EPD

Environmental Product Declaration

Vacuum Interrupter VG4-S

Production site: Ratingen, Germany

DOCUMENT KIND		IN COMPLIANCE WITH			
Environmental Product Declaration		ISO 14025 and EN50693			
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ABB Switzerland Ltd	3XAA008728		B001	EN	1/19

EPD Owner	ABB Switzerland Ltd, Group Technology Management
Manufacturer name and address	ABB AG Oberhausener Str. 33, 40472 Ratingen
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Declared product, functional unit (FU) and reference flow (RF)	VG4-S FU: The functional unit of this study is to establish or interrupt the electrical continuity of a circuit within a switchgear compartment in power systems during a reference service life of 20 years including related accessories and packaging. RF: A single vacuum interrupter including related accessories and packaging.
Product description	Vacuum interrupters (VIs) are the core component for all switching applications in medium voltage. The main purpose of the vacuum interrupter is to establish or to interrupt a current flow by separation of the electrical contacts which results in a metal vapor arc. This arc is quickly extinguished due to the insulating properties of vacuum.
CPC code	46211 - Electrical apparatus for switching or protecting electrical circuits, or for making connexions to or in electrical circuits, for a voltage exceeding 1000 V
Independent verification	Independent verification of the declaration and data, according to ISO 14025: 2010. ☐ INTERNAL ☒ EXTERNAL Independent verifier approved by EPD Norway: Anne Rønning Signature:
Approved by	Håkon Hauan, CEO EPD-Norge Signature:
Reference PCR and version number	Core PCR: EPDItaly007 – PCR for Electronic and Electrical Products and Systems, Rev. 2, 2020/10/21. PCR: EPDItaly012 - Electronic and electrical products and systems – Switches, Rev. 0, 2020/03/16.
Core PCR	EN 50693:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems.
Product RSL description	20 years
Markets of applicability	World (raw materials), Germany (production, use and end-of-life) Europe (use and end-of-life)

LCA study	This EPD is based on the LCA study described in the LCA report 3XAA008727
EPD type	Product specific
EPD scope	“Cradle to grave”
Year of reported primary data	2021
Technical support	2B Srl (Italy) Via della Chiesa Campocroce 4, Mogliano Veneto (TV)
LCA software	SimaPro 9.4.0.1 (2021)
LCI database	ecoinvent v3.8 (2021)
LCIA methodology	EN 50693:2019
Comparability	EPDs published within the same product category, though originating from different programs, may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible.
Liability	The owner of the declaration shall be liable for the underlying information and evidence. EPD Norway shall not be liable with respect to manufacturer, life cycle assessment data and evidences.
Author of the life cycle assessment	Cemre Akdag – cemre.akdag@de.abb.com R&D Engineer

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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 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 human behavior.

General Information

The range of ABB Ratingen includes innovative and smart systems, with components and services for power distribution and switching and control technology. The product range of the Ratingen plant includes components such as vacuum interrupters, pole parts, circuit breakers, current limiters and core modules for the production of primary gas-insulated switchgear. These components are widely used in associated plants within the worldwide ABB value chain as well as by OEM partners in the industry.

ABB DE-ELDS 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 – Requirements
- UNI EN ISO 45001:2018 - Occupational Health and Safety Management Systems

The VI type VG4-S declared in this EPD includes one main version within different application cases, but all are covered with the same VI. This includes certain voltage levels (12 kV / 17.5 kV / 24 kV) and specific current levels for rated current (1250 A) and short-circuit current (31.5 kA / 25 kA)

Technical information	
Product Name	**VG4-S**
Rated voltage [kV]	12 / 17.5 / 24
Rated current [A]	1250
Rated short circuit breaking current [kA]	25 / 31.5

Forming the heart of medium-voltage switchgear, vacuum interrupters (VIs) are an indispensable part of the medium-voltage distribution network. As the core component for all switching applications, VIs are widely used in utility power transmission systems, power generation units, and power-distribution systems for railways, arc furnace applications, and industrial plants. The main purpose of the vacuum interrupter is to establish or interrupt a current flow by separation of the electrical contacts which results in a metal vapor arc. This arc is quickly extinguished due to the insulating properties of the vacuum.

