	Use	End-of-Life (EoL)
Acquisition of raw materials Transport to manufacturing site Components/parts manufacturing Assembly Packaging EoL treatment of generated waste	Transport to distributor/ logistic center Transport to place of use	Installation EoL treatment of generated waste (packaging)	Usage Maintenance	Deinstallation Collection and transport EoL treatment

Table 4: Phases for the evaluation of construction products according to EN50693:2019 [3].

Temporal and geographical boundaries

The ABB component suppliers are sourced all over the world. All primary data collected are from 2023, which is a representative production year. Secondary data are also representative for this year, as provided by ecoinvent [6].

The selected ecoinvent [6] 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.

Boundaries in the life cycle

As indicated in the PCR capital goods such as buildings, machinery, tools and infrastructure, the packaging for internal transport which cannot be allocated directly to the production of the reference product, may be excluded from the system boundary.

Infrastructures, when present, such as processes deriving from the ecoinvent [6] database have not been excluded.

Data quality

In this LCA, both primary and secondary data are used. Site specific foreground data have been provided by ABB. Main data sources are the bill of materials & drawings which are available on the ERP (SAP) & Windchill. For all processes for which primary are not available, generic data originating from the ecoinvent database [6], allocation cut-off by classification, are used. The ecoinvent database available in the SimaPro software [7] is used for the calculations.

The data quality characterized by quantitative and qualitative aspects, is presented in Appendix 1. Each data quality parameter has been rated according to DQR tables from Chapter 7.19.2.2 of the Product Environmental Footprint Guide v.6.3 to give an indication of geography, technology and temporal representativeness.

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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 [1] and EN 50693 [3] the environmental impact indicators must be determined using the characterization factors and impact assessment methods specified in EN 15804:2012+A2:2019 [8].

PCR [1] and the EN 50693:2019 [3] standard establish four indicators for climate change: Climate change (total) which includes all greenhouse gases; Climate change (fossil fuels); Climate change (biogenic) which includes the emissions and absorption of biogenic carbon dioxide and biogenic carbon stored in the product; Climate change (land use) - land use and land use transformation. Other indicators as per the PCR [1].

Allocation rules

An allocation key is used for consumptions related to the manufacturing process in the production site, as well for company waste. Since the factory produces several products (different ACB and MCCB products) only a part of the environmental impact has been allocated to the XT7/XT7M/E2.2 production line. The production line is common for these 3 products.

Allocation coefficients are based on the XT7-XT7M-E2.2 line's occupancy area for electricity and methane consumption since, apart from assembly processes, the whole production line is temperature-regulated throughout the year. The allocation of the total amount of waste generated by the production line as well, has been based on this criterion.

The total number of operators was considered for water consumption. All these flows have been allocated and divided by the total number of XT7-XT7M-E2.2 circuit breakers produced in 2023.

Limitations and simplifications

Raw materials life cycle stage includes the extraction of raw materials as well as the transport distances to the manufacturing suppliers. These distances are assumed to be 1000 km assuming no specific data available PCR [1]. This distance has been added to the one already included in the market processes used for the model, as a result of a conservative choice made by the LCA operators.

Surface treatments like galvanizing, silver plating as well as their related transport processes (back and forth from the finishing suppliers) have been considered in the LCA model. Scraps for metal working and plastic processes are included when already defined in Ecoinvent [6].

The only limitations and simplifications applied to this study are listed in the following table.

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Category	Description
Packaging	An average raw material packaging content of 5% of the mass of the reference equipment has been considered as follow- Wood 50%, Cardboard 40%, Low density polyethylene 10%.
Tranports	Specific transport parameters along the entire supply chain of the two reference products have been considered as representative for all the products covered by the study
MU Emissions	Impacts related to the production, transportation and installation of capital goods (buildings, infrastructure, machinery, internal transport packaging) and general operations that cannot be directly allocated to products have been excluded

