

PRODUCT ENVIRONMENTAL PROFILE

Environmental Product Declaration

AF400-460 Contactors



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THE ELEMENTS OF THE PRESENT PEP CANNOT BE COMPARED WITH ELEMENTS FROM ANOTHER PROGRAM.	
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Manufacturer name and address	ABB Electrification Sweden AB, Motorgraend 20 Bnr 415, Vaesteras, Sweden
Company contact	EPD_ELSP@in.abb.com
Reference product	AF400-30 Contactor
Description of the product	AF400-30 is a 3 pole - 1000 V IEC or 600 V UL contactor with pre-mounted auxiliary contacts and Main Circuit Bars, controlling motors up to 200kW / 400V AC (AC-3) or 350 hp / 480V UL and switching power circuits up to 600 A (AC-1) or 550 A UL general use. The contactor has a wide control voltage range (24-500V 50/60 Hz and DC), managing large control voltage variations, reducing panel energy consumptions and ensuring distinct operations in unstable networks.
Functional unit	The Functional Unit is to switch on and off during 20 years electrical power supply of a downstream installation with an electrical and/or mechanical control. The functional unit is characterized by type 3NO, a control circuit voltage U_c , a power circuit voltage U_p and a maximum allowed intensity by the power circuit I_p . Power Circuit Voltage U_p [V]: 1000V Maximum allowed intensity by the power circuit I_p [A]: 400A Rated Control Circuit Voltage U_c [V]: 24-500V Number of poles: 3
Other products covered	The PEP covers offerings for the 3-pole variants of AF400-AF460 Contactors (AF400/460-30-*, AF460N-30-*, AF400F/460F-30-*, AF460W-30-*, AFS400/AFS460-30-*) are equipped with low voltage inputs for control, for example by a PLC.
Reference lifetime	20 years
Product category	Electrical, Electronic and HVAC-R Products
Use Scenario	The use phase has been modeled based on the sales mix data (2021), and the corresponding low voltage electricity countries mix
Geographical representativeness	Raw materials & Manufacturing: [Europe / Global] Assembly: [Sweden] Distribution / Use: [Global] specific sales mix EoL: [Global]
Technological representativeness	Materials and processes data are specific for the production of AF400-30 Contactors
LCA Study	This study is based on the LCA study described in the LCA report 1SFC100101D0201
EPD type	Product Family Declaration
EPD scope	"Cradle to grave"
Year of reported primary data	2021
LCA software	SimaPro 9.3.0.3 (2022)
LCI database	ecoinvent v3.8 (2021)
LCIA methodology	EN 50693:2019

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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 110 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

The ABB facility located in Vasteras, is for the Smart Power Division, the competence center for Contactors >100A, Softstarters and one of leading manufacturing site.

All the products are produced in an automated system with precision and accuracy. These are supplied to utilities, industrial, and tertiary sector customers.

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

SS-EN ISO 9001: 2015 - Quality Management Systems- Requirements

SS-EN ISO 14001: 2015 - Environmental management systems - Requirements with guidance for use

ISO 45001:2018 - Occupational Health and Safety Assessment Series

SS-EN ISO 50001: 2018 - Energy management systems

AF contactors are most commonly used for controlling electric motors and switch various none-motor loads. Contactors can break current over a wide range of currents, from a few amperes to thousands of amperes, and voltages upto 1000V AC.

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AF Contactors product cluster

Product cluster declared in this LCA includes the following AF400-460 Contactors.

Product Range	Product	Number of poles	Power Circuit Voltage [U _p]	Maximum allowed intensity by the power circuit [I _p]	Rated Control Circuit Voltage [U _c]
AF400-460	AF400-AF460	3	1000V	400-460A	24-500V

Table 1: Technical characteristics of AF400-460 Contactors.

The accessories associated with these products are also included in the study.

Reference Product:

The reference product for the LCA of the complete range of AF400-460 is AF400-30.



Constituent Materials

The AF400-30 weights about 12.7kg including its installed accessories, packaging, and paper documentation.

AF400-30				
Materials	Name	IEC 62474 MC	[g]	%
Metals	Steel	M-119	4545.8	35.7%
	Cu Alloys	M-121	2293	18.0%
	Stainless Steel	M-100	376.3	3.0%
	Precious Metals	M-124	63.8	0.5%
Plastics	Unsaturated Polyester	M-301	3978.8	31.2%
	Polyamide	M-258	485.3	3.8%
	Polyethylene	M-251	255.1	2.0%
	Rubber	M-320	16.5	0.1%
	PBT	M-261	57.8	0.4%
Other	Paper / Cardboard	M-341	582.9	4.6%
	Other	N/A	88	0.7%
Total			12743.3	100%

