COL GROUP COL GIOVANNI PAOLO S.p.A.

EPD ITALY

# ENVIRONMENTAL PRODUCT DECLARATION

**PRODUCT NAME:**

1. RIO UP 1 Channel Indoor
2. RIO UP 1 Channel Outdoor
3. RIO UP 4 Channels

**PRODUCTION SITE:**

Via Pindaro, 19,
20128 Milano (MI)

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

| | |
|---|---|
| Program operator | EPDItaly |
| Publisher | EPDItaly |

| | |
|---|---|
| Declaration number | COL-TW-RIOUP14 |
| Registration number | EPDITALY0827 |

| | |
|---|---|
| Issue date | 13/12/2024 |
| Valid to | 13/12/2029 |


# 1. GENERAL INFORMATION

| | |
|---|---|
| **EPD owner** | Col Giovanni Paolo S.p.A. (www.colgp.it)<br>Via Antonio Chiribiri, 1, 10028 Trofarello (TO) |
| **Reference production site** | TW-TeamWare SRL (www.teamware.it)<br>Via Pindaro, 19, 20128 Milano (MI) |
| **Scope of application** | This is a product-specific EPD referring to the RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels devices designed as per Enel group technical specification code: MAT-NT&I-SGD-2021-0030-EGIN Version no.01 dated 24/03/2021 under the GSTR004 product family, manufactured by TW-TeamWare SRL, for use as remote input/output (RIO) devices for interfacing with physical and existing power components, within the geographical scope of the Italian territory in the reference year 2021. |
| **Programme operator** | EPDItaly – info@epditaly.it<br>Via Gaetano De Castillia, 10, 20124 Milano (MI) |
| **Independent verification** | This declaration has been developed in accordance with the regulations of EPDItaly; further information and the same regulations are available at: www.epditaly.it<br>Independent verification of the declaration and data carried out in accordance with ISO 14025: 2010<br>☐ Internal ☑ External<br>Third party verification done by: ICMQ S.p.A. (www.icmq.it), Via Gaetano De Castillia, 10, 20124 Milano (MI) – Italia. Accredited by ACCREDIA, Accreditation number 0004VV REV. 000 |
| **CPC code** | 4621 “Electricity distribution or control apparatus” |
| **Company contact** | Massimo BURATTO, Remote control B.U manager<br>e-mail: massimo.buratto@teamware.it |
| **Technical support** | Emmanuel NYERO, Environmental Specialist, TW-TeamWare SRL<br>e-mail: emmanuel.nyero@teamware.it |
| **PCR – Product Category Rules** | Core PCR: EPDItaly007 – PCR for Electronic and Electrical Products and Systems, REV.3-13/01/2023, Issue date 20/01/2020 |
| **Reference documents** | EN ISO 14025:2010, Environmental labels and declarations – Type III environmental declarations – Principles and procedures<br>EN 50693:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems<br>Regulations of the EPDItaly Programme. Revision 6.0. Issue date 30/10/2023 |



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| | |
|---|---|
| **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 EPD owner relieves EPDItaly from any non-compliance with the environmental legislations. The holder of the declaration will be liable for the supporting information and evidence. EPDItaly disclaims any liability regarding the manufacturer's information, data, and results of the life cycle assessment. |

## 2. THE COMPANY

Col Giovanni Paolo S.p.A. (COL GROUP) is a leading Italian company owned by Oaktree Capital Management, L.P. in the fast-growing global energy transmission and distribution market. It specializes in the development and production of critical components and advanced solutions for smart grid applications in medium and high voltage electrical infrastructure with sustainability at the heart of all its activities. COL GROUP has been working to support the sustainable future of our planet and the long-term success of its customers as well as the company's own business. Testament to that are the ambitions embodied in two of COL GROUP's Strategy 2030 goals i.e., to lead with low-carbon circular economy solutions, and to enhance sustainability across the value chain. The company possesses numerous certifications according to international standards, among which are UNI EN ISO 9001:2015, UNI EN ISO 14001:2015, UNI ISO 45001:2018, UNI EN ISO 50001:2018, and ISO 27001: 2013. Established in 1920, COL GROUP has amassed over a century worth of valuable experience in the electro-technical and plant engineering fields, and it is one of the few authorized suppliers for major utility companies in Europe, Middle East, South America, and Southeast Asia. The company has developed a highly innovative technology portfolio in medium voltage switchgear, substation automation, battery control systems and several other smart grid and high-voltage applications in collaboration with other dominant global utilities and industrial players. A few years back, COL GROUP acquired TW-TeamWare SRL to accelerate its progress towards power quality, cyber security, and electric distribution remote control. The company now has production sites in Torino, Catania, Milano, and Cremona, with over 150 highly skilled, specialized, and efficient employees led by a capable management team.

