

# PRODUCT ENVIRONMENTAL PROFILE

## Environmental Product Declaration

### XT2 Molded case Circuit Breaker With TMA/TMD



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<b>Reference product</b>	XT2 3P 160A circuit breaker IEC fixed version equipped with Thermal magnetic trip unit
<b>Description of the product</b>	<p>ABB's new Tmax XT series of Molded Case circuit-breakers, combine the finest protection that has always characterized ABB's molded case circuit breakers with the most precise metering and connectivity functionalities, providing designers, installers and end-users exclusive solutions for their daily needs. Suitable for applications from 160 A to 1600 A, the Tmax XT offers exceptional breaking capacity for all voltages and applications</p> <p>The functional unit to this study is a single circuit breaker (including its packaging and accessories), to protect during 20 years of the installation against overloads and short-circuits in circuit with assigned voltage U and rated current In. This protection is ensured in accordance with the following parameters</p>
<b>Functional unit</b>	<p>IEC Type            Rated voltage [V]: 690            Rated current [A]: 160            Rated breaking capacity [kA]: 200            Number of poles: 3/4            Tripping Curve: L, S, I</p>
<b>Other products covered</b>	XT2 Fixed Circuit Breakers of types [IEC & UL] N/S/H/L/V and ratings 1.6A to 160A / 3poles /4poles
<b>Reference lifetime</b>	20 years
<b>Product category</b>	Electrical, Electronic and HVAC-R Products
<b>Use Scenario</b>	The use phase has been modeled based on the sales mix data (2021), and the corresponding low voltage electricity countries mix
<b>Geographical representativeness</b>	<p>Raw materials &amp; Manufacturing: [Europe / Global]            Assembly: [Italy]            Distribution / Use: [Global] specific sales mix            EoL: [Global]</p>
<b>Technological representativeness</b>	Materials and processes data are specific to the production of XT2 circuit breaker
<b>LCA Study</b>	This study is based on the LCA study described in the LCA report 1SDH002210A1001
<b>EPD type</b>	Products family declaration
<b>EPD scope</b>	“Cradle to grave”
<b>Year of reported primary data</b>	2021
<b>LCA software</b>	SimaPro 9.3.0.3 (2022)
<b>LCI database</b>	Ecoinvent v3.8 (2021)
<b>LCIA methodology</b>	EN 15804:2012+A2:2019

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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 Circuit Breakers for any application, also distribution. 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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## XT2 product cluster

ABB's new Tmax XT series of Molded Case circuit-breakers, combine the finest protection that has always characterized ABB's molded case circuit breakers with the most precise metering and connectivity functionalities, providing designers, installers and end-users exclusive solutions for their daily needs. Suitable for applications from 160 A to 1600 A, the Tmax XT offers exceptional breaking capacity for all voltages and applications. Combined with high-precision electronic relays of the smallest sizes, the new series protects equipment investments and ensures uninterrupted operation and high availability. Product cluster XT2 analyzed in this LCA includes both IEC and UL types

- **XT2 product ratings**

Circuit breaker	XT2 IEC Type	XT2 UL Type
Rated voltage U [V]	690	600
Rated current In [A]	160	125
Rated short circuit breaking current Icu [kA]	200	200
Number of poles	3/4	3/4

Table 1: Technical characteristics of XT2 circuit breakers (Refer Technical catalogue for complete details).

Packaging is common for all variants of the XT2 breakers and weighs 124g, with the following substance composition:

Material	Unit	Total	%
Corrugated Cardboard	g	137.7	90.95%
Polyethylene	g	11.5	7.60%
Paper	g	2.2	1.45%

Table 2: Weight of packaging materials XT2

No cut-off criteria have been applied to the analysis of the product and its packaging. Additional packaging for semifinished products along the supply chain haven't been considered.

Official declarations LB-DT 17-21D [11] and LB-DT 18-21D [12] states compliance of ABB molded case circuit breakers and air circuit breakers respectively to RoHS II and REACH regulations; annex 1SDL000571R0 [13] provides exemptions considered for RoHS II while annex 1SDL000572R0 [14] lists REACH substances present in a concentration above 0,1% adding reference to products where involved parts are mounted.



