# Jiangsu Rugao High Voltage Electric Apparatus Co., Ltd

# ENVIRONMENTAL PRODUCT DECLARATION

## Product Name: Circuit Breakers-Dead Tank and HGIS

## Site Plant: Rugao, Jiangsu Province, China

**in compliance with ISO 14025 and EN 50693**

| | |
|---|---|
| **Program Operator** | EPD Italy |
| **Publisher** | EPD Italy |

| | |
|---|---|
| **Declaration Number** | RugaoGCB/HGIS(T) |
| **EPDItaly Registration Number** | EPDITALY0202 |

| | |
|---|---|
| **Issue Date** | 07/01/2022 |
| **Valid to** | 07/01/2027 |

Sieyuan 思源电气

# 1. GERNERAL INFORMATIONS

| | |
|---|---|
| EPD OWNER: | Jiangsu Rugao High Voltage Electric Apparatus Co., Ltd<br>Add: No.1 West Huimin Road Jiangsu Province, 226500 P.R.China |
| PRODUCT NAME: | Circuit Breakers – Dead Tank and HGIS |
| PRODUCTION SITE: | No.1 West Huimin Road Jiangsu Province, 226500 P.R.China |
| FIELD OF APPLICATION: | High voltage power station |
| PROGRAM OPERATOR: | EPDITALY (www.epditaly.it)<br>Add: via Gaetano De Castillia n° 10 - 20124 Milano, Italy |
| CPC CODE: | 46211 – "Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits, for a voltage exceeding 1000 V" |
| COMPANY CONTACT: | Mr. Hang Fei (hf.13480@sieyuan.com) |
| EXTERNAL AUDIT: | This declaration has been developed referring to EPDItaly, following the General Program Instruction; further information and the document itself are available at: www.epditaly.it.<br>Independent verification of the declaration and data, according to EN ISO 14025:2010.<br>☐ INTERNAL ☒ EXTERNAL<br>Third party verifier: ICMQ S.p.A., via Gaetano De Castillia n° 10 - 20124 Milano, Italia. Accreditated by Accredia |
| LCA Consultant | This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:<br>Ecovane Environmental Co., Ltd (www.1mi1.org / www.ecovane.cc ) |
| PRODUCT CATEGORY RULES (PCR): | EPDItaly007: *Electronic and electrical products and systems* (October, 2020, Revision REV.2)<br>EPDItaly012: *Electronic and electrical products and systems – Switches* (March 2020, Revision REV.0) |
| COMPARABILITY: | EPDs 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. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared. |
| LIABILITY: | The owner of the declaration will be responsible for the information and supporting evidence. EPDItaly disclaims any liability regarding the manufacturer's information data. |
| REFERENCE DOCUMENT: | This declaration is based on the EPDItaly regulation (Regulation EPDItaly rev.5), available on the websitewww.epditaly.com<br>The standard EN 50693 :2019 "Product category rules for life cycle assessments of electronic and electrical products and systems" is also used as a reference. |

# 2. COMPANY INTRODUCTION

Jiangsu Rugao High Voltage Electric Co., Ltd. (hereinafter referred to as "Jiangsu Rugao"), belongs Sieyuan electric group, established in December 1993, is a well-known listed company in China specialized in R&D of electric power technology, equipment manufacturing and engineering services. Since its listing on the Shenzhen Stock Exchange in 2004 (stock code 002028), the company is developing steadily by 30% compound growth rate every year and added new contract orders of 7.48 billion Yuan in 2018. Sieyuan has been honored these titles of National Key Torch Plan High-tech Enterprise, China Energy Equipment Top Ten Private Company, Innovative Company in Shanghai, and etc.

Figure 1 Jiangsu Rugao High Voltage Electric Apparatus Co., Ltd


# 3. SCOPE AND TYPE OF EPD

## 3.1 Scope of EPD

The entire life cycle stages of the product (type of EPD: « cradle-to-grave ») are considered in the LCA study, which include all stages from extraction of raw materials, manufacturing, transportation and installation, maintenance and end-of-life. Table 1 below shows the various stages that are included in this LCA study. The terms of defining life cycle stages from the core PCR, EN15804 and EN50693 are adopted and shown respectively.

*Table 1 Life Cycle Stages*

| Life cycle stages according to EPDItaly PCR | Life cycle stages according to EN50693 | - | Life cycle stages according to EN15804 | |
|---|---|---|---|---|
| **Upstream module** | Manufacturing Stage | X | A1 | Raw material supply |
| | | X | A2 | Transport (to the manufacturer) |
| **Core module** | | X | A3 | Manufacturing |
| **Downstream module** | Distribution Stage | X | A4 | Transport |
| | Installation Stage | X | A5 | Construction - installation |

| | | | | |
|---|---|---|---|---|
| | | | | process |
| | Use Stage | X | B1 | Use |
| | | MND | B2 | Maintenance |
| | | MND | B3 | Repair |
| | | MND | B4 | Replacement |
| | | MND | B5 | Refurbishment |
| | | MND | B6 | Operational energy use |
| | | MND | B7 | Operational water use |
| | De-installation Stage | X | C1 | De-construction and demolition |
| | End-of-life Stage | X | C2 | Transport (to waste processing) |
| | | X | C3 | Waste processing |
| | | X | C4 | Disposal |
| | Benefits and avoided loads beyond the product system boundary | X | D | reuse, recovery and/or recycling potentials |
| **Note: X=Declared Module, MND=Module not Declared in this LCA study** | | | | |

## 3.2 Type of EPD

This EPD is a product specific EPD. The declaration covers in total 6 series of Circuit Breakers type dead tank and HGIS, including LW58A-40.5, LW58A-72.5, LW58A-145 LW58A-252, ZHW58A-40.5 and ZF28A-145.

## 3.3 Geographical Validity

The circuit breakers that are analyzed within this study are manufactured in one factory located in Rugao, Jiangsu Province. The reference market is "global".

## 3.4 Database used

In this study, generic data for materials, energy as well as waste disposal and transportation were taken from the LCI-database Ecoinvent 3.4 with adaptation of regional energy and material data by Ecovane.

## 3.5 Software

For the modeling and calculation, the LCA-software SimaPro 9.2 was used.

## 3.6 Declared unit

The single circuit breaker is chosen as the declared unit (UD).

## 3.7 Exclusion from the system boundaries

The following steps/stages are not included in the system boundary due to the reason that the elements below are considered irrelevant or not within the boundary to the LCA study of circuit breaker products：

- Production and disposal of the infrastructure and capital equipment (buildings, machines, transport media, roads, etc.) during electric products manufacturing, installation, and maintenance.

- Auxiliary materials such as clean agents during the manufacturing process as the consumption is extremely low.
- Emissions during the installation and operation due to no obvious emission observable;
- Storage phases and sales of electric products due to no observable impact.
- Product losses due to abnormal damage such as natural disasters or fire accidents. These losses would mostly be accidental.
- The recycling process of defective products as it is reused internally for manufacturing process.
- Handling operations at the distribution center and retail outlet due to small contribution and negligible impact.
- The scrap and general waste during the installation stage due to no observable impact.