## 3. THE PRODUCTS

RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels are RIO devices for interfacing with field equipment in secondary substations (SS), designed as per Enel group technical specification code: MAT-NT&I-SGD-2021-0030-EGIN Version no.01 dated 24/03/2021 under the GSTR004 product family. The main function of the RIO devices is to enable the Quantum Edge (QEd) which is a new ENEL device used for protection, control and monitoring of the MV/LV Substations, to interact with the physical and existing



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power components, such as switch disconnectors or circuit breakers. The data exchange profile between the RIO (server) and virtual UP (client) is based on the IEC 61850 MMS communication protocol. Structurally, the enclosure of the RIO 1 channel for indoor installations consists of the container with maximum dimensions of 300 x 200mm, made for surface mounting, using screws. The enclosure for RIO 1 channel for outdoor installations is assembled on a 19'' 1U rack with the screws and cage bolts. The RIO UP 4 device is housed in a standard rack box 19” 4U. The image on the cover of this EPD document shows a fully assembled RIO UP 1 Channel Indoor **(top left),** RIO UP 1 Channel Outdoor **(top right),** and RIO UP 4 Channels device **(bottom),** and **table 1** summarizes some of the technical features of the RIO UP products.

**Table 1.** Technical features for the RIO UP devices as per GSTR004, plus the packaging materials

| **Product model** | | **RIO UP 1 Channel Indoor** | **RIO UP 1 Channel Outdoor** | **RIO UP 4 Channels** |
|---|---|---|---|---|
| **TEAMWARE Product code** | | **TW149-PFEL-0013-00** | **TW149-PFEL-0014-00** | **TW149-PFEL-0015-00** |
| **Client Product code** | | **510084** | **510085** | **510086** |
| **Product weight (kg)** | | **1,538** | **1,911** | **3,025** |
| **Ethernet port** | | 1 RJ45 connector | 1 RJ45 connector | 1 RJ45 connector |
| **SG Connectors (12-pin)** | | - | - | 4 SG ports used to control and command the OdM |
| **FPI Connectors (9-pin)** | | - | - | 4 FPI ports used for connection to fault detectors |
| **Terminal boards** | | 1 MB used for connection with the FPI | 1 MB used for connection with the FPI | 1 TS with 4 digital inputs, +24v input terminal |
| | | 1 MI_Indoor used for connection to the OdM and PSBC | 1 MI_Outdoor used for connection with the IMS | 1 MP Power supply terminal board |
| | | - | 1 MP used for connection with the PSBC | - |
| **Reset button** | | 1 | 1 | 1 |
| **Open and close buttons** | | Yes | Yes | - |
| **Status LED** | | Yes | Yes | Yes |
| **Power supply** | | 24Vdc provided by the Power Supply Battery Charger (PSBC) | 24Vdc provided by the Power Supply Battery Charger (PSBC) | 24Vdc provided by the Power Supply Battery Charger (PSBC) |
| **Packaging materials (kg)** | **Cardboard box** | **0,124** | **0,124** | **0,248** |
| | **Polyethylene (PE film)** | **0,020** | **0,020** | **0,040** |
| | **Wooden pallet** | **0,086** | **0,086** | **0,171** |



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## Material composition

The declaration on the content of materials for the three RIO UP products was done by the manufacturer in accordance with EN IEC 62474. The unique ID and percentage mass share of all the materials and declarable substances contained in the fully assembled RIO UP products plus their packaging materials are reported in **table 2.**

**Table 2.** Material composition for the each of the 3 fully assembled and packaged RIO UP devices

| Material class name | ID | Percentage mass share (%) | | |
|---|---|---|---|---|
| | | RIO UP 1 Channel Indoor | RIO UP 1 Channel Outdoor | RIO UP 4 Channels |
| **Other ferrous alloys, non-stainless steels** | M-119 | 70,6562 | 74,9367 | 68,9395 |
| **Polyethylene (PE)** | M-201 | 1,1256 | 0,9297 | 1,1424 |
| **Polyethylene Terephthalate (PET)** | M-209 | 0,0002 | 0,0001 | - |
| **Other unfilled thermoplastics** | M-249 | 0,5996 | 0,6167 | 0,0001 |
| **Wood** | M-340 | 4,8418 | 3,9992 | 4,9140 |
| **Paper** | M-341 | 7,0138 | 5,7932 | 7,1185 |
| ***Other** | OTHER | 15,7629 | 13,7244 | 17,8855 |

***Miscellaneous electronic materials with no unique ID

## Reference service life

The reference service life (RSL) of each of the three RIO UP products was regarded as 10 years.