To increase external dielectric strength and to protect the vacuum interrupter from the external influence it is embedded in silicone or epoxy resin or thermoplastic. The vacuum interrupter itself cannot work stand-alone, it always requires additional outer protection and terminal connection (pole part) and a mechanism to open the contacts (circuit breaker). The vacuum interrupters are embedded in a special cast resin or thermoplastic which makes the pole parts of the circuit-breaker notably robust and at the same time protects the ABB vacuum interrupters from impact, dust, moisture and external damage. The vacuum interrupter and the pole parts are maintenance-free products/components. The whole system cannot work stand-alone, it requires a mechanical or electrical drive to create a gap between the two contacts. With additional drive the system can be seen as completed as a circuit breaker.

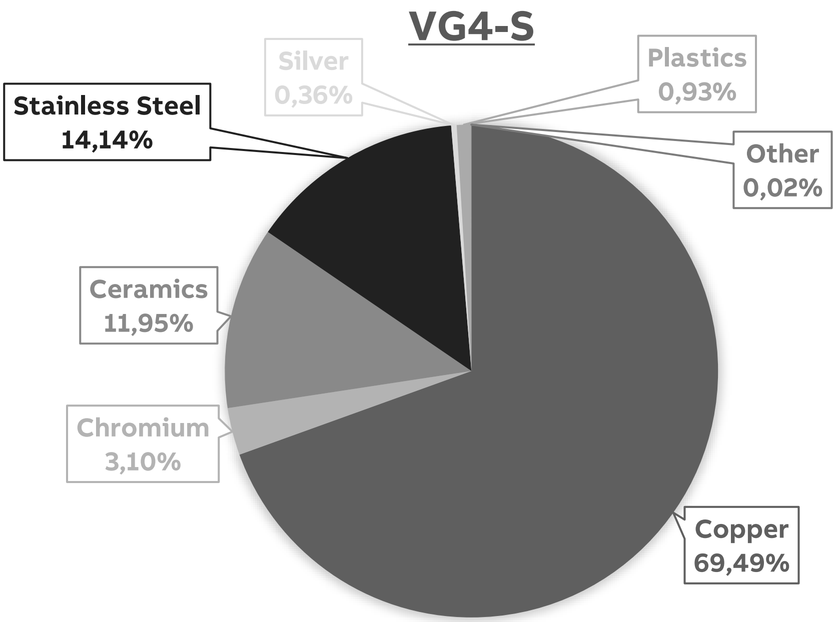
Vacuum circuit breakers are used in electrical distribution for control and protection of cables, overhead lines, distribution substations, motors, transformers, generators and capacitor banks. The scope of the medium voltage circuit breakers is to interrupt an electric current with a mechanical actuator (spring mechanism).

The manufacturing of the VI's and pole parts is located in ABB Ratingen, where the vacuum interrupters are assembled and produced. All components and some of the subassemblies are produced by ABB's suppliers and are then assembled in the factory.

Constituent materials

The **VG4-S** part weights about 2.58 kg. All parts are included in the analysis.

Materials	Name	CAS Number	Product weight [kg]	%
Plastics	Polyamide & Polybutylen-terephthalate glass filled	---	0.024	0.93
	Other plastics and rubbers	---	---	---
Metals	Stainless Steel	65997-19-5	0.36	14.14
	Copper	7440-50-8	1.79	69.49
	Chromium	7440-47-3	0.08	3.1
	Silver	7440-22-4	0.009	0.36
Others	Ceramics	66402-68-4	0.31	11.95
	Others	---	0.0059	0.02
Total			2.58	100



For the packaging small parts as sticking labels and grease, which are representing a smaller fraction of the total mass, are neglected as their mass represents less than 2% of that of the whole component, as stated in the paragraph of cut-off criteria of EPDItaly-012: “Materials making up the switch itself whose total mass does not exceed 2% of the total weight of the device”.