## 3.8 Cut-off

In accordance with the PSR EPDItaly012 and the PCR EPDItaly007, the cut-off criteria is followed as described below:

- All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented.
- According to PCR, data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts shall be included. Therefore, the cut-off criteria were set to 1% in this study.

## 3.9 Data quality and source

The present study was mainly based on primary data provided by the client. The primary data used in the study concerns the following information: material, weight, origin and way of transport for each component from upstream phase; energy and water consumption and waste produced in the core phase; energy dissipated in the use phase. Secondary data were modeled by using Ecoinvent 3.4 database.

The data quality requirements for this study were as follows:

- Existing LCI data were, at most, 10 years old. Newly collected LCI data were current orup to 3 years old;
- The LCI data related to the geographical locations where the processes took place, e.g.electricity and transportation data from China were utilized;
- The scenarios represented the average technologies at the time of data collection.

## 3.10 Allocations

Allocation refers to the partitioning of input or output flows of a process or a product system between the product systems under study and one or more other product systems. In this study, there are two types of allocation procedures considered:

**Allocation between co-products**

In the production of circuit breakers, the consumption of energy and water during manufacturing is equally allocated via production volume as all the products are produced in the same production line following the same procedure. No other by-products are produced from the same production line, hence there is no need to allocate the energy or water consumption with other products.

**Allocation for recovery operations**

For the allocation of reuse, recycling and recovery, the polluter pays principle (PPP) is followed in this report. This means that the waste transportation to the treatment site and the waste processing (mainly shredding) is considered in this report. While the benefit, the load from waste treatment for recycling purposes such as de-pollution and crushing, etc., is allocated to the next life cycle of substituted products, but not the primary producers. Thus, no burden or benefit will be allocated to the primary producer of the electric products (cut-off approach). The result of the reuse, recovery and/or recycling potentials are reported separately in module (D) of the downstream phase.

### 3.11 Time reference

All the data relating to the core phase, which is pertinent to the Rugao production site, is refer to the annal production from Jan. 2020 to Dec. 2020.

# 4. DETAILED PRODUCT DESCRIPTION

## 4.1 Description of the Product

Sieyuan Electric produces more than a dozen series of circuit breakers. Within this project, in total there are 6 series of circuit breakers that were analyzed, including LW58A-40.5, LW58A-72.5, LW58A-145 LW58A-252, ZHW58A-40.5 and ZF28A-145.

The circuit breakers produced by Jiangsu Rugao have a small volume and are safe and stable, free of maintenance. The product uses SF6 gas as the arc extinguishing and insulation medium, adopting the self-energy power arc extinguishing double-action-type interrupter structure technique. It is equipped with a new type of spring operating mechanism, with features of strong switching ability, less operating power, low noise and high reliability. The technical indicators of this circuit breaker have reached the advanced level of a similar product both internationally and domestically.

## 4.2 Technical Data

*Table 2 Technical Data*

| Circuit breakers | | Nominal voltage/kV | Nominal current/A | Number of poles of the switch, P | Nominal short-circuit breaking capacity, kA |
|---|---|---|---|---|---|
| Dead Tank | LW58A-40.5 | 40.5 | 2500 | 3 | 31.5 |
| | LW58A-72.5 | 72.5 | 4000 | 3 | 40 |
| | LW58A-145 | 145 | 3150 | 3 | 40 |
| | LW58A-252 | 252 | 4000 | 3 | 50 |
| HGIS | ZHW58A-40.5 | 40.5 | 2500 | 3 | 31.5 |
| | ZF28A-145 | 145 | 2500 | 3 | 40 |

## 4.3 Material Composition

*Table 3 Material Composition*

| Materials | Unit | LW58A-40.5 | LW58A-72.5 | LW58A-145 | LW58A-252 | ZHW58-40.5 | ZF28A-145 |
|---|---|---|---|---|---|---|---|
| Steel | kg | 633.01 | 1532.22 | 2080.19 | 3300.95 | 1995.30 | 2075.51 |
| Aluminum | kg | 399.87 | 629.62 | 685.69 | 1431.40 | 862.44 | 1024.39 |
| Stainless steel | kg | 141.51 | 89.92 | 111.59 | 414.32 | 212.139 | 143.72 |
| Copper | kg | 6.47 | 7.87 | 22.68 | 142.73 | 31.4 | 335.14 |
| Bushing | kg | 168.9 | 474 | 1110 | 1830 | 217.26 | 1110 |
| Plastic | kg | 13.50 | 59.20 | 546.62 | 180.20 | 32.1015 | 59.71 |
| Packaging board | kg | 500 | 700 | 590 | 1594 | 850 | 948 |
| SF6 | kg | 8 | 15 | 37 | 125 | 20 | 55 |
| **Total weight (packaging excluded)** | **kg** | **1363.26** | **2792.82** | **4556.76** | **7299.58** | **3350.63** | **4748.46** |

*Table 4 Compositions of 1kg bushing*

| Raw materials | Unit | value |
|---|---|---|
| Insulator | kg | 0.9208 |
| Flange | kg | 0.0536 |
| Cement | kg | 0.0244 |
| Silicone product | kg | 0.0012 |

## 4.4 System boundaries

The circuit breaker products under study includes 6 series models (see Table 2). All of them are manufactured following the same manufacturing processes.

The system boundary considered in this LCA study is from cradle to grave, with the exception of using phase. According to the PCR, the life cycle stages must refer to segmentation in the following three modules:

1. **Upstream module (Manufacturing stage)**

   The upstream includes the acquisition of raw materials, including waste recycling processes and the production of semi-finished and ancillary products(A1), and transportation of raw materials to the manufacturing company (A2).

2. **Core module (Manufacturing stage)**

   The core module describes all the activities that are managed directly by the client, whose established reference is located in Rugao city, Jiangsu province. The module includes the following activities: processing and assembly of the product constituents, the loading of the equipment with SF6 gas for equipment's necessary performance test, the disposal and treatment of waste generated during the production process and the final product packaging (A3).