Energy Models

LCA Stage	EN 15804:2012 +A2:2019 module	Energy model	Notes
Raw material extraction and processing	A1-A2	Electricity, {RER}| market group for | Cut-off Electricity, {GLO}| market group for | Cut-off	Based on materials and supplier's locations
Manufacturing	A3	Electricity, {IT}| market for | Cut-off	Specific Energy model for ABB Frosinone manufacturing plant, 100% renewable
Installation (Packaging EoL)	A5	Electricity, {GLO}| market group for | Cut-off	
Use Stage	B1	Electricity, [country]x | market for | Cut-off, S **	Low voltage from solar, based on 2023 country sales mix
EoL	C1-C4	Electricity, {GLO}| market group for | Cut-off	

Table 5: Energy models used in each LCA stage

** Please refer the use phase page 14 for further description

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Inventory analysis

In this LCA, both primary and secondary data are used. Site specific foreground data have been provided by ABB. For data collection, Bills of Material (BOM) extracted from ABB's internal SAP software were used. They are a list of all the components and assemblies that constitute the finished product, organized by level. Each item is matched with its code, quantity, weight and supplier. The BOMs were then processed, adding material, surface area and other weight data, taken from technical drawings. Finally, the manufacturing process and surface treatment were assigned, according to information provided by R&D personnel. Road distances between the suppliers and ABB were calculated using Google Maps, and marine distances using Distances & Time (Searates).

All primary data collected from ABB are from 2023, which was a representative production year. The ecoinvent cut-off by classification system processes [6] are used to represent the LCA model

To improve both the inventory and modelling phase of the product, a specific modular dataset framework has been adopted. Raw materials and Manufacturing processes datasets from Ecoinvent database [6] have been clustered and listed inside two distinct mater data tables ABB Raw Materials and ABB Materials & Processes. Data used in the analysis is not older than 10 years.

Manufacturing stage

The Circuit Breakers are composed of a multitude of components, all of which are made from of numerous materials. Most of the inputs to the products' manufacturing stage are already produced component parts.

The single use packaging as well as paper documentation are also included in the analysis in the manufacturing stage. ABB receives packaged product from supplier, sorts, repacks and delivers to the customer according to the orders.

Most of the inputs to the products' manufacturing stage are already produced component parts from the supply chain.

The entire supplier's network has been modelled with the calculation of each transportation stage, from the first manufacturing supplier to the next.

All the distances from the last subassembly suppliers' factories to the ABB facility have been calculated.
The complete energy mix has been modeled considering the GO on energy origins provided to ABB for the year 2023.

Distribution

The transport distances from ABB manufacturing plant to the distribution centers (regional distribution centers / local sales organizations) have been calculated considering the specific 2023 sales mix data for cluster (SAP ERP sales data as a source). An additional 1000km distance is considered as per the PCR [1].

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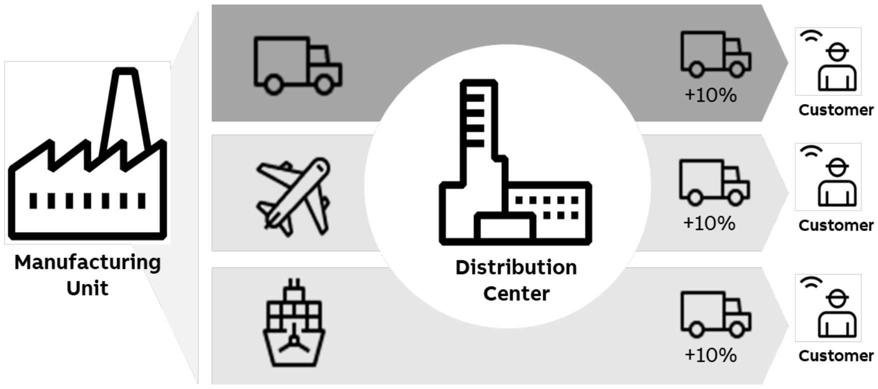

Figure 2: Distribution methodology.

Installation

The installation phase only implies manual activities, and no energy is consumed. This phase also includes the disposal of the packaging of the coil.

For the disposal of the packaging after installation of the product at the end of its life, a transport distance of 100 km (according to PSR [2]) was assumed).