Scraps for metal working and plastic processes are included when already defined in ecoinvent. The single-use packaging and reusable packaging are also included in the analysis in the manufacturing core stage. The packaging is common for VG4-S, it is composed of steel fixing brackets, a cardboard box, and a wooden pallet, resulting in a total weight of 27.7 kg for single-use box and 36.2 kg for reusable packaging with additional packaging elements. ABB receives packaging components from outside suppliers and packages the vacuum interrupter before shipping them.

LCA background information

Functional Unit

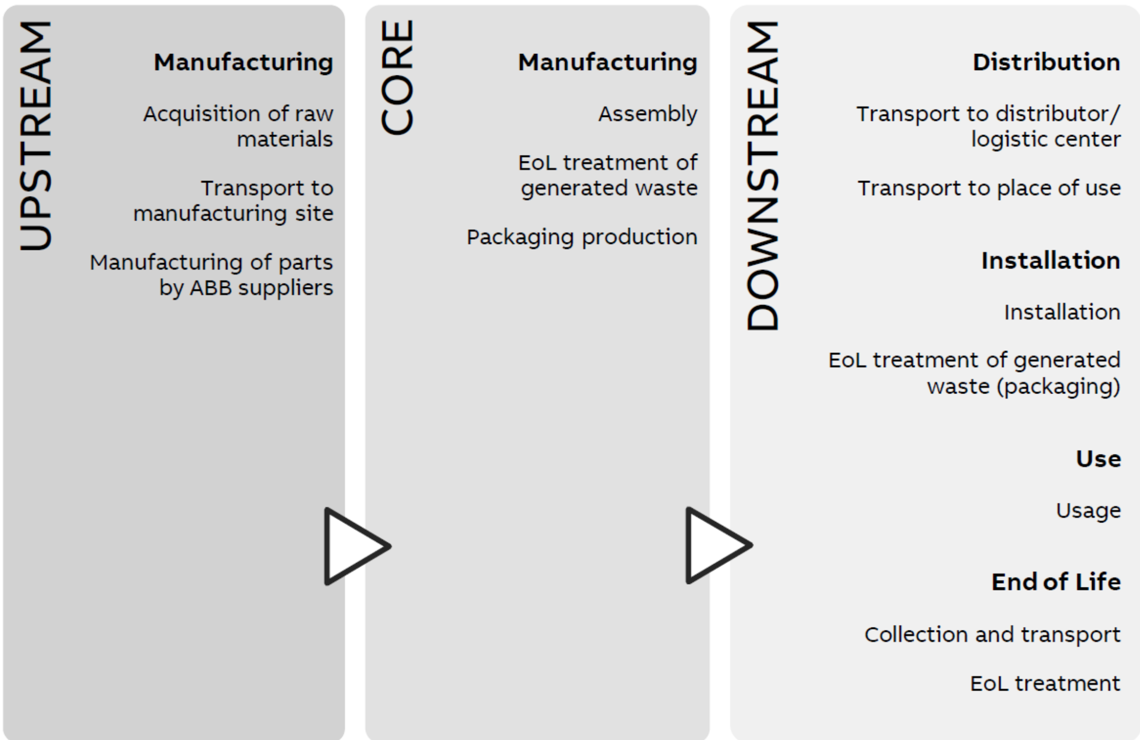
The functional unit of this study is to establish or interrupt the electrical continuity of a circuit within a switchgear compartment in power systems during a reference service life of 20 years.

The reference flow is a single vacuum interrupter including related accessories and packaging.

System Boundaries

The life cycle of the vacuum interrupter VG4-S is a "from cradle to grave" analysis and covers the following main life cycle stages: manufacturing, including the relevant upstream process (e.g. acquisition of raw material, preparation of semi-finished goods, etc.) and the main manufacturing 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 for the evaluation of electronic and electrical products and systems.



The stages of the product life cycle and the information considered for the evaluation of the VG4-S are:

- Manufacturing upstream includes raw materials, and production activities of ABB suppliers, including transport of semi-finished items and subassemblies to ABB Ratingen site.
- The core part of the manufacturing stage includes local consumptions (ABB Ratingen) the relevant assembling and waste due to manufacturing as well as the packaging production.
- The distribution stage includes the impacts related to the distribution of the product at the installation site.
- The installation stage includes the end of life of the packaging.
- The use and maintenance stages include the impact related to energy consumption during the service life of the product.
- The end-of-life stage includes all activities related to waste treatment and disposal of the product at the end of its service life.