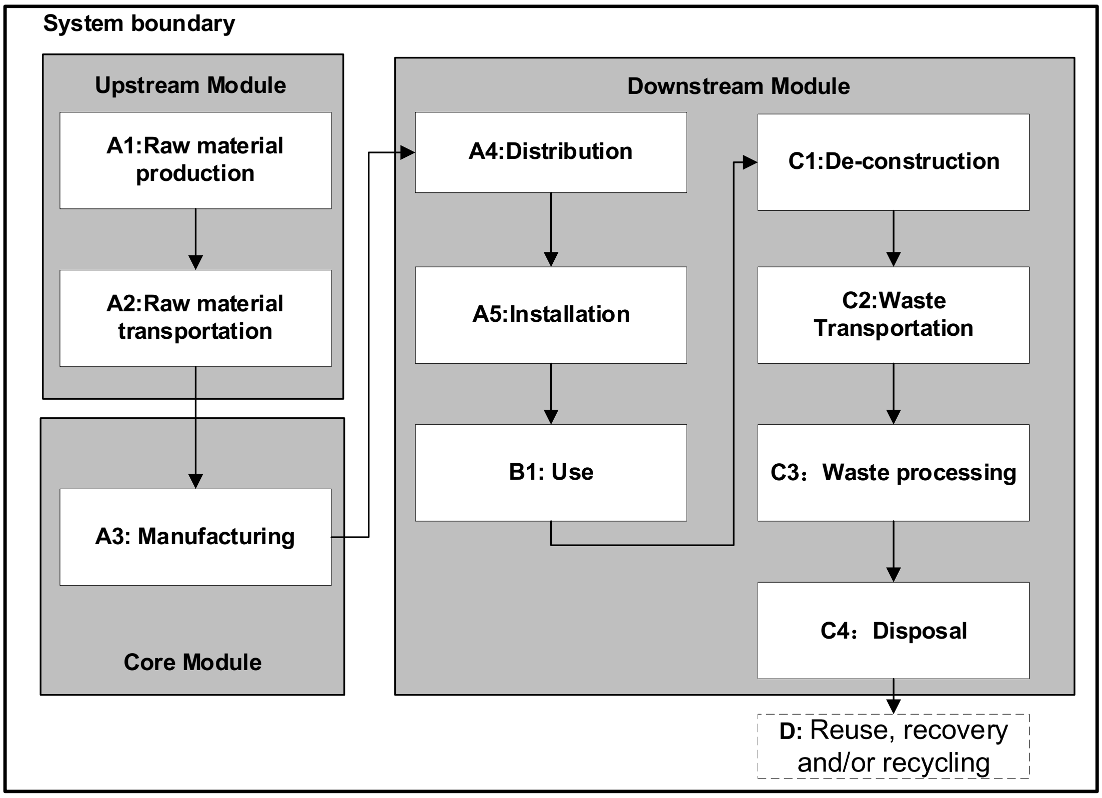
3. **Downstream module (Distribution, Installation, Use&Maintenance and End of Life)**

   The downstream module is divided into four phases: distribution stage (A4), installation stage (A5), Use & Maintenance stage (B1-B7) and End-of-life stage (C1-C4). The installation phase includes the on-site loading of the equipment with the SF6 gas, the end-of-life treatment of product packaging, as required by the PSR EPDItaly012. In the use phase, what is counted is the energy dissipated in the operation phase by the resistance of the main circuit. As for the recharge of SF6, according to the manufacturer, the circuit breakers are designed to be free of maintenance during its service life since they have a reliable sealing performance.

The end-of-life phase includes the energy consumption during the de-installation operation, in-situ SF6 gas removal, the transport of equipment from the operating site to the disassembly center, the operation of disassembly, the distribution of various of sub-constitutes to recycle, landfill and incineration center based on their material type. Regarding reuse, recovery and/or recycling potentials (D), the module D is declared separately following IEC/TR 62635-2012 specifications.

Figure 6 below illustrates the system boundaries for Jiangsu Rugao circuit breaker products, including raw material production and transportation, manufacturing, distribution, installation and End-of-life.

*Figure 1 System boundary*




## 4.5 Distribution

The distribution of circuit breakers is included in the study. The type of transportation and distance are collected and calculated from their real market share.

## 4.6 Installation

As for the installation, assuming the high-voltage power is 50kW, the installation will last for 1h, thus the total electricity consumption is 50kWh.

## 4.7 Use & Maintenance

The energy dissipated during the equipment operation by the circuit resistance was calculated by applying the formula indicated by PSR EPDItaly012. However, the referenced current specified in PCR is 50% of the nominal current, while according to Jiangsu Rugao, the real testing current normally is only 10% of the nominal current. Thus, in this study the reference current is calculated as 10% of the nominal current.

For the maintenance of the electric products, the Jiangsu Rugao high-voltage electric equipments are designed to be free of maintenance during its service life. The product is proclaimed to have a reliable sealing performance, thus requires no additional recharge of SF6 during its service life. Therefore, no inputs and outputs are taken place in maintenance stage in this study.

## 4.8 Reference Service Life

To ensure the comparability among EPDs of different products, a consistent reference service life shall be adopted to report the environmental impacts generated by the product during its life cycle. According to the PCR, the RSL for circuit breakers is defined as 20 years.

## 4.9 End-of-life

For the end-of-life stage, De-construction (C1) of the electric products during the end-of-life stage is assumed to use only electricity. 200km transportation distance from plant site to waste treatment site (C2) is assumed, and waste processing (C3) stage is modeled by using general processing data from Ecoinvent database. For the end-of-life disposal process (C4), the existing data of recycling rate and disposal rate for circuit breakers is missing. Thus, the IEC/TR 62635 guidelines is referred to for the C4 stage. The recycling rate for steel, stainless steel, aluminum, and copper is 95%. Following the end-of-life load and benefit allocation approach, the reuse, recovery and/or recycling potentials is separately declared in module D in this study. Therefore, 5% of the metal components will end up in the incineration treatment. As for the bushing, it is assumed that it will end up in landfill as it is inert material and the recycling of them has no obvious benefit. As for the waste paper and transformer oil, incineration without energy recovery is assumed in this study.

The end-of-life treatment of SF6 is modelled by referring to a literature, where the SF6 is firstly removed by a vacuum pump with a leakage of 3%, then it is purified through a membrane separation process with 0.25% of leakage. And finally the purified gas is decomposed by a low-temperature plasma. The leakage and energy consumption of each process is considered in the study.

# 5. LCA RESULTS

This LCA follows the requirements of PCR EPDItaly012: Electronic and electrical products and systems – Switches and uses the recommended impact analysis method for the calculation. Environmental impact indicators follow the characterization factors as stated in EN 15804:2012+A2:2019.