The actual disposal site is unknown and is managed by the customer. The disposal scenario of the packaging was calculated based on the latest Eurostat data (EU-27) 2019 available for European countries and for Non-European Countries 100% incineration has been considered.

Use

During the use phase, circuit breakers dissipate some electricity due to power losses. The respective energy for each specific configuration of the entire product family has been calculated according to the data provided in the catalogue of the circuit breaker and following the PCR [1] & PSR [2] rules:

The Energy model used for this phase was built based on the 2023 actual sales mix data for the entire product range (SAP ERP sales data as a source). This approach has been taken since this list of countries will be the most representative also for the other products listed in the extrapolation tables.

From Ecoinvent [6] database, the low voltage electricity country mix for each country(x) has been selected with its respective percentage on the total sales mix (Electricity, low voltage [country]x | market for | Cut-off, S).

Parameters		
Iu	[A]	2500
Iu	[%]	50
h/year	[h]	8760
RSL	[years]	20
Time operating coefficient	[%]	30

Table 6: Use phase parameters

The formula for the calculation of the electricity consumed is shown below and it is described as follows, where P_{use} is the power consumed by the switch at a given value of voltage:

$$E_{use}\,[kWh] = \frac{P_{use} * 8760 * RSL * \alpha}{1000}$$

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The Energy model used for this phase has been modeled based on the 2023 actual sales mix data (SAP ERP sales data as a source). From Ecoinvent [6] database, the low voltage electricity country mix for each country$_{(x)}$ has been selected with its respective percentage on the total sales mix (Electricity, low voltage [Country] | market for | Cut-off, S).

Since no maintenance happens during the use phase, the environmental impacts linked to this procedure have been considered as null in the analysis.

End of life

The end-of-life stage is modelled according to IEC/TR 62635 [9]. The percentages for end-of-life treatments of materials are taken from IEC/TR 62635 [9].

Since no specific data is available, the transport distances from the place of use to the place of disposal are assumed to be 1000 km (local/domestic transport by lorry, according to PCR [1]).

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Environmental impacts

E2.2 S IEC 3P E9

The following table show the environmental impact indicators of the life cycle of a E2.2 S IEC 3P E9 Circuit Breaker as indicated by PCR [1] and EN 50693:2019 [3]. The indicators are divided into the contribution of the processes to the different stages (manufacturing, distribution, installation, use and end-of-life).