Temporal and geographical boundaries

The ABB component suppliers are sourced all over the world. All primary data collected from ABB are from 2021, which is a representative production year. Secondary data are also representative for this year, as provided by ecoinvent v3.8.

The selected ecoinvent processes in the LCA model have global representativeness, due to the unclear origin of each component. In this way, a conservative approach has been adopted. The results of this study are only applicable to VG4-S vacuum interrupters produced in Ratingen in 2021.

Boundaries in the life cycle

As indicated in the PCR EPDItaly012, 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 database have not been excluded.

Data quality

In this EPD, both primary and secondary data are used. Site-specific foreground data have been provided by ABB. The main data sources are the bill of materials available on the enterprise resource planning. For all processes for which primary are not available, generic data originating from the ecoinvent v3.8 database, allocation cut-off by classification, are used. The ecoinvent database is available in the SimaPro 9.4.0.1 software used for the calculations.

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 EPDItaly007 and EN 50693 the environmental impact indicators must be determined using the characterization factors and impact assessment methods specified in EN 15804:2012+A2:2019.

PCR EPDItaly007 and the EN 50693 standards establish four indicators for climate impact (GWP-GHG): GWP (total) which includes all greenhouse gases; GWP (fossil fuels); GWP (biogenic carbon) which includes the emissions and absorption of biogenic carbon dioxide and biogenic carbon stored in the product; GWP (land use and land use change).

Allocation rules

Allocation keys are used for consumptions related to the manufacturing process in the production site as well as for company waste and product distribution. Since the factory produces several products (components, apparatus and switchgears), only a part of the environmental impact has been allocated to the specific production line. The values for the electricity, heat, pressurized air, and water consumption have been read and recorded from the counters which are distributed in the whole factory and are connected to certain areas or even single machines or single workstations.

For the end-of-life allocation, the “polluter pays” principle is adopted according to what is defined in the CEN/TR 16970 standard, as required by the PCR EPDItaly007. This means that waste treatment processes are allocated to the product system that generates the waste until the end-of-waste state is reached. The environmental burdens of recycling and energy recovery processes are therefore allocated to the product system that generates the waste, while the product system that uses the exported energy and recycled materials receives it burden-free. However, the potential benefits and avoided loads from recovery and recycling processes are not considered because it is not required by EPDItaly007.

Limitations and simplifications

The raw material life cycle stage includes the extraction of all raw materials. There is no neglection of any components or materials within the analysis.

For the packaging small parts such as sticking labels and grease, which are representing a smaller fraction of the total mass, are neglected as their mass represents less than 2% of that of the whole component, as stated in the paragraph of the cut-off criteria of EPDItaly-012: “Materials making up the switch itself whose total mass does not exceed 2% of the total weight of the device”. Scraps for metal working and plastic processes are included when already defined in ecoinvent.

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 and PLM 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 the R&D and Industrialization functions. Road distances between the suppliers and ABB were calculated using Google Maps, and marine distances using distances & time according to searates.com.

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 are used to model the background system of the processes.

The raw material inputs are modeled with data from ecoinvent representing a global market coverage. These datasets are assumed to be representative.

Manufacturing stage

The vacuum interrupter is composed of several components all of which are made from numerous materials. Most of the inputs to the products' manufacturing stage are already produced components. Copper is the most frequently used material followed by stainless steel and ceramics.

The single-use packaging and reusable packaging are also included in the analysis in the manufacturing core stage including all elements and components belonging to packaging. ABB receives packaging components from outside suppliers and packages the vacuum interrupter before shipping them.

The transport distances from raw materials suppliers to the manufacturing are not known. However, this information is included in the data sets of ecoinvent "market for". The distance from the subassembly or single parts manufacturing factory to ABB facility is calculated. In the factory, the different components and subassemblies are assembled into the vacuum interrupter. All the components are produced by ABB's suppliers.

The energy mix used for the production phase is representative for Ratingen production site and includes an autonomous combined heat and power plant (CHP) driven by natural gas.