*Table 5. LCA Results- Environmental impacts for circuit breaker LW58A-40.5*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| GWP, t | kg CO2 eq | 1.70E+04 | 1.43E+02 | 1.60E+02 | 2.43E+02 | 4.16E+01 | 7.45E+03 | 4.16E+01 | 4.63E+01 | 7.89E+01 | 9.42E+03 | -3.67E+03 |
| GWP, f | kg CO2 eq | 1.74E+04 | 1.43E+02 | 1.61E+02 | 2.43E+02 | 4.19E+01 | 7.45E+03 | 4.19E+01 | 4.63E+01 | 8.00E+01 | 9.42E+03 | -3.68E+03 |
| GWP, b | kg CO2 eq | -4.06E+02 | -1.93E-01 | -1.19E+00 | -3.30E-01 | -3.33E-01 | -6.20E+00 | -3.33E-01 | -6.09E-02 | -1.11E+00 | -2.01E-02 | 1.24E+01 |
| GWP, luluc | kg CO2 eq | 3.98E+00 | 3.26E-02 | 2.15E-03 | 4.38E-02 | 8.78E-04 | 9.76E-03 | 8.78E-04 | 8.37E-03 | 4.40E-03 | 1.20E-01 | -3.88E-01 |
| ODP | kg CFC-11 eq | 3.55E-04 | 2.48E-05 | 2.34E-06 | 4.22E-05 | 2.02E-07 | 2.44E-06 | 2.02E-07 | 8.23E-06 | 1.36E-06 | 3.02E-06 | -1.99E-04 |
| AP | mole H+ eq | 1.30E+02 | 7.23E-01 | 8.66E-01 | 1.81E+00 | 2.85E-01 | 5.21E+00 | 2.85E-01 | 2.40E-01 | 5.17E-01 | 1.31E-01 | -2.71E+01 |
| EP-freshwater | kg P eq | 2.68E+00 | 7.65E-03 | 1.79E-02 | 1.08E-02 | 5.77E-03 | 9.11E-02 | 5.77E-03 | 2.10E-03 | 1.48E-02 | 6.85E-03 | -3.56E+00 |
| POCP | kg NMVOC eq | 7.24E+01 | 7.18E-01 | 3.84E-01 | 1.54E+00 | 1.40E-01 | 2.59E+00 | 1.40E-01 | 2.45E-01 | 2.42E-01 | 6.95E-02 | -1.35E+01 |
| ADPE | kg Sb eq | 1.25E+00 | 1.17E-02 | 4.72E-04 | 1.36E-02 | 3.57E-04 | 2.89E-03 | 3.57E-04 | 2.92E-03 | 5.74E-03 | 5.36E-02 | -1.54E-01 |
| ADPF | MJ | 1.42E+05 | 2.06E+03 | 1.41E+03 | 3.51E+03 | 3.16E+02 | 5.85E+03 | 3.16E+02 | 6.78E+02 | 6.44E+02 | 2.14E+02 | -2.68E+04 |
| WDP | m3 water eq | 2.83E+05 | 1.13E+01 | 6.72E+00 | 1.90E+01 | 1.69E+00 | 3.00E+01 | 1.69E+00 | 3.71E+00 | 4.28E+00 | 8.33E+00 | -4.78E+02 |

*Table 6. LCA Results- Environmental impacts for circuit breaker LW58A-72.5*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| GWP, t | kg CO2 eq | 2.93E+04 | 6.87E+02 | 3.28E+02 | 4.97E+02 | 4.16E+01 | 1.45E+04 | 4.16E+01 | 9.48E+01 | 1.62E+02 | 1.77E+04 | -6.48E+03 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GWP, f | kg CO2 eq | 2.99E+04 | 6.88E+02 | 3.30E+02 | 4.98E+02 | 4.19E+01 | 1.45E+04 | 4.19E+01 | 9.49E+01 | 1.64E+02 | 1.77E+04 | -6.50E+03 |
| GWP, b | kg CO2 eq | -5.73E+02 | -9.58E-01 | -2.44E+00 | -6.76E-01 | -3.33E-01 | -1.59E+01 | -3.33E-01 | -1.25E-01 | -2.27E+00 | -4.86E-02 | 2.24E+01 |
| GWP, luluc | kg CO2 eq | 1.22E+01 | 1.84E-01 | 4.40E-03 | 8.97E-02 | 8.78E-04 | 2.50E-02 | 8.78E-04 | 1.71E-02 | 9.01E-03 | 2.56E-01 | -6.44E-01 |
| ODP | kg CFC-11 eq | 6.34E-04 | 1.17E-04 | 4.79E-06 | 8.65E-05 | 2.02E-07 | 6.26E-06 | 2.02E-07 | 1.69E-05 | 2.78E-06 | 6.57E-06 | -3.41E-04 |
| AP | mole H+ eq | 2.16E+02 | 3.44E+00 | 1.77E+00 | 3.71E+00 | 2.85E-01 | 1.33E+01 | 2.85E-01 | 4.91E-01 | 1.06E+00 | 2.56E-01 | -4.57E+01 |
| EP-freshwater | kg P eq | 4.94E+00 | 4.17E-02 | 3.67E-02 | 2.22E-02 | 5.77E-03 | 2.33E-01 | 5.77E-03 | 4.30E-03 | 3.02E-02 | 1.20E-02 | -6.34E+00 |
| POCP | kg NMVOC eq | 1.23E+02 | 3.34E+00 | 7.86E-01 | 3.16E+00 | 1.40E-01 | 6.62E+00 | 1.40E-01 | 5.03E-01 | 4.97E-01 | 1.47E-01 | -2.43E+01 |
| ADPE | kg Sb eq | 2.24E+00 | 6.68E-02 | 9.66E-04 | 2.79E-02 | 3.57E-04 | 7.39E-03 | 3.57E-04 | 5.99E-03 | 1.18E-02 | 8.48E-02 | -2.48E-01 |
| ADPF | MJ | 2.47E+05 | 9.83E+03 | 2.88E+03 | 7.19E+03 | 3.16E+02 | 1.50E+04 | 3.16E+02 | 1.39E+03 | 1.32E+03 | 4.51E+02 | -4.96E+04 |
| WDP | m3 water eq | 4.47E+05 | 5.36E+01 | 1.38E+01 | 3.89E+01 | 1.69E+00 | 7.69E+01 | 1.69E+00 | 7.60E+00 | 8.78E+00 | 1.67E+01 | -8.10E+02 |

*Table 7. LCA Results- Environmental impacts for circuit breaker LW58A-145*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| GWP, t | kg CO2 eq | 4.14E+04 | 1.56E+03 | 5.34E+02 | 8.11E+02 | 4.16E+01 | 3.20E+04 | 4.16E+01 | 1.55E+02 | 2.64E+02 | 4.37E+04 | -8.65E+03 |
| GWP, f | kg CO2 eq | 4.18E+04 | 1.56E+03 | 5.38E+02 | 8.12E+02 | 4.19E+01 | 3.20E+04 | 4.19E+01 | 1.55E+02 | 2.67E+02 | 4.37E+04 | -8.67E+03 |
| GWP, b | kg CO2 eq | -5.30E+02 | -2.17E+00 | -3.99E+00 | -1.10E+00 | -3.33E-01 | -8.73E+00 | -3.33E-01 | -2.03E-01 | -3.71E+00 | -2.19E-01 | 2.26E+01 |
| GWP, luluc | kg CO2 eq | 8.67E+01 | 4.16E-01 | 7.18E-03 | 1.46E-01 | 8.78E-04 | 1.37E-02 | 8.78E-04 | 2.80E-02 | 1.47E-02 | 3.34E-01 | -7.52E-01 |
| ODP | kg CFC-11 eq | 1.14E-03 | 2.66E-04 | 7.82E-06 | 1.41E-04 | 2.02E-07 | 3.44E-06 | 2.02E-07 | 2.75E-05 | 4.54E-06 | 1.00E-05 | -4.06E-04 |
| AP | mole H+ eq | 2.86E+02 | 7.80E+00 | 2.89E+00 | 6.05E+00 | 2.85E-01 | 7.33E+00 | 2.85E-01 | 8.01E-01 | 1.73E+00 | 5.16E-01 | -5.62E+01 |
| EP-freshwater | kg P eq | 8.22E+00 | 9.42E-02 | 5.99E-02 | 3.63E-02 | 5.77E-03 | 1.28E-01 | 5.77E-03 | 7.01E-03 | 4.93E-02 | 2.07E-02 | -8.00E+00 |
| POCP | kg NMVOC eq | 1.68E+02 | 7.59E+00 | 1.28E+00 | 5.16E+00 | 1.40E-01 | 3.64E+00 | 1.40E-01 | 8.20E-01 | 8.10E-01 | 3.33E-01 | -3.29E+01 |
| ADPE | kg Sb eq | 3.68E+00 | 1.51E-01 | 1.58E-03 | 4.56E-02 | 3.57E-04 | 4.06E-03 | 3.57E-04 | 9.77E-03 | 1.92E-02 | 9.32E-02 | -2.87E-01 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADPF | MJ | 3.50E+05 | 2.23E+04 | 4.70E+03 | 1.17E+04 | 3.16E+02 | 8.23E+03 | 3.16E+02 | 2.27E+03 | 2.15E+03 | 8.37E+02 | -8.87E+04 |
| WDP | m3 water eq | 4.90E+05 | 1.22E+02 | 2.25E+01 | 6.34E+01 | 1.69E+00 | 4.23E+01 | 1.69E+00 | 1.24E+01 | 1.43E+01 | 2.98E+01 | -1.38E+03 |