# 4. SCOPE AND TYPE OF EPD

This is a product-specific EPD for three RIO UP devices i.e., RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels which are used for interfacing with power equipment in the field, produced by TW-TeamWare SRL, a COL GROUP company, in compliance with ISO 14025 and EN 50693 under the EPDItaly program regulations. It is based on a cradle to grave life cycle assessment (LCA) methodology in accordance with the ISO 14040 and 14044 standards. The geographical (spatial) and temporal scope for the data used in this study are summarized in **table 3** basing on the current global level of technology. The results were automatically generated using the excel-based LCA tool "LCA-COL GROUP Tool 2.2" of 07/11/2024., and they were intended for internal research and development (R&D), as well as external B2B and B2C communication. In effect, these results facilitated judicious corporate decisions through comparison of the environmental attributes of products that have similar functional requirements.

**Table 3.** The spatial and temporal scope of the LCA study at the current global level of technology

| Representativeness | Scope |
|---|---|
| Spatial | Italy |
| Temporal | January to December, 2021 |



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## Functional unit

The functional unit (FU) was a fully assembled, tested, and packaged RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels device with the technical specifications stated in **table 1**, distributed to sites within Italy, installed and used for enabling interaction between the QEd and the physical and existing power components, such as switch disconnectors or circuit breakers, during a RSL of 10 years, operating continuously.

## System boundary

The system boundary implemented in this LCA covered the entire lifecycle of all the three products i.e., from cradle to grave as shown in **table 4** with the life cycle stages and the geographical scopes for all the major activities involved, grouped into three distinct modules i.e., upstream, core, and downstream with reference to EN 50693. The product life cycle and inventory analysis describing all the activities, simplifying assumptions, and modelling scenarios used in the LCA has been thoroughly conducted under **section 5** of this document.

**Table 4.** The life cycle stages, geographical scope, and modules declared in the system boundary

| Manufacturing | | | Distribution | Installation | Use | End of life |
|---|---|---|---|---|---|---|
| CN | IT | IT | IT | IT | IT | IT |
| Upstream | | Core | Downstream | | | |
| ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |

**CN** = China**, IT** = Italy**,** ✓ = Lifecycle stages and modules declared in the LCA

## Cut-off criteria

The mandatory cut-off for mass and energy flows in this LCA study was set at 1% as defined and modelled in the LCA TOOL "LCA-COL GROUP Tool 2.2" of 07/11/2024. All the material and energy flows within the system boundary known to have potential to cause significant impacts on the LCA results have been accounted for. However, cut-off was applied to the potential impacts that could have resulted from production and disposal of the packaging materials of all the semi-finished products included in the BOMs (e.g., sheets, electronics, screws, etc.) transported to TW-TeamWare SRL for processing and later assembling of the final products as it was assumed that such impacts were negligible. Furthermore, a cut-off was similarly applied to the impacts associated with the skilled labour required during installation before use and dismantling of the three RIO UP products at their end-of-life. Potential impacts that could have arisen from ordinary or extraordinary maintenance were also ignored since the products were assumed to be maintenance free for the entire expected service life.

## Allocation rules

The allocation criteria adopted for the LCA model was guided by the PCR of the reference product. Since many other products are produced at the reference site, the "multi-output" allocation rule was applied to calculate the environmental impact of the RIO UP products being studied. The primary data relating to waste generation, water, and energy consumption (petrol, electricity, and natural gas) used was provided



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for the reference year, and these were allocated based on economic value (revenue generated in millions of euros) using the total annual revenue of the company, annual revenue from selling each of the RIO UP products being studied, and the number of the studied RIO UP product sold in the reference year, to get the allocation factor.

## Data quality

The most recent and verifiable site-specific data collected in 2021 was used in this study, and the International System of Units (SI) was adopted while recording the data. The initial primary data forming the basis for the LCA were the production specifications i.e., BOMs, mechanical drawings, and technical information from the client provided by TW-TeamWare SRL to its external suppliers for each sub-assembly of the final products, and these were analyzed using Microsoft excel. In instances where data was missing for some individual electronic components, approximations were made in the BOMs and proxy data with the nearest equivalence in terms of functionality and mass was used for modelling such components. The weight and surface area of the structural components were calculated using the Solid Edge software. For the electronic components, information from product datasheets obtained from the websites of Farnell Italia and Mouser Electronics were used, these were complimented with data from Altium and Microarea Mago4 software. Additional primary data used included the water and energy (petrol, electricity, and natural gas) consumption for the core activities at TW-TeamWare SRL premises during the reference year, and these were downloaded from the company's reference production site account on the website of the service providers. A similar approach was applied to download annual data for fuel consumption by company vehicles from the Q8 online portal which documents electronic fuel vouchers. In addition to that, the distances from the manufacturing sites of all the external suppliers to TW-TeamWare SRL were evaluated with the aid of Google Maps and Ports.com for transport by road and sea, respectively. The same technique was applied to determine the distributing distance from TW-TeamWare SRL to the client's location within Italy, and justification was provided for all the simplifying assumptions stated. In terms of secondary data, databases from legitimate sources already embedded in the LCA TOOL "LCA-COL GROUP Tool 2.2" of 07/11/2024 were used to obtain generic data for some up- and down-stream processes in the life cycle of the products.