Distribution

The transport distances from ABB plant to the place of use were exactly defined. There are four customers identified. The reference port is Rotterdam, NL.

Installation

The installation phase only implies manual activities and no energy is consumed. This phase also includes the disposal of the packaging of the VG4-S.

Use

Use and maintenance are modelled according to the PCR EPDItaly012 – Switches for the VG4-S. As written in the PCR EPDItaly012 they are modelled according to the PCR EPDItaly007 and EN_50593 . For the use phase, the general European medium voltage electricity mix from ecoinvent v3.8 is used.

Since no maintenance happens during the use phase the environmental impacts linked to this procedure have been omitted from the analysis. During the use phase, the VG4-S dissipates some electricity due to ohmic losses. Electricity consumption was calculated with the following formula:

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

$$P_{use} = R*(0.5*I)^2$$

$$\alpha = 0.3$$

with

- P_{use} = Power losses
- E_{use} = Energy losses
- RSL = Reference Service Lifetime
- R = Resistance
- I = Rated Current which is flowing through component during steady-state
- 8760 h = The number of hours in a year;
- α = Coefficient describing the amount of time in which the switch is requested to operate its function

Parameters	Values
Nominal current [A]	1250
RSL [Years]	20
α [%]	30
P_{use} [W]	3.52
E_{use} [kWh]	184.78

The RSL is adopted from the PCR EPDItaly012 with 20 years, the operational time and power are assumed to be 30% for all the service life. Since no maintenance happens during the use phase, the environmental impacts linked to this procedure are omitted from the analysis.

End of life

The transport distances from the place of use to the place of disposal are assumed to be 100 km.

The end-of-life stage is modelled according to PCR EPDItaly012 and IEC/TR 62635. The percentages for end-of-life treatments of circuit breakers are taken from IEC/TR 62635, while the data for packaging waste scenarios are provided by EUROSTAT.

Environmental indicators

The following tables show the environmental impact indicators of the life cycle of a single vacuum interrupter of type VG4-S, as indicated by PCR EPDItaly007, PCR EPDItaly012 and EN 50693:2019.

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).

Impact category	Unit	Total	UPSTREAM	CORE	DOWNSTREAM			
			Manufacturing		Distribution	Installation	Use	End of life
Climate change	kg CO2 eq	1.25E+02	2.69E+01	2.18E+01	4.11E-01	5.02E-01	7.50E+01	5.20E-01
Climate change - Fossil	kg CO2 eq	1.22E+02	2.64E+01	2.24E+01	4.11E-01	6.39E-02	7.24E+01	4.61E-01
Climate change - Biogenic	kg CO2 eq	2.67E+00	4.46E-01	-6.31E-01	1.04E-04	4.39E-01	2.36E+00	5.80E-02
Climate change - Land use and Land use change	kg CO2 eq	2.18E-01	4.47E-02	2.22E-03	2.53E-04	5.19E-05	1.71E-01	3.86E-04
Ozone depletion	kg CFC11 eq	7.50E-06	1.65E-06	2.13E-06	8.68E-08	5.01E-09	3.59E-06	3.54E-08
Acidification	mol H+ eq	1.76E+00	1.33E+00	3.09E-02	9.86E-03	2.09E-04	3.90E-01	1.71E-03
Eutrophication, freshwater	kg P eq	1.83E-01	1.10E-01	7.33E-04	1.73E-05	8.08E-06	7.25E-02	1.00E-04
Photochemical ozone formation	kg NMVOC eq	4.96E-01	2.88E-01	3.78E-02	7.25E-03	2.14E-04	1.61E-01	1.39E-03
Depletion of abiotic resources – minerals and metals	kg Sb eq	3.62E-02	3.60E-02	3.07E-05	6.83E-07	2.26E-07	1.70E-04	4.06E-06
Depletion of abiotic resources – fossil fuels	MJ	2.12E+03	3.27E+02	2.37E+02	5.63E+00	4.87E-01	1.54E+03	4.74E+00
Water use (AWARE)	m3	3.96E+01	2.20E+01	8.00E-01	1.34E-02	2.14E-03	1.68E+01	7.21E-02