*Table 8. LCA Results- Environmental impacts for circuit breaker LW58A-252*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| GWP, t | kg CO2 eq | 8.52E+04 | 2.69E+03 | 8.56E+02 | 1.30E+03 | 4.16E+01 | 1.06E+05 | 4.16E+01 | 2.48E+02 | 4.23E+02 | 1.47E+05 | -1.48E+04 |
| GWP, f | kg CO2 eq | 8.66E+04 | 2.70E+03 | 8.63E+02 | 1.30E+03 | 4.19E+01 | 1.06E+05 | 4.19E+01 | 2.48E+02 | 4.28E+02 | 1.47E+05 | -1.49E+04 |
| GWP, b | kg CO2 eq | -1.35E+03 | -3.75E+00 | -6.39E+00 | -1.77E+00 | -3.33E-01 | -9.68E+00 | -3.33E-01 | -3.26E-01 | -5.94E+00 | -7.90E-01 | 5.05E+01 |
| GWP, luluc | kg CO2 eq | 4.09E+01 | 7.22E-01 | 1.15E-02 | 2.34E-01 | 8.78E-04 | 1.52E-02 | 8.78E-04 | 4.48E-02 | 2.35E-02 | 5.75E-01 | -1.47E+00 |
| ODP | kg CFC-11 eq | 2.65E-03 | 4.59E-04 | 1.25E-05 | 2.26E-04 | 2.02E-07 | 3.82E-06 | 2.02E-07 | 4.41E-05 | 7.28E-06 | 1.72E-05 | -7.74E-04 |
| AP | mole H+ eq | 6.03E+02 | 1.35E+01 | 4.64E+00 | 9.69E+00 | 2.85E-01 | 8.13E+00 | 2.85E-01 | 1.28E+00 | 2.77E+00 | 1.25E+00 | -1.04E+02 |
| EP-freshwater | kg P eq | 2.43E+01 | 1.63E-01 | 9.60E-02 | 5.81E-02 | 5.77E-03 | 1.42E-01 | 5.77E-03 | 1.12E-02 | 7.90E-02 | 5.91E-02 | -1.45E+01 |
| POCP | kg NMVOC eq | 3.19E+02 | 1.31E+01 | 2.05E+00 | 8.27E+00 | 1.40E-01 | 4.04E+00 | 1.40E-01 | 1.31E+00 | 1.30E+00 | 6.97E-01 | -5.57E+01 |
| ADPE | kg Sb eq | 8.33E+00 | 2.62E-01 | 2.53E-03 | 7.30E-02 | 3.57E-04 | 4.51E-03 | 3.57E-04 | 1.57E-02 | 3.08E-02 | 1.95E-01 | -5.64E-01 |
| ADPF | MJ | 6.51E+05 | 3.85E+04 | 7.53E+03 | 1.88E+04 | 3.16E+02 | 9.13E+03 | 3.16E+02 | 3.63E+03 | 3.45E+03 | 1.84E+03 | -1.16E+05 |
| WDP | m3 water eq | 1.02E+06 | 2.10E+02 | 3.60E+01 | 1.02E+02 | 1.69E+00 | 4.69E+01 | 1.69E+00 | 1.99E+01 | 2.29E+01 | 5.05E+01 | -1.89E+03 |

*Table 9. LCA Results- Environmental impacts for circuit breaker ZHW58-40.5*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GWP, t | kg CO2 eq | 3.86E+04 | 8.34E+02 | 3.93E+02 | 5.97E+02 | 4.16E+01 | 1.77E+04 | 4.16E+01 | 1.14E+02 | 1.94E+02 | 2.35E+04 | -8.74E+03 |
| GWP, f | kg CO2 eq | 3.92E+04 | 8.35E+02 | 3.96E+02 | 5.97E+02 | 4.19E+01 | 1.77E+04 | 4.19E+01 | 1.14E+02 | 1.97E+02 | 2.35E+04 | -8.77E+03 |
| GWP, b | kg CO2 eq | -6.94E+02 | -1.17E+00 | -2.93E+00 | -8.12E-01 | -3.33E-01 | -8.06E+00 | -3.33E-01 | -1.50E-01 | -2.73E+00 | -4.16E-02 | 3.10E+01 |
| GWP, luluc | kg CO2 eq | 9.45E+00 | 2.26E-01 | 5.28E-03 | 1.08E-01 | 8.78E-04 | 1.27E-02 | 8.78E-04 | 2.06E-02 | 1.08E-02 | 3.39E-01 | -8.80E-01 |
| ODP | kg CFC-11 eq | 9.31E-04 | 1.42E-04 | 5.75E-06 | 1.04E-04 | 2.02E-07 | 3.18E-06 | 2.02E-07 | 2.02E-05 | 3.34E-06 | 7.65E-06 | -4.65E-04 |
| AP | mole H+ eq | 2.94E+02 | 4.17E+00 | 2.13E+00 | 4.45E+00 | 2.85E-01 | 6.77E+00 | 2.85E-01 | 5.89E-01 | 1.27E+00 | 3.08E-01 | -6.21E+01 |
| EP-freshwater | kg P eq | 8.55E+00 | 5.10E-02 | 4.41E-02 | 2.67E-02 | 5.77E-03 | 1.18E-01 | 5.77E-03 | 5.15E-03 | 3.63E-02 | 1.82E-02 | -8.62E+00 |
| POCP | kg NMVOC eq | 1.61E+02 | 4.05E+00 | 9.43E-01 | 3.79E+00 | 1.40E-01 | 3.36E+00 | 1.40E-01 | 6.03E-01 | 5.96E-01 | 1.54E-01 | -3.28E+01 |
| ADPE | kg Sb eq | 2.84E+00 | 8.21E-02 | 1.16E-03 | 3.35E-02 | 3.57E-04 | 3.75E-03 | 3.57E-04 | 7.19E-03 | 1.41E-02 | 1.16E-01 | -3.38E-01 |
| ADPF | MJ | 3.13E+05 | 1.19E+04 | 3.46E+03 | 8.62E+03 | 3.16E+02 | 7.60E+03 | 3.16E+02 | 1.67E+03 | 1.58E+03 | 5.03E+02 | -6.48E+04 |
| WDP | m3 water eq | 6.11E+05 | 6.50E+01 | 1.65E+01 | 4.66E+01 | 1.69E+00 | 3.90E+01 | 1.69E+00 | 9.11E+00 | 1.05E+01 | 1.77E+01 | -1.06E+03 |