Impact category	Unit	Total	Manufacturing	Distribution	Installation	Use	End of Life
GWP-total	kg CO2 eq	1.40E+03	5.99E+02	1.27E+02	4.42E+01	5.70E+02	6.40E+01
GWP-fossil	kg CO2 eq	1.39E+03	6.28E+02	1.27E+02	1.18E+00	5.69E+02	6.37E+01
GWP-biogenic	kg CO2 eq	1.34E+01	-3.04E+01	1.33E-02	4.30E+01	3.96E-01	3.04E-01
GWP-luluc	kg CO2 eq	1.68E+00	8.15E-01	1.68E-02	2.50E-04	7.98E-01	5.40E-02
ODP	kg CFC11-eq	6.33E-05	2.16E-05	1.96E-06	1.06E-08	3.91E-05	6.81E-07
AP	mol H+ eq	2.53E+01	2.00E+01	5.66E-01	6.27E-03	4.40E+00	2.73E-01
EP-freshwater	kg P eq	2.06E+00	1.68E+00	3.38E-03	2.21E-04	3.52E-01	1.82E-02
EP-marine	kg N eq	2.42E+00	1.46E+00	2.18E-01	3.09E-03	6.53E-01	8.79E-02
EP-terrestrial	mol N eq	2.82E+01	1.83E+01	2.38E+00	3.02E-02	6.89E+00	6.27E-01
POCP	kg NMVOC eq	8.85E+00	5.33E+00	7.77E-01	8.23E-03	2.52E+00	2.13E-01
ADP-m&m	kg Sb eq	3.78E-01	3.38E-01	8.81E-05	1.73E-06	3.98E-02	1.27E-04
ADP-fossil	MJ	1.82E+04	8.59E+03	1.71E+03	8.97E+00	7.10E+03	8.05E+02
WDP	m3 of equiv. depriv.	1.05E+03	4.56E+02	3.71E+00	2.48E-01	5.84E+02	5.07E+00
PENRE	MJ	1.79E+04	8.26E+03	1.71E+03	8.97E+00	7.10E+03	8.06E+02
PENRM	MJ	3.31E+02	3.31E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.82E+04	8.59E+03	1.71E+03	8.97E+00	7.10E+03	8.06E+02
PERE	MJ	3.12E+04	1.94E+03	9.29E+00	1.64E-01	2.92E+04	6.70E+01
PERM	MJ	4.29E+02	4.29E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.16E+04	2.37E+03	9.29E+00	1.64E-01	2.92E+04	6.70E+01
SM	kg	3.24E+01	3.24E+01	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
PET	MJ	4.98E+04	1.10E+04	1.72E+03	9.14E+00	3.63E+04	8.73E+02
FW	m3	3.24E+01	1.19E+01	1.17E-01	7.85E-03	2.02E+01	2.20E-01
HWD	kg	5.39E-01	8.88E-02	1.17E-02	5.96E-05	4.36E-01	2.58E-03
N-HWD	kg	2.90E+02	1.27E+02	3.04E+01	6.70E-01	3.24E+01	9.91E+01
RWD	kg	3.10E-02	1.78E-02	1.73E-04	2.29E-06	1.18E-02	1.26E-03
CfR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MfR	kg	1.03E+02	3.18E+01	0.00E+00	0.00E+00	0.00E+00	7.08E+01
MfER	kg	3.31E+01	2.80E+00	0.00E+00	2.94E+01	0.00E+00	8.61E-01
EN	MJ by energy vector	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM	disease inc.	1.13E-04	6.68E-05	3.45E-06	8.73E-08	3.96E-05	3.51E-06
IRP	kBq U-235 eq	1.22E+02	6.92E+01	7.10E-01	9.27E-03	4.70E+01	5.15E+00
ETP-fw	CTUe	3.83E+04	3.10E+04	1.75E+02	8.39E+00	6.87E+03	2.10E+02
HTP-c	CTUh	1.81E-05	1.28E-05	2.19E-07	1.00E-08	4.94E-06	1.28E-07
HTP-nc	CTUh	2.22E-04	1.93E-04	1.26E-06	6.22E-08	2.79E-05	4.47E-07
SQP	Pt	1.61E+04	1.29E+04	4.43E+02	6.00E+00	2.49E+03	2.61E+02

Table 7: Impact indicators for E2.2 S IEC 3P E9

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Impact category	Unit	E2.2 2500A IEC-3P
Biogenic Carbon content of the product	kg	4.17E-04
Biogenic Carbon content of the associated packaging	kg	1.08E+01

Table 8: Inventory flow other indicators

Environmental impact indicators

GWP-total	Global Warming Potential total (Climate change)
GWP-fossil	Global Warming Potential fossil
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
EP-freshwater	Eutrophication potential - freshwater compartment
EP-marine	Eutrophication potential - fraction of nutrients reaching marine end compartment
EP-terrestrial	Eutrophication potential -Accumulated Exceedance
POCP	Formation potential of tropospheric ozone
ADP-m&m	Abiotic Depletion for non-fossil resources potential
ADP-fossil	Abiotic Depletion for fossil resources potential
WDP	Water deprivation potential
Resource use indicators	
PERE	Use of renewable primary energy excluding renewable primary energy resources used as raw material
PERM	Use of renewable primary energy resources used as raw material
PERT	Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)
PENRE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material
PNERM	Use of non-renewable primary energy resources used as raw material
PENRT	Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)
PET	Total use of primary energy in the lifecycle
Secondary materials, water and energy resources	
SM	Use of secondary materials
RSF	Use of renewable secondary fuels
NRSF	Use of non-renewable secondary fuels
FW	FW: Net use of fresh water
Waste category indicators	
HWD	Hazardous waste disposed
N-HWD	Non-hazardous waste disposed
RWD	Radioactive waste disposed
Output flow indicators	
CfR	Components for reuse
MfR	Materials for recycling
MfER	Materials for energy recovery
EN	Exported energy
Other indicators	
PM	Emissions of Fine particles
IRP	Ionizing radiation, human health
ETP-fw	Ecotoxicity, freshwater
HTP- c	Human toxicity, carcinogenic effects
HTP- nc	Human toxicity, non-carcinogenic effects
SQP	Impact related to Land use / soil quality