# Constituent Materials

## XT2 – Circuit Breaker with Thermal Magnetic Trip Unit

For thermal / magnetic group the representative product is XT2 3Pole N-S-H-L type 160A IEC Fixed Circuit Breaker with TMA trip unit, which weighs 1.79kg including its installed accessories, paper documentation and packaging.

Materials	Name	IEC 62474 MC	[g]	Weight %
Metals	Steel	M-119	530	29.6%
	Cu and CU alloys	M-121	207	11.5%
	Stainless Steel	M-100	20	1.1%
	Precious metals	M-159	9	0.5%
Plastics	Unsaturated Polyester	M-301	558	31.1%
	Polyamide (PA)	M-258	94	5.2%
	Polycarbonate (PC)	M-254	18	1.0%
	Polyethylene (PE)	M-251	12	0.6%
	Acrylonitrile Butadiene Styrene (ABS)	M-256	4	0.2%
	Elastomer	M-320	38	2.1%
	PC-ABS	M-231	40	2.3%
	PC-PTFE-GF (Other filled Thermo-plastic)	M-299	3	0.2%
	Phenolic resin (Other Duromer)	M-319	22	1.2%
	Polybutylene Terephthalate (PBT)	M-261	25	1.4%
Others	Paper	M-341	205	11.4%
	Other	N/A	10	0.6%
<b>Total</b>			<b>1795</b>	<b>100%</b>

Table 3: Weight of materials XT2 IEC-3P-N-S-H-L-TMA 160A

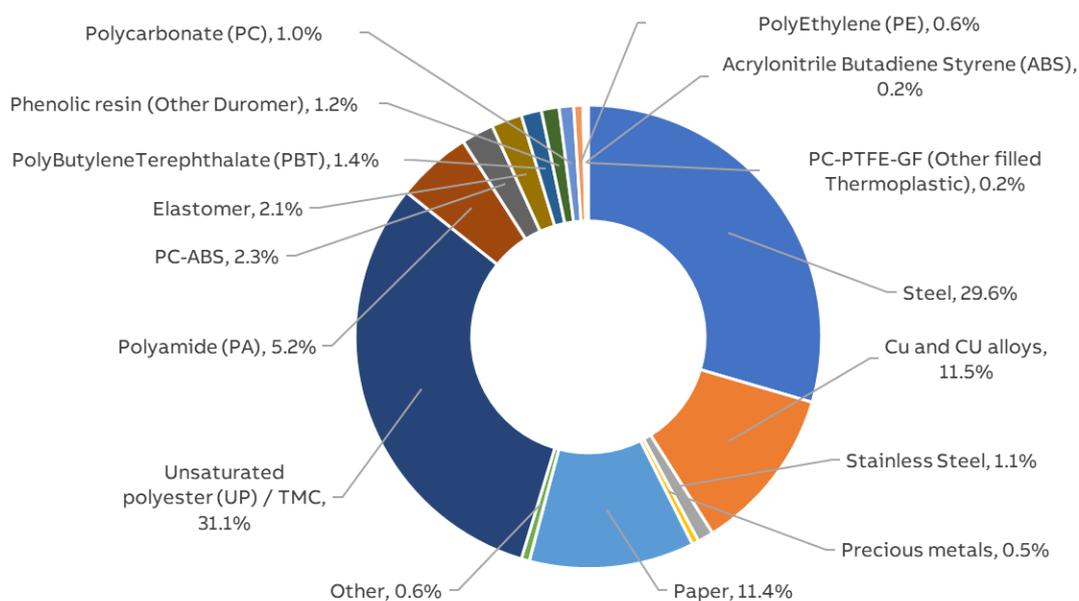


Figure 1: Composition of XT2 IEC-3P-N-S-H-L-TMA 160A

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# 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 of the installation against overloads and short-circuits in circuit with assigned voltage U and rated current I<sub>n</sub> (see chapter 1.3, table 1). This protection is ensured in accordance with the following parameters:

<b>Number of poles</b>	3/4
<b>Rated breaking capacity [kA]</b>	200
<b>Tripping Curve</b>	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.