*Table 10. LCA Results- Environmental impacts for circuit breaker ZF28A-145*

| Environmental Impacts | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| GWP, t | kg CO2 eq | 5.55E+04 | 1.44E+03 | 5.57E+02 | 8.45E+02 | 4.16E+01 | 4.70E+04 | 4.16E+01 | 1.61E+02 | 2.75E+02 | 6.47E+04 | -9.67E+03 |
| GWP, f | kg CO2 eq | 5.63E+04 | 1.44E+03 | 5.61E+02 | 8.46E+02 | 4.19E+01 | 4.70E+04 | 4.19E+01 | 1.61E+02 | 2.79E+02 | 6.47E+04 | -9.71E+03 |
| GWP, b | kg CO2 eq | -8.56E+02 | -2.00E+00 | -4.16E+00 | -1.15E+00 | -3.33E-01 | -8.69E+00 | -3.33E-01 | -2.12E-01 | -3.86E+00 | -3.21E-01 | 3.33E+01 |
| GWP, luluc | kg CO2 eq | 2.77E+01 | 3.83E-01 | 7.48E-03 | 1.52E-01 | 8.78E-04 | 1.37E-02 | 8.78E-04 | 2.91E-02 | 1.53E-02 | 3.97E-01 | -1.01E+00 |
| ODP | kg CFC-11 eq | 3.56E-03 | 2.45E-04 | 8.14E-06 | 1.47E-04 | 2.02E-07 | 3.43E-06 | 2.02E-07 | 2.87E-05 | 4.74E-06 | 1.15E-05 | -5.19E-04 |
| AP | mole H+ eq | 5.36E+02 | 7.19E+00 | 3.02E+00 | 6.30E+00 | 2.85E-01 | 7.30E+00 | 2.85E-01 | 8.35E-01 | 1.80E+00 | 7.44E-01 | -7.09E+01 |
| EP-freshwater | kg P eq | 3.96E+01 | 8.67E-02 | 6.24E-02 | 3.78E-02 | 5.77E-03 | 1.28E-01 | 5.77E-03 | 7.30E-03 | 5.14E-02 | 7.30E-02 | -9.51E+00 |
| POCP | kg NMVOC eq | 2.37E+02 | 6.99E+00 | 1.34E+00 | 5.38E+00 | 1.40E-01 | 3.62E+00 | 1.40E-01 | 8.55E-01 | 8.44E-01 | 4.06E-01 | -3.62E+01 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADPE | kg Sb eq | 7.82E+00 | 1.39E-01 | 1.64E-03 | 4.75E-02 | 3.57E-04 | 4.05E-03 | 3.57E-04 | 1.02E-02 | 2.00E-02 | 1.40E-01 | -3.95E-01 |
| ADPF | MJ | 4.63E+05 | 2.05E+04 | 4.90E+03 | 1.22E+04 | 3.16E+02 | 8.20E+03 | 3.16E+02 | 2.36E+03 | 2.24E+03 | 1.08E+03 | -7.26E+04 |
| WDP | m3 water eq | 7.30E+05 | 1.12E+02 | 2.34E+01 | 6.61E+01 | 1.69E+00 | 4.21E+01 | 1.69E+00 | 1.29E+01 | 1.49E+01 | 3.32E+01 | -1.25E+03 |

The LCIA results of the primary renewable / non-renewable energy demand, and waste / hazardous waste, water consumption as well as outflows for all circuit breakers are depicted in tables below