Resource use parameters	Unit	Total	UPSTREAM	CORE	DOWNSTREAM			
			Manufacturing		Distribution	Installation	Use	End of Life
PENRE	MJ	2.12E+03	3.26E+02	2.34E+02	5.63E+00	4.88E-01	1.54E+03	4.74E+00
PERE	MJ	3.50E+02	7.36E+01	9.01E+00	4.98E-02	2.14E-02	2.66E+02	3.39E-01
PENRM	MJ	4.32E+00	1.41E+00	2.91E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	8.29E+00	0.00E+00	8.29E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.12E+03	3.27E+02	2.37E+02	5.63E+00	4.88E-01	1.54E+03	4.74E+00
PERT	MJ	3.58E+02	7.36E+01	1.73E+01	4.98E-02	2.14E-02	2.66E+02	3.39E-01
Net use of fresh water (from AWARE)	m3	1.87E+00	5.55E-01	2.37E-02	4.49E-04	1.21E-04	1.29E+00	2.51E-03
Use of secondary material	kg	1.80E-01	1.77E-01	3.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00

*PENRE: Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; *PERE: Use of renewable primary energy excluding renewable primary energy resources used as raw material; *PENRM: Use of non-renewable primary energy resources used as raw material; *PERM: Use of 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) ;*PERT: Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)

Waste production indicators	Unit	Total	UPSTREAM	CORE	DOWNSTREAM			
			Manufacturing		Distribution	Installation	Use	End of life
Hazardous waste disposed	kg	5.62E-03	4.71E-03	3.42E-04	8.22E-06	1.00E-06	5.48E-04	7.68E-06
Non-hazardous waste disposed	kg	1.63E+01	9.90E+00	4.92E-01	1.96E-01	3.08E-02	5.11E+00	6.21E-01
Radioactive waste disposed	kg	1.27E-02	1.10E-03	1.99E-04	3.87E-05	2.42E-06	1.13E-02	2.03E-05
Materials for energy recovery	kg	4.41E-01	0.00E+00	1.41E-01	0.00E+00	2.83E-01	0.00E+00	1.69E-02
Materials for recycling	kg	3.55E+00	5.01E-01	7.41E-01	0.00E+00	3.33E-01	0.00E+00	1.97E+00
Exported thermal Energy	MJ	1.68E+00	0.00E+00	6.50E-01	0.00E+00	1.03E+00	0.00E+00	4.60E-04
Exported electricity energy	MJ	8.42E-01	0.00E+00	3.29E-01	0.00E+00	5.13E-01	0.00E+00	2.35E-04

Additional environmental information

Reciclability potential

The recyclability potential of the reference product is calculated by dividing "MFR: material for recycling" with the total weight of the vacuum interrupter This is based on the end-of-life scenario adopted from IEC/TR 62635 Edition 1.0 which is representative for Europe. The scenario is based on the rates given for materials that go through a separation process, and the production losses in the recycling processes have also been considered; thus, a conservative approach is adopted.

	Recyclability potential
VG4-S	76.3 %

GHG emissions from the use of electricity in the manufacturing phase

The energy mix used for the production phase is representative for Ratingen production site and includes an autonomous combined heat and power plant (CHP) driven by natural gas.

Data source	Amount	Unit
Ecoinvent 3.8 heat and power co-generation, natural gas	0.6015	kg CO2-eq/kWh

Dangerous substances

The product contains no substances given by the REACH Candidate list.

Indoor environment

The product meets the requirements for low emissions.

Carbon footprint

Carbon footprint has not been worked out for the product.

References

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- EN 15804:2012+A2:2019 – Sustainability of constructions – Environmental products declarations (September 2019)
- PCR EPDItaly007 - Electronic and electrical products and systems (rev.2), October 2020
- PCR EPDItaly012 - Electronic and electrical products and systems - Switches, March 2020
- 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
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- https://ec.europa.eu/eurostat
- General Program Instructions for The Norwegian EPD Foundation/EPD-Norge (www.epd-norge.no) version 5:2019
- EPDItaly Regulations rev. 5.2 (16/02/2022)

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