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		Installation		Deinstallation
Transport to manufacturing site	Transport to distributor/ logistic center	EoL treatment of generated waste (packaging)	Usage	Collection and transport
Components/parts manufacturing	Transport to place of use		Maintenance	EoL treatment
Assembly				
Packaging				
EoL treatment of generated waste				

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 2021, 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.

## 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-ed4-EN-2021 09 06” 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-ed4-EN-2021 09 06 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].

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## Allocation rules

Allocation coefficients are based on the XT2 line's occupancy area for electricity and methane consumption as well as the total amount of waste generated by the production line.

The total number of operators was considered for water consumption. All these flows have been allocated and divided by the total number of XT2 circuit breakers produced in 2021.

## 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 as per the PCR. 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.

Application of grease lubricant on the circuit breakers operating mechanism has been excluded since it is negligible. Surface treatments like galvanizing, tin and silver plating as well as their related transport processes (back and forth from the finishing suppliers) have been considered in the LCA model. Specific phosphate surface treatment, Stearate coating have been excluded by operational choice. Scraps for metal working and plastic processes are included when already defined in ecoinvent[6].

Printed circuit boards (PCB) have been modelled with a representative cluster dataset including: every single component, the unpopulated board as well as the surface mounting technology (SMD) process. For some components with no equivalent on ecoinvent database[6], the dataset "Electronic component, passive, unspecified {GLO} market for | Cut-off, S" was used.

## 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, based on 2021 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 2021, which was a representative production year. The ecoinvent cut-off by classification system processes [6] are used to represent the LCA model

Due to the large amounts of components in the Circuit Breaker, raw material inputs have been modelled with data from ecoinvent[6] representing either a European [RER] or Global [RoW] market coverage based on the supplier's location. These datasets are assumed to be representative.

### 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.

All the circuit breaker's components have been modelled according to their specific raw materials and manufacturing processes.

The single use packaging as well as paper documentation are also included in the analysis in the manufacturing stage. ABB receives packaging components from outside suppliers and packages the circuit breakers before shipping them.

Most of the inputs to the products' manufacturing stage are already produced component parts from the supply chain. In the ABB manufacturing plant, the different components and subassemblies are assembled into the circuit breaker. All the semi-finished and ancillary products are produced by ABB's suppliers

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 manufacturing facility have been calculated.

In the ABB factory, the different components and subassemblies are assembled into the circuit breaker. All the semi-finished and ancillary products are produced by ABB's suppliers.

The energy mix used for the production phase is representative for ABB Frosinone production site and includes renewable energy only (Hydroelectric + Wind + Solar).

The complete energy mix has been modeled considering the GSE report on energy origins provided to ABB for the year 2021.

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## Distribution

The transport distances from ABB manufacturing plant to the distribution centers (regional distribution centers / local sales organizations) have been calculated considering the specific reference products sales mix data from 2021 (SAP ERP sales data as a source).

Reference product distribution is representative of the entire size and equivalent to distribution of other products listed in the extrapolation tables

The other parameter affecting the environmental impact for this LCA stage is the total mass of the product (including its packaging). Different mass values for each specific configuration covered by this study have been considered in the model.

An additional 10% distance by road has been considered to cover the last distribution stage to the end customer (usage location).

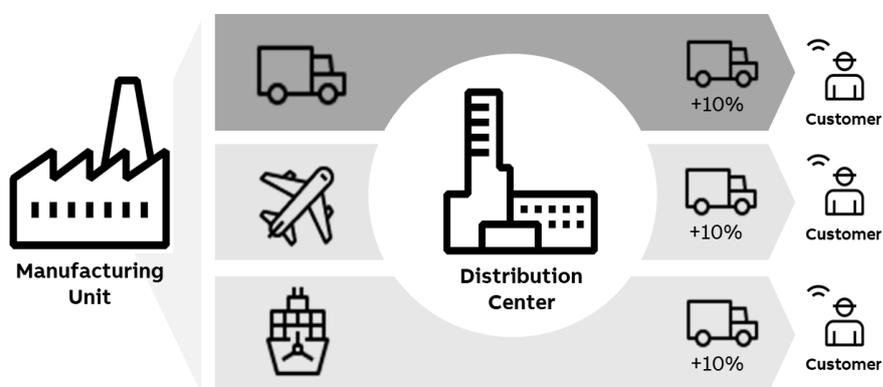


Figure 2: Distribution methodology.