*Table 11 LCA Results – Resource use and waste production of LW58A-40.5*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 2.04E+05 | 2.06E+03 | 1.93E+03 | 3.50E+03 | 5.22E+02 | 9.69E+03 | 5.22E+02 | 6.73E+02 | 9.50E+02 | 2.17E+02 | -3.60E+04 |
| PERE | MJ | 1.49E+04 | 2.71E+01 | 1.01E+02 | 4.72E+01 | 6.47E+01 | 1.20E+03 | 6.47E+01 | 8.29E+00 | 1.13E+02 | 2.77E+01 | -9.20E+02 |
| PENRM | MJ | 2.15E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 2.25E+05 | 2.06E+03 | 1.93E+03 | 3.50E+03 | 5.22E+02 | 9.69E+03 | 5.22E+02 | 6.73E+02 | 9.50E+02 | 2.17E+02 | -3.60E+04 |
| PERT | MJ | 1.49E+04 | 2.71E+01 | 1.01E+02 | 4.72E+01 | 6.47E+01 | 1.20E+03 | 6.47E+01 | 8.29E+00 | 1.13E+02 | 2.77E+01 | -9.20E+02 |
| FW | m3 | 3.01E+04 | 1.21E+01 | 4.62E+00 | 1.80E+01 | 3.32E+00 | 4.99E+01 | 3.32E+00 | 3.48E+00 | 1.05E+01 | 5.08E+00 | -2.95E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 6.94E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 3.53E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.29E+02 | 0.00E+00 |
| RWD | kg | 1.73E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.13E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Table 12 LCA Results – Resource use and waste production of LW58A-72.5*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 3.49E+05 | 9.84E+03 | 3.96E+03 | 7.17E+03 | 5.22E+02 | 2.48E+04 | 5.22E+02 | 1.38E+03 | 1.95E+03 | 4.42E+02 | -6.65E+04 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERE | MJ | 2.29E+04 | 1.38E+02 | 2.07E+02 | 9.66E+01 | 6.47E+01 | 3.07E+03 | 6.47E+01 | 1.70E+01 | 2.31E+02 | 5.45E+01 | -1.53E+03 |
| PENRM | MJ | 3.90E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 3.88E+05 | 9.84E+03 | 3.96E+03 | 7.17E+03 | 5.22E+02 | 2.48E+04 | 5.22E+02 | 1.38E+03 | 1.95E+03 | 4.42E+02 | -6.65E+04 |
| PERT | MJ | 2.29E+04 | 1.38E+02 | 2.07E+02 | 9.66E+01 | 6.47E+01 | 3.07E+03 | 6.47E+01 | 1.70E+01 | 2.31E+02 | 5.45E+01 | -1.53E+03 |
| FW | m3 | 3.94E+04 | 6.39E+01 | 9.47E+00 | 3.68E+01 | 3.32E+00 | 1.28E+02 | 3.32E+00 | 7.13E+00 | 2.15E+01 | 9.84E+00 | -5.27E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 1.09E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 5.56E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.93E+02 | 0.00E+00 |
| RWD | kg | 2.72E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.20E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Table 13 LCA Results – Resource use and waste production of LW58A-145*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 4.69E+05 | 2.23E+04 | 6.45E+03 | 1.17E+04 | 5.22E+02 | 1.36E+04 | 5.22E+02 | 2.25E+03 | 3.18E+03 | 9.01E+02 | -1.08E+05 |
| PERE | MJ | 2.90E+04 | 3.12E+02 | 3.38E+02 | 1.58E+02 | 6.47E+01 | 1.69E+03 | 6.47E+01 | 2.77E+01 | 3.76E+02 | 9.79E+01 | -2.04E+03 |
| PENRM | MJ | 6.47E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 5.33E+05 | 2.23E+04 | 6.45E+03 | 1.17E+04 | 5.22E+02 | 1.36E+04 | 5.22E+02 | 2.25E+03 | 3.18E+03 | 9.01E+02 | -1.08E+05 |
| PERT | MJ | 2.90E+04 | 3.12E+02 | 3.38E+02 | 1.58E+02 | 6.47E+01 | 1.69E+03 | 6.47E+01 | 2.77E+01 | 3.76E+02 | 9.79E+01 | -2.04E+03 |
| FW | m3 | 5.13E+04 | 1.45E+02 | 1.55E+01 | 6.01E+01 | 3.32E+00 | 7.03E+01 | 3.32E+00 | 1.16E+01 | 3.50E+01 | 1.69E+01 | -6.95E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 1.19E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 6.06E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.31E+03 | 0.00E+00 |
| RWD | kg | 2.96E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.25E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Table 14 LCA Results – Resource use and waste production of LW58A-252*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 8.86E+05 | 3.86E+04 | 1.03E+04 | 1.87E+04 | 5.22E+02 | 1.51E+04 | 5.22E+02 | 3.60E+03 | 5.09E+03 | 2.23E+03 | -1.54E+05 |
| PERE | MJ | 6.11E+04 | 5.40E+02 | 5.42E+02 | 2.53E+02 | 6.47E+01 | 1.87E+03 | 6.47E+01 | 4.44E+01 | 6.03E+02 | 2.57E+02 | -3.50E+03 |
| PENRM | MJ | 1.11E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 9.97E+05 | 3.86E+04 | 1.03E+04 | 1.87E+04 | 5.22E+02 | 1.51E+04 | 5.22E+02 | 3.60E+03 | 5.09E+03 | 2.23E+03 | -1.54E+05 |
| PERT | MJ | 6.11E+04 | 5.40E+02 | 5.42E+02 | 2.53E+02 | 6.47E+01 | 1.87E+03 | 6.47E+01 | 4.44E+01 | 6.03E+02 | 2.57E+02 | -3.50E+03 |
| FW | m3 | 1.19E+05 | 2.50E+02 | 2.48E+01 | 9.62E+01 | 3.32E+00 | 7.80E+01 | 3.32E+00 | 1.86E+01 | 5.61E+01 | 3.58E+01 | -1.21E+03 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 2.48E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 1.26E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.11E+03 | 0.00E+00 |
| RWD | kg | 6.18E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.19E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Table 15 LCA Results – Resource use and waste production of ZHW58A-40.5*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 4.53E+05 | 1.19E+04 | 4.75E+03 | 8.60E+03 | 5.22E+02 | 1.26E+04 | 5.22E+02 | 1.65E+03 | 2.34E+03 | 4.93E+02 | -8.80E+04 |
| PERE | MJ | 3.03E+04 | 1.68E+02 | 2.49E+02 | 1.16E+02 | 6.47E+01 | 1.56E+03 | 6.47E+01 | 2.04E+01 | 2.77E+02 | 7.04E+01 | -2.06E+03 |
| PENRM | MJ | 4.57E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 4.99E+05 | 1.19E+04 | 4.75E+03 | 8.60E+03 | 5.22E+02 | 1.26E+04 | 5.22E+02 | 1.65E+03 | 2.34E+03 | 4.93E+02 | -8.80E+04 |
| PERT | MJ | 3.03E+04 | 1.68E+02 | 2.49E+02 | 1.16E+02 | 6.47E+01 | 1.56E+03 | 6.47E+01 | 2.04E+01 | 2.77E+02 | 7.04E+01 | -2.06E+03 |
| FW | m3 | 6.35E+04 | 7.80E+01 | 1.14E+01 | 4.42E+01 | 3.32E+00 | 6.49E+01 | 3.32E+00 | 8.55E+00 | 2.58E+01 | 1.23E+01 | -7.13E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 1.50E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 7.62E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.76E+02 | 0.00E+00 |
| RWD | kg | 3.72E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.98E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Table 16 LCA Results – Resource use and waste production of ZF28A-145*

| Resource use/waste production | Unit | Manufacturing | | | Distribution | Installation | Use & Maintenance | End-of-life (including de-installation) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upstream | | Core | Downstream | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | B1 | C1 | C2 | C3 | C4 | D |
| PENRE | MJ | 6.18E+05 | 2.06E+04 | 6.73E+03 | 1.22E+04 | 5.22E+02 | 1.36E+04 | 5.22E+02 | 2.34E+03 | 3.31E+03 | 1.24E+03 | -9.75E+04 |
| PERE | MJ | 4.24E+04 | 2.87E+02 | 3.52E+02 | 1.64E+02 | 6.47E+01 | 1.68E+03 | 6.47E+01 | 2.89E+01 | 3.92E+02 | 1.43E+02 | -2.37E+03 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PENRM | MJ | 7.98E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 6.98E+05 | 2.06E+04 | 6.73E+03 | 1.22E+04 | 5.22E+02 | 1.36E+04 | 5.22E+02 | 2.34E+03 | 3.31E+03 | 1.24E+03 | -9.75E+04 |
| PERT | MJ | 4.24E+04 | 2.87E+02 | 3.52E+02 | 1.64E+02 | 6.47E+01 | 1.68E+03 | 6.47E+01 | 2.89E+01 | 3.92E+02 | 1.43E+02 | -2.37E+03 |
| FW | m3 | 8.16E+04 | 1.33E+02 | 1.61E+01 | 6.26E+01 | 3.32E+00 | 7.00E+01 | 3.32E+00 | 1.21E+01 | 3.65E+01 | 3.04E+01 | -7.88E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 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 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HWD | kg | 1.78E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NHWD | kg | 9.05E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.29E+03 | 0.00E+00 |
| RWD | kg | 4.42E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MRF | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.45E+03 | 0.00E+00 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ETE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EEE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

**Caption:**

1E+01 is equal to 1 x 101

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)