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Extrapolation for Homogeneous environmental family

This LCA covers different build configurations than the representative product. All the analyzed configurations have the same main functionality, product standards and manufacturing technology

The different life cycle stages can be extrapolated to other products of the same homogeneous environmental family by applying a rule of proportionality to the parameters in the following tables, divided by different life cycle stages

E2.2 Extrapolation:

Circuit Breaker	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
E2.2 S/H IEC 3P E9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E2.2 S/H IEC 4P E9	1.35	1.37	-0.10	1.39	1.28	1.47	1.47	1.41	1.43	1.44	1.46	1.40	1.43
E2.2 H IEC 3P E10	1.00	1.00	0.97	1.00	0.87	0.87	0.90	0.95	0.93	0.93	0.96	1.00	0.93
E4.2 S/H IEC-3P-E9	1.49	1.57	-3.33	1.68	1.30	1.96	1.87	1.69	1.74	1.76	1.62	1.58	1.97
E4.2 S IEC-3P-E10	1.54	1.62	-3.33	1.73	1.15	1.91	1.84	1.70	1.73	1.75	1.64	1.63	1.94
E4.2 S/H/V IEC-3P-E12	1.50	1.58	-3.34	1.67	1.34	1.90	1.81	1.66	1.70	1.73	1.58	1.60	1.95
E4.2 S/H IEC-4P-E9	1.92	2.01	-3.04	2.14	1.64	2.59	2.46	2.20	2.27	2.30	2.14	2.05	2.52
E 6.2 H/X IEC-3P-E9	2.55	2.65	-3.16	2.84	2.19	3.60	3.43	3.01	3.14	3.14	3.03	2.65	3.36
E6.2 H/X IEC-4P-E9	3.21	3.32	-3.62	3.55	2.70	4.52	4.30	3.76	3.93	3.96	3.78	3.42	4.21

Table 9: Manufacturing phase Extrapolation factors for E2.2
Reference product: E2.2 S IEC 3P E9

Circuit Breaker	LCA Phase	All
E2.2 S/H IEC 3P E9	Distr	1.00
E2.2 S/H IEC 4P E9		1.13
E2.2 H IEC 3P E10		1.00
E4.2 S/H IEC-3P-E9		1.54
E4.2 S IEC-3P-E10		1.54
E4.2 S/H/V IEC-3P-E12		1.56
E4.2 S/H IEC-4P-E9		1.70
E 6.2 H/X IEC-3P-E9		1.42
E6.2 H/X IEC-4P-E9		1.77

Table 10: Distribution phase Extrapolation factors for E2.2
Reference product: E2.2 S IEC 3P E9

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Circuit Breaker	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
E2.2 S/H IEC 3P E9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E2.2 S/H IEC 4P E9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E2.2 H IEC 3P E10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E4.2 S/H IEC-3P-E9	2.09	8.75	1.92	12.59	13.07	7.39	5.33	3.81	6.37	7.56	13.36	11.47	1.89
E4.2 S IEC-3P-E10	2.17	7.98	2.02	11.23	11.65	6.81	4.95	3.49	5.95	6.93	11.94	10.25	1.59
E4.2 S/H/V IEC-3P-E12	2.17	7.98	2.02	11.23	11.65	6.81	4.95	3.49	5.95	6.93	11.94	10.25	1.59
E4.2 S/H IEC-4P-E9	2.09	8.75	1.92	12.59	13.07	7.39	5.33	3.81	6.37	7.56	13.36	11.47	1.89
E 6.2 H/X IEC-3P-E9	2.48	10.09	2.27	13.67	14.67	8.29	5.85	4.32	7.24	8.55	14.76	12.80	2.14
E6.2 H/X IEC-4P-E9	2.81	11.36	2.58	15.61	16.65	9.42	6.69	4.91	8.22	9.70	16.80	14.55	2.43