## Installation

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

All the components needed to install the product (mounting hardware, phase barriers etc) have been included in the analysis.

For the disposal of the packaging after installation of the circuit breaker at the end of its life, a transport distance of 1000 km (according to PCR [1]) 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) available.

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## 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 2021 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		
I <sub>u</sub>	[A]	250
I <sub>u</sub>	[%]	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<sub>use</sub> is the power consumed by the switch at a given value of current:

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

The above calculations have been performed according to the number of poles (3) on which relevant current flows during use phase.

The Energy model used for this phase has been modeled based on the 2021 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]x | 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 PCR [1] and 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

The following table show the environmental impact indicators of the life cycle of a single XT2 circuit breaker (IEC type) N-S-H-L-V 160A with TMA trip unit, 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	Manuf	Distr	Install	Use	EoL
GWP-total	kg CO2 eq	3.79E+02	1.26E+01	3.15E+00	7.23E-02	3.62E+02	5.02E-01
GWP-fossil	kg CO2 eq	3.73E+02	1.26E+01	3.14E+00	2.45E-02	3.57E+02	4.77E-01
GWP-biogenic	kg CO2 eq	5.06E+00	1.97E-02	1.21E-03	4.78E-02	4.97E+00	2.41E-02
GWP-luluc	kg CO2 eq	6.96E-01	1.38E-02	2.74E-04	5.55E-06	6.82E-01	2.47E-04
ODP	kg CFC11 eq	2.21E-05	2.40E-06	7.18E-07	3.39E-09	1.89E-05	4.29E-08
AP	mol H+ eq	1.78E+00	1.76E-01	1.67E-02	7.85E-05	1.59E+00	1.97E-03
EP-freshwater	kg P eq	1.97E-01	1.79E-02	5.43E-05	1.01E-06	1.79E-01	7.62E-05
EP-marine	kg N eq	3.14E-01	2.27E-02	6.01E-03	5.38E-05	2.83E-01	1.80E-03
EP-terrestrial	mol N eq	3.11E+00	2.62E-01	6.58E-02	2.94E-04	2.78E+00	5.02E-03
POCP	kg NMVOC eq	8.63E-01	7.23E-02	1.73E-02	9.27E-05	7.72E-01	1.47E-03
ADP-m&m	kg Sb eq	9.37E-03	7.17E-03	1.38E-06	3.44E-08	2.20E-03	4.60E-07
ADP-fossil	MJ	5.64E+03	1.84E+02	4.45E+01	2.24E-01	5.41E+03	4.38E+00
WDP	m3	7.49E+01	6.79E+00	4.53E-02	1.86E-03	6.81E+01	3.67E-02
PENRE	MJ	5.62E+03	1.66E+02	4.45E+01	2.24E-01	5.40E+03	4.38E+00
PENRM	MJ	1.77E+01	1.77E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	5.64E+03	1.84E+02	4.45E+01	2.24E-01	5.40E+03	4.38E+00
PERE	MJ	8.67E+02	1.94E+01	1.83E-01	3.16E-03	8.47E+02	2.73E-01
PERM	MJ	3.17E+00	3.17E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	8.70E+02	2.25E+01	1.83E-01	3.16E-03	8.47E+02	2.73E-01
SM	kg	4.00E-01	4.00E-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
FW	m3	3.88E+00	1.90E-01	1.68E-03	6.09E-05	3.68E+00	1.39E-03
HWD	kg	6.41E-03	1.73E-03	1.17E-04	5.37E-07	4.55E-03	6.56E-06
N-HWD	kg	2.37E+01	2.83E+00	4.17E-01	3.47E-02	1.96E+01	8.96E-01
RWD	kg	1.81E-02	5.75E-04	3.14E-04	1.49E-06	1.72E-02	2.16E-05
MfR	kg	1.33E+00	2.71E-01	0.00E+00	1.20E-01	0.00E+00	9.35E-01
MfER	kg	5.79E-02	0.00E+00	0.00E+00	1.74E-02	0.00E+00	4.05E-02
Efp	disease inc.	9.21E-06	9.19E-07	6.09E-08	1.71E-09	8.19E-06	3.52E-08
IrHH	kBq U-235 eq	6.61E+01	1.39E+00	2.02E-01	1.13E-03	6.45E+01	2.70E-02
ETX FW	CTUe	6.58E+03	1.94E+03	2.48E+01	2.70E-01	4.61E+03	6.89E+00
HTX CE	CTUh	1.42E-07	4.00E-08	3.62E-10	6.97E-12	1.01E-07	3.59E-10
HTX N-CE	CTUh	5.17E-06	1.83E-06	3.89E-08	3.09E-10	3.28E-06	2.12E-08
IrLS	Pt	9.48E+02	1.16E+02	9.89E+00	2.55E-01	8.18E+02	3.82E+00