Table 2: Weight of materials AF400-30

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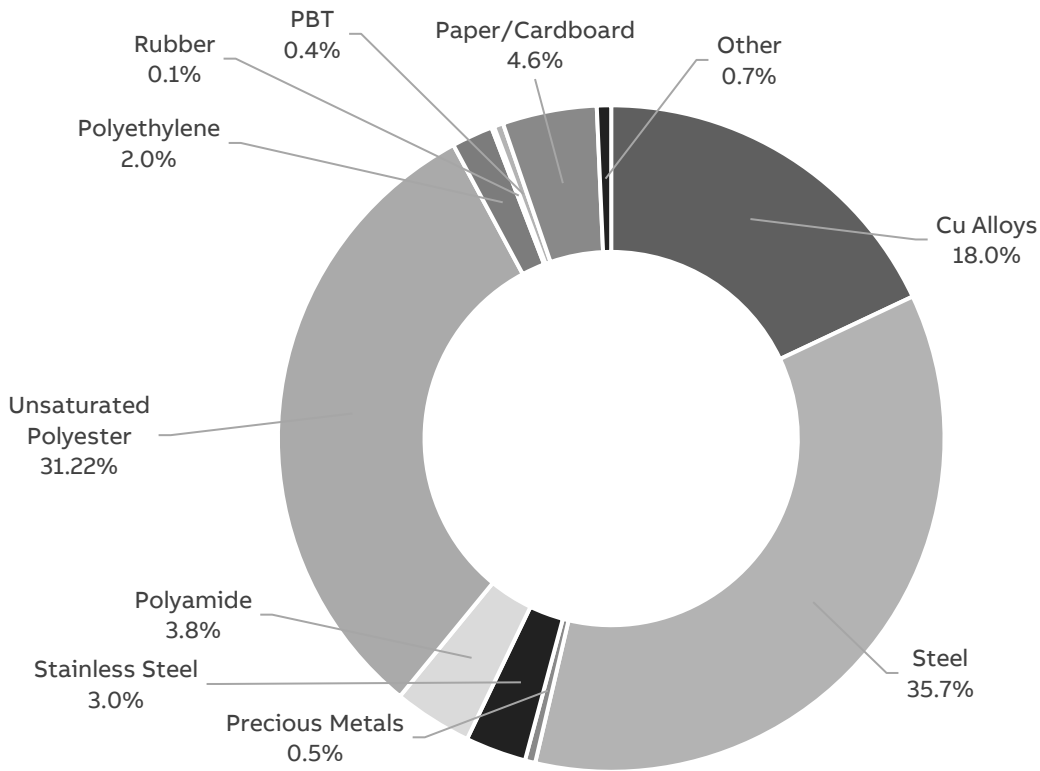


Figure 1: Composition of AF400-30

Along the whole AF400-460 product cluster, a set of different build configurations have been covered by this analysis.

Packaging weighs 518g, with the following substance composition:

Material	Unit	Total	%
Corrugated Cardboard	g	518	4.1%

Table 3: Weight of Packaging for AF400-30

Official declarations 2CMT2021-006277 [10] and 2CMT2021-006202 [11] states compliance of ABB AF Contactors respectively to RoHS and REACH regulations; 2CMT2021-006277 [10] provides exemptions considered for RoHS while 2CMT2021-006202 [11] lists REACH substances present in a concentration above 0.1% adding reference to products where involved parts are mounted.

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Functional unit and Reference Flow

The Functional Unit is to switch on and off during 20 years electrical power supply of a downstream installation with an electrical and/or mechanical control. The functional unit is characterized by a type 3NO, a control circuit voltage U_c , a power circuit voltage U_p and a maximum allowed intensity by the power circuit I_p . (table 1)

The Reference Flow of the study is a single Contactor (including its packaging and accessories) with mass described, table 2.

System boundaries and life cycle stages

The life cycle of the Contactor, 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				
Components/parts manufacturing	Transport to distributor/ logistic center	EoL treatment of generated waste	Usage	Collection and transport
Assembly	Transport to place of use		Maintenance	
Packaging		(packaging)		EoL treatment
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].

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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 GWP: GWP (total) which includes all greenhouse gases; GWP (fossil fuels); GWP (biogenic) which includes the emissions and absorption of biogenic carbon dioxide and biogenic carbon stored in the product; GWP (land use) - land use and land use transformation. Other indicators as per the PCR[1].

Allocation rules

Allocation coefficients are based on the AF400 line’s occupancy area for electricity 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 and water consumption, has been based on this criterion.

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 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.

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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.

Scraps for metal working and plastic processes are included when already defined in ecoinvent[6].

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 locations
Manufacturing	A3	Electricity, {SE} market for Cut-off	Specific Energy model for ABB Vasteras 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 11 for further description



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 v3.8 cut-off by classification system processes [6] are used to model the background system of the processes.