FW: Net use of fresh water

SM: Use of secondary raw materials

RSF: Use of renewable secondary fuels

NRSF: Use of non-renewable secondary fuels

HWD: Hazardous landfill waste

NHWD: Non-hazardous waste disposed

RWD: Radioactive waste disposed

MER: Materials for energy recovery

MRF: Materials for energy recovery

CRU: Components for reuse

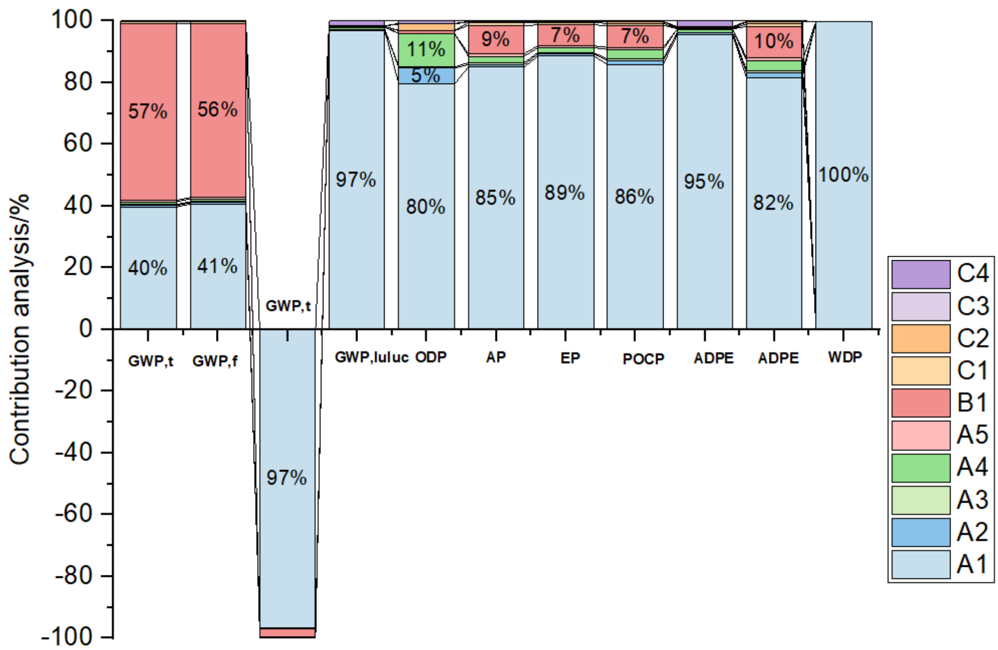
ETE: Exported thermal energy

EEE: Exported electricity energy

# 6. Interpretation of the results

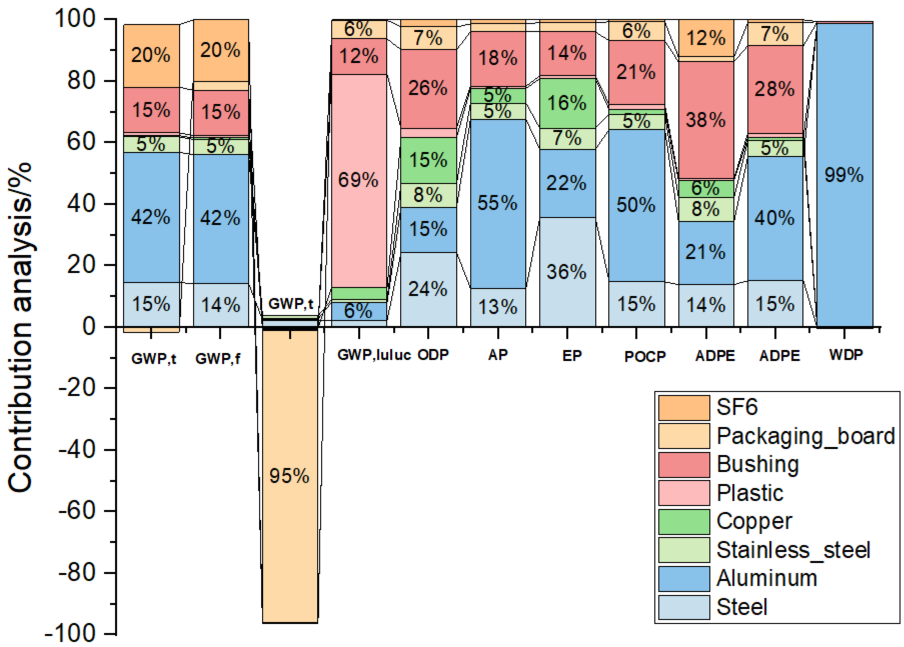
To analyze the contribution of processes to the environmental impact, an LCIA was conducted by using EN 15804 method. Since all the circuit breakers share similar components, an example of circuit breaker is chosen for the contribution analysis.

*Figure 2 Process contribution analysis*




From the contribution analysis, it can be concluded that raw material production stage (A1) from the upstream phase has the largest impact, followed by Use stage (B1) from the downstream phase.

Figure 3 Life cycle stage (A1) contribution analysis



When considering the raw materials' environmental impacts of circuit breaker, it can be seen that aluminum has the largest impact on Climate change – Total, Climate change – Fossil, Acidification (AP), and Photochemical oxidant formation potential (POCP), who represent 42%, 42%, 55% and 50%, respectively. Besides, the water resource depletion represents 99% of the total impact. As shown in Figure 12, plastic has the largest impact on Climate change - Land use and land use change, which is 69%. For Climate change – Biogenic, the largest impact is sourced from the consumption of packaging board, which is 95%.

In summary, the main environmental impact of the whole life cycle stages comes from the stage of raw materials production(A1) of upstream phase and the use stage (B1) from downstream phase. In terms of the raw materials production stage, aluminum and bushing are the two major impact components for circuit breaker.

# 7 References


### EPDItaly

Regulations of the EPDItaly Programme, version 5.0

EPDItaly PCR EPDItaly012 Electronic and Electrical Products and Systems - Switches; rev. 0 of 16/03/2020;

EPDItaly PCR EPDItaly007 Electronic and Electrical Products and Systems; rev. 2 of 21/10/2020;0;

### SUSTAINABILITY REPORTING STANDARDS

European Standards. (2019). EN 15804:2012+A2:2019 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.

European Standards. (2019). EN 50693:2019 Product category rules for life cycle assessments of electronic and electrical products and systems

ISO. (2006). ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines.

ISO. (2009). ISO 14040: Environmental management - Life cycle assessment - principles and frameworks.

ISO. (2011). ISO 14025: Environmental labels and declarations - Type III environmental declarations - principles and procedures.

IEC/TR 62635: Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment

### LCA report

LCA for Jiangsu Rugao circuit breaker and disconnect switch Dec2021(report number: PJ-SIEYUANRG-21001), by Ecovane Environmental Co., Ltd, December 2021

# 8 Contact Information

EPD Owner

**Jiangsu Rugao High Voltage Electric Apparatus Co., Ltd**

Mr. Hang Fei (hf.13480@sieyuan.com)

Website: http://www.sieyuan.com

LCA and EPD Practitioner

**Ecovane Environmental Co., Ltd**

Ms. Lin Zhao (zhaolin@1mi1.cn)

Website：www.1mi1.org