Table 7: Impact indicators for XT2 IEC-3P-N-S-H-L-TMA 160A

Impact category	Unit	XT2-IEC-3P- N-S-H-L-V-TMD/TMA/TMG -160A
Biogenic Carbon content of the product	kg	3.49E-02
Biogenic Carbon content of the associated packaging	kg	2.91E-02

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
WDP	Water deprivation potential.

### Resource use indicators

PENRE	Use of non-renewable primary energy excluding renewable primary energy resources used as raw material
PENRM	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)
PERE	Use of renewable primary energy excluding non-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)

### 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

MfR	Materials for recycling
MfER	Materials for energy recovery

### Others indicators

Efp	Emissions of Fine particles
IrHH	Ionizing radiation, human health
ETX FW	Ecotoxicity, freshwater
HTX CE	Human toxicity, carcinogenic effects
HTX N-CE	Human toxicity, non-carcinogenic effects
IrLS	Impact related to Land use / soil quality

### Extrapolation for Homogeneous environmental family

This LCA covers different build configurations than 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.

### LCA Phase: manufacturing

IEC/UL	3P/4P	Trip Unit	Breaking Capacity	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
IEC	3P	TMD/TMA/TMG	N-S-H-L-V	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
IEC	4P	TMD/TMA/TMG	N-S-H-L-V	1.31	1.31	3.26	1.31	1.19	1.39	1.38	1.33	1.35	1.34	1.38	1.31	1.32
IEC	3P	MF/MA	N-S-H-L-V	1.04	1.04	1.30	1.05	1.47	1.11	1.05	1.05	1.05	1.06	1.05	1.03	1.11
UL	3P	TMA/TMF	N-S-H-L-V-X	1.01	1.01	0.99	0.98	1.00	0.93	0.95	0.98	0.97	0.98	0.95	1.01	0.99
UL	4P	TMA/TMF	N-S-H-L-V-X	1.32	1.31	3.25	1.29	1.19	1.30	1.31	1.31	1.31	1.31	1.31	1.32	1.30
UL	3P	MA	N-S-H-L-V-X	1.06	1.06	1.29	1.06	1.47	1.12	1.05	1.06	1.06	1.06	1.05	1.05	1.13
UL	3P	MCS	N-H-L-V	0.97	0.97	0.34	0.95	0.99	0.91	0.93	0.96	0.95	0.95	0.95	0.97	0.96
UL	4P	MCS	N-H-L-V	1.26	1.26	2.37	1.25	1.17	1.26	1.28	1.27	1.28	1.27	1.30	1.27	1.25

Table 9a: Extrapolation factors for Manufacturing stage  
Reference product: IEC-3P-N-S-H-L-V-TMD/TMA/TMG 160A

### LCA Phase: Distribution

IEC/UL	3P/4P	Trip Unit	Breaking Capacity	LCA Phase	ALL
IEC	3P	TMD/TMA/TMG	N-S-H-L-V	Distribution	1.00
IEC	4P	TMD/TMA/TMG	N-S-H-L-V		1.11
IEC	3P	MF/MA	N-S-H-L-V		1.00
UL	3P	TMA/TMF	N-S-H-L-V-X		1.00
UL	4P	TMA/TMF	N-S-H-L-V-X		1.11
UL	3P	MA	N-S-H-L-V-X		1.00
UL	3P	MCS	N-H-L-V		1.00
UL	4P	MCS	N-H-L-V		1.11

Table 9b: Extrapolation factors for Manufacturing stage  
Reference product: IEC-3P-N-S-H-L-V-TMD/TMA/TMG 160A

### LCA Phase: Installation and Use

Installation phase impacts are common across all variants of the breaker.