Table 11: Extrapolation factors for IEC Emax 2.2 Circuit Breaker.
Reference product: E2.2 S IEC 3P E9 -Installation

Circuit Breaker	LCA Phase	All
E2.2 1200 S/H IEC 3P/4P E9	Use	0.32
E2.2 2000 S/H IEC 4P E9		0.82
E2.2 2500 H IEC 3P E10		1.00
E4.2 3200 S/H IEC-3P/4P-E9		1.35
E4.2 4000 S IEC-3P-E10		1.64
E4.2 5000 S/H/V IEC-3P-E12		1.55
E4.2 6300 S/H IEC-3P/4P-E9		2.82

Table 12: Use phase Extrapolation factors for E2.2
Reference product: E2.2 S IEC 3P E9

LCA Phase: End of Life

Circuit Breaker	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
E2.2 S/H IEC 3P E9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E2.2 S/H IEC 4P E9	1.56	1.38	40.30	1.33	1.37	1.35	1.33	1.35	1.36	1.37	1.23	1.36	1.13
E2.2 H IEC 3P E10	0.92	0.92	0.90	0.92	0.92	0.92	0.92	0.95	0.93	0.93	0.98	0.92	0.88
E4.2 S/H IEC-3P-E9	1.58	1.58	1.92	1.60	1.59	1.58	1.60	1.46	1.55	1.55	1.27	1.60	1.75
E4.2 S IEC-3P-E10	1.57	1.57	1.83	1.58	1.57	1.57	1.59	1.45	1.54	1.54	1.30	1.59	1.73
E4.2 S/H/V IEC-3P-E12	1.58	1.58	1.89	1.58	1.58	1.57	1.58	1.54	1.55	1.55	1.30	1.59	1.60
E4.2 S/H IEC-4P-E9	2.06	2.06	2.32	2.04	2.05	2.02	2.04	1.91	1.99	2.00	1.56	2.06	1.97
E 6.2 H/X IEC-3P-E9	2.78	2.78	2.99	2.78	2.77	2.75	2.78	2.64	2.69	2.69	2.05	2.80	2.88
E6.2 H/X IEC-4P-E9	3.50	3.50	3.56	3.41	3.45	3.39	3.41	3.32	3.34	3.35	2.46	3.46	2.93

Table 13: Extrapolation factors for IEC Emax 2.2 Circuit Breaker.
Reference product: E2.2 S IEC 3P E9 -EoL

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Additional environmental information

According to the waste treatment scenario calculation in Simapro [7], based on the recycling rate in the technical report IEC/TR 62635 Edition 1.0 [9] Table D.6, the following recyclability potentials were calculated. The recyclability potential is calculated based on the product weight (excluding packaging).

	E2.2 S IEC 3P E9
Recyclability potential	80.10%

Table 14: Recyclability potential of Emax E2.2 S IEC 3P E9

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[6] ecoinvent v3.10 (2023). ecoinvent database version 3.10 - (https://ecoinvent.org/)

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[8] UNI EN 15804:2012+A2:2019: Sustainability of constructions - Environmental product declarations (September 2019).

[9] IEC/TR 62635 - Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment - Edition 1.0 2012-10

[10] https://www.ecosystemspa.com/

[11] 1SDH002245A1001– Annex LCA BOM / Processes

[12] 1SDH002244A1001 – Annex LCA Data Details

[13] 1SDL000282R1377 - RoHS II (MCCBs and ACBs)

[14] 1SDL000282R1378 - REACH (MCCBs and ACBs)

[15] 1SDL000571R0 Ver 01 - RoHS Exemptions (MCCBs and ACBs)

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