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

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Manufacturing stage

The Contactors are composed of a multitude of components, all of which are made from 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 packaging components from outside suppliers and packages the Contactors 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 Contactor. All the semi-finished and ancillary products are produced by ABB's suppliers.

The entire AF Contactors suppliers' 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.

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 Contactor. 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 Vasteras production site and includes renewable energy only (Hydroelectric). The complete energy mix has been modeled considering the certificate on Guarantee of origins provided to ABB for the year 2021.

Distribution

The transport distances from ABB manufacturing plant to the distribution centers (regional distribution centers / local sales organizations) have been calculated considering the specific 2021 sales mix data for AF400-460 Contactors product cluster (SAP ERP sales data as a source).

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

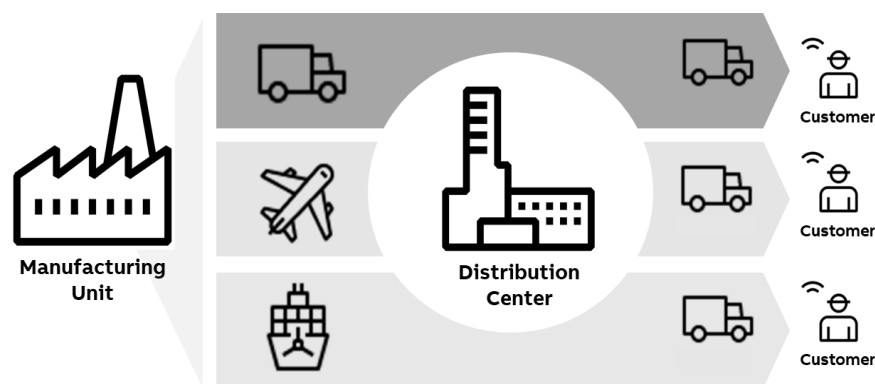


Figure 2: Distribution Methodology

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Installation

The installation phase only implies manual activities, and no energy is consumed. This phase also includes the disposal of the packaging and paper technical documentation of the AF Contactor.

For the disposal of the packaging and documentation after installation of the AF Contactor at the end of its life, a transport distance of 1000 km (according to PCR[1]) was assumed. The chosen transportation datasets from Ecoinvent [6].

The actual disposal site is unknown and is managed by the customer.

Use

Use and maintenance are modelled according to the PCR [1].

During the use phase, AF Contactor, dissipates some electricity due to power losses. They are calculated according to the data provided in the catalogue of the AF Contactor and following the PCR [1] & PSR [2] rules:

Parameters		
I _u	[A]	400/460
I _u	[%]	50
h/year	[h]	8760
RSL	[years]	20
Time operating coefficient	[%]	50

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 Contactor at a given value of current:

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

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 the 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.

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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]).

Disassembly manuals can be provided to the customer to support product disposal.

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Environmental impacts

The following tables show the environmental impact indicators of the life cycle of a single Contactor, as indicated by PEP Ecopassport PCR and EN 50693:2019 [3]. The indicators are divided into the contribution of the processes to the different modules (upstream, core and downstream) and stages (manufacturing, distribution, installation, use and end-of-life).