IEC / UL	Trip Unit	In [A]	LCA Phase	Factor	IEC / UL	Trip Unit	In [A]	LCA Phase	Factor
IEC	TMD TMA TMG MF MA	1.6	Use	0.12	UL	TMF TMA MCS	15	USE	0.10
		2		0.15			20		0.14
		2.5		0.16			25		0.16
		3.2		0.17			30		0.20
		4		0.16			35		0.25
		6.3		0.20			40		0.32
		8		0.16			45		0.00
		10		0.18			50		0.36
		12.5		0.06			60		0.39
		16		0.08			70		0.39
		20		0.10			80		0.51
		25		0.12			90		0.58
		32		0.16			100		0.71
		40		0.23			110		0.77
		50		0.25			125		1.00
		UL		MA			63		USE
80	0.36		7		0.66				
100	0.50		15		0.46				
125	0.71		30		0.27				
160	1.00		50		0.36				
			70		0.39				
		80	0.49						
		100	0.58						
		125	1.00						

Table 9c: Extrapolation factors for XT2 Circuit Breaker with Thermal magnetic trip units  
Reference product: IEC-3P-N-S-H-L-V-TMD/TMA/TMG - Use Phase

### LCA Phase: End of Life

IEC/UL	3P/4P	Trip Unit	Breaking Capacity	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
IEC	3P	TMD/TMA/TMG	N-S-H-L-V	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
IEC	4P	TMD/TMA/TMG	N-S-H-L-V	1.31	1.31	1.48	1.33	1.19	1.39	1.38	1.34	1.35	1.35	1.38	1.32	1.30
IEC	3P	MF/MA	N-S-H-L-V	1.04	1.04	1.06	1.06	1.46	1.11	1.05	1.05	1.05	1.06	1.05	1.03	1.10
UL	3P	TMA/TMF	N-S-H-L-V-X	1.00	1.00	1.00	0.98	1.00	0.93	0.95	0.99	0.97	0.98	0.95	1.01	0.99
UL	4P	TMA/TMF	N-S-H-L-V-X	1.31	1.31	1.48	1.31	1.19	1.30	1.31	1.31	1.31	1.31	1.31	1.32	1.28
UL	3P	MA	N-S-H-L-V-X	1.05	1.05	1.06	1.06	1.46	1.12	1.05	1.06	1.06	1.06	1.05	1.05	1.12
UL	3P	MCS	N-H-L-V	0.97	0.97	0.86	0.95	0.98	0.90	0.93	0.96	0.95	0.95	0.95	0.97	0.96
UL	4P	MCS	N-H-L-V	1.26	1.26	1.29	1.26	1.17	1.26	1.28	1.28	1.28	1.28	1.30	1.27	1.24

Table 9d: Extrapolation factors for XT2 Circuit Breaker with Thermal magnetic trip units  
Reference product: IEC-3P-N-S-H-L-V-TMD/TMA/TMG - EOL Phase



## 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).

	IEC-3P-N-S-H-L-V-TMD/TMA/TMG 160A
<b>Recyclability potential</b>	<b>58.1%</b>

Table 10: Recyclability potential of of XT2 IEC-3P-N-S-H-L

## References

- [1] PCR “PEP-PCR-ed4-EN-2021\_09\_06” - Product Category Rules for Electrical, Electronic and HVAC-R Products (published: 6<sup>th</sup> September 2021)
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- [3] EN 50693:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems
- [4] ISO 14040:2006 - Environmental management -Life cycle assessment - Principles and framework
- [5] ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines
- [6] ecoinvent v3.8 (2021). ecoinvent database version 3.8 - (<https://ecoinvent.org/>)
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- [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] LB-DT 17-21D - RoHS II (MCCBs and ACBs)
- [12] LB-DT 18-21D - REACH (MCCBs and ACBs)
- [13] 1SDL000571R0 Ver 01 - RoHS Exemptions (MCCBs and ACBs)
- [14] 1SDL000572R0 Ver 01 - SVHC present in excess of 0.1% (MCCBs and ACBs)

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