AF400-30

Impact category	Unit	Total	Manufacturing	Distribution	Installation	Use	End of Life
GWP-total	kg CO2 eq	6.08E+02	8.87E+01	2.81E+00	3.47E-01	5.12E+02	3.99E+00
GWP-fossil	kg CO2 eq	5.91E+02	8.74E+01	2.81E+00	1.43E-01	4.96E+02	3.94E+00
GWP-biogenic	kg CO2 eq	1.57E+01	1.17E+00	2.29E-03	2.04E-01	1.43E+01	4.76E-02
GWP-luluc	kg CO2 eq	1.77E+00	1.28E-01	1.21E-03	5.07E-05	1.64E+00	2.33E-03
ODP	kg CFC11 eq	3.85E-05	7.86E-06	6.53E-07	3.25E-08	2.96E-05	3.25E-07
AP	mol H+ eq	3.98E+00	1.62E+00	2.89E-02	7.09E-04	2.32E+00	1.78E-02
EP-freshwater	kg P eq	5.60E-01	1.64E-01	1.60E-04	8.93E-06	3.95E-01	7.51E-04
EP-marine	kg N eq	6.04E-01	1.72E-01	8.24E-03	3.60E-04	4.11E-01	1.21E-02
EP-terrestrial	mol N eq	5.93E+00	2.05E+00	9.09E-02	2.65E-03	3.74E+00	4.20E-02
POCP	kg NMVOC eq	1.64E+00	5.67E-01	2.53E-02	8.16E-04	1.04E+00	1.22E-02
ADP-m&m	kg Sb eq	6.56E-02	6.20E-02	5.99E-06	3.18E-07	3.59E-03	3.56E-06
ADP-fossil	MJ	1.00E+04	1.26E+03	4.26E+01	2.13E+00	8.70E+03	3.74E+01
WDP	m3	1.64E+02	4.72E+01	1.36E-01	1.02E-02	1.16E+02	3.10E-01
PENRE	MJ	9.92E+03	1.14E+03	4.26E+01	2.13E+00	8.70E+03	3.74E+01
PENRM	MJ	1.18E+02	1.18E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.00E+04	1.26E+03	4.26E+01	2.13E+00	8.70E+03	3.74E+01
PERE	MJ	1.56E+03	1.43E+02	5.01E-01	2.83E-02	1.42E+03	2.72E+00
PERM	MJ	9.67E+00	9.67E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.57E+03	1.52E+02	5.01E-01	2.83E-02	1.42E+03	2.72E+00
SM	kg	3.72E+00	3.72E+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	7.93E+00	1.35E+00	4.65E-03	3.42E-04	6.57E+00	1.23E-02
HWD	kg	1.58E-02	9.46E-03	9.28E-05	5.13E-06	6.24E-03	4.94E-05
N-HWD	kg	6.02E+01	1.92E+01	3.36E+00	2.61E-01	3.14E+01	5.93E+00
RWD	kg	4.98E-02	4.01E-03	2.89E-04	1.43E-05	4.53E-02	1.71E-04
MfR	kg	1.01E+01	2.00E+00	0.00E+00	6.25E-01	0.00E+00	7.47E+00
MfER	kg	4.37E-01	1.31E-01	0.00E+00	5.40E-02	0.00E+00	2.52E-01
Efp	disease inc.	1.67E-05	6.71E-06	2.91E-07	1.63E-08	9.38E-06	3.06E-07
IrHH	kBq U-235 eq	1.91E+02	1.04E+01	2.12E-01	1.08E-02	1.81E+02	2.38E-01
ETX FW	CTUe	2.35E+04	1.69E+04	3.21E+01	2.00E+00	6.57E+03	6.39E+01
HTX CE	CTUh	5.52E-07	3.73E-07	1.09E-09	5.16E-11	1.75E-07	3.58E-09
HTX N-CE	CTUh	2.37E-05	1.81E-05	3.32E-08	2.20E-09	5.27E-06	2.18E-07
IrLS	Pt	2.47E+03	8.60E+02	4.18E+01	2.44E+00	1.54E+03	3.00E+01

Table 7: Impact indicators for AF400-30

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Impact category	Unit	Total
Biogenic Carbon content of the product	kg	1.87E-01
Biogenic Carbon content of the associated packaging	kg	2.4E-02

Table 8: Inventory Flow indicators of AF400-30.

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 renewable primary energy excluding renewable primary energy resources used as raw material
PENRM	Use of re-newable primary energy resources used as raw material
PENRT	Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)
PERE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material
PERM	Use of non-renewable primary energy resources used as raw material
PERT	Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materi-als)

Secondary materials, water and energy resources

SM	Use of secondary materials
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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

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Additional environmental information

According to the waste treatment scenario calculation in Simapro, 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).

	AF400-30
Recyclability potential	79.19%

Table 12: Recyclability potential of AF400-30.

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Extrapolation for Homogeneous environmental family

This LCA covers different build configurations than the representative product from the IEC and UL types. 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.

Contactors	LCA Stage	GWP-total	GWP-fossil	GWP-biogenic	GWP-luluc	ODP	AP	EP-freshwater	EP-marine	EP-terrestrial	POCP	ADP-minerals & metals	ADP-fossil	WDP
AF400	Manu.	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
	EoL	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
AF460	Manu.	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
	EoL	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

Table 9: Extrapolation factors for AF400

Reference product: AF400-30 -Manufacturing / End of Life

Contactor	LCA Stage	Factor
AF400	Distribution	1.00
AF460		1.00

Table10: Extrapolation factors for AF400.

Reference product: AF400-30 -Distribution

Contactor	LCA Stage	Factor
AF400	Use Phase	1.00
AF460		1.28

Table 11: Extrapolation factors for AF400

Reference product: AF400-30-Use Phase

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(published: 6th September 2021)
- [2] PEP Ecopassport PSR-0005-ed2-EN-2016 03 29 “Product Specific Rules for Electrical Switchgear and Control gear Solutions” (published: May 2016)
- [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 version 3.8. Swiss, Centre for Life Cycle Inventories, Dübendorf, Switzerland
- [7] PRé Consultants, 2021. Software SimaPro versione 9.3.1 (www.pre.nl).
- [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] 2CMT2021-006277- RoHS
- [11] 2CMT2021-006202- REACH
- [12] 1SFC100101D0201-LCA Report

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