# 5. PRODUCT LIFE CYCLE AND INVENTORY ANALYSIS

The life cycle inventory (LCI) lists and quantifies all the flows entering and leaving all the declared life cycle stages of the product within the system boundary considered in relation to the scope of the study. The reference flow for the LCI is 1 piece of a fully assembled and packaged RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels devices, whose individual weights are as indicated in **table 5.**

**Table 5.** Weights of the fully assembled and packaged RIO UP devices

| Product | RIO UP 1 Channel Indoor | RIO UP 1 Channel Outdoor | RIO UP 4 Channels |
|---|---|---|---|
| **Total weight (kg)** | 1,768 | 2,140 | 3,484 |



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## Manufacturing

This first life cycle stage covers all the activities spanning across the upstream and core modules. The supply chain processes commence with the extraction of raw materials to produce sub-assemblies comprising of electronic and structural components which are constituents of the final RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels devices, and the packaging materials for each of the final products. The electronic components ordinarily are made of cables and printed circuit boards (PCB) on which smaller components are mounted, whereas the structural component consists of metallic panels, bolts, and screws. The production of these various components was done by external suppliers on their manufacturing sites whose distances from TW-TeamWare SRL were obtained using Google Maps. The electronic components were made in China and assumed to be shipped to the port of Genova, and then transported by road in a 16 - 32 tonne EURO5 lorry to TW-TeamWare SRL premises. Along similar lines, the structural components and packaging materials manufactured within Italy were transported in a 16 - 32 tonne EURO5 lorry to the reference production site where the core activities of assembling, testing, and final packaging of each of the RIO UP devices were done. Each of the fully assembled RIO UP product was then packaged by the application of a double-layered technique, starting by covering the product in a PE-film, and thereafter placing it in a cardboard box to minimize any potential damage on the wooden pallet during distribution. All the wastes generated on-site from these activities (except packaging) are documented by category in the production site register and declared annually in the MUD "*Modello Unico di Dichiarazione ambientale*" following the applicable regulations and deadlines. Furthermore, these wastes were assumed to be transported periodically in a 16 - 32 tonne ACI mix lorry to a waste treatment plant located **50 km** away.

## Distribution

From this point forth, all the activities are classified under the downstream module. Each of the fully assembled and packaged RIO UP products on the pallet is loaded onto a 16 - 32 tonne EURO5 lorry for last mile delivery to the single client. Accordingly, the distribution of the products was homogeneous during the reference year because all the RIO UP products were transported to the same location within the Italian territory as requested by the sole client, and the distribution distance from TW-TeamWare SRL was determined to be **72,1 km** from Google Maps.

## Installation

Upon arrival at the client's location, the RIO UP products are unloaded, carefully removed from the packaging, and installed by skilled technicians. It is immediately after this process that the packaging materials are returned for reuse as per the reduction of packaging waste agreement between TW-TeamWare SRL and its external suppliers. At the end of life of the packaging materials, they are assumed to be transported in a 7 - 16 tonne EURO5 lorry to a waste treatment plant **50 km** away.

## Use

In the use phase, the installed RIO UP devices consume kWh of electricity, $\mathbf{E_{use}}$ as reported in **table 6**, during a **RSL** of 10 years, operating constantly, and this was computed using **Equation 1** with **8760** representing the number of hours in a year; and **1000** is the conversion factor that allows the energy



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consumed in kWh over the product's service life to be expressed. The nominal power of the device (in Watts), $\mathbf{P_{use}}$ was obtained by multiplying current and voltage whose values were determined after connecting the device to a D.C. regulated bench power supply unit with three banana connectors (i.e., positive, ground, and negative) and a digital display showing current, and voltage measured in amps and volts respectively.

$$E_{use}[\mathbf{kWh}] = \frac{P_{use} * \mathbf{8760} * \mathbf{RSL}}{\mathbf{1000}} \qquad (1)$$

**Table 6.** Electricity consumption in kWh of the RIO UP devices during use phase

| Product | RIO UP 1 Channel Indoor | RIO UP 1 Channel Outdoor | RIO UP 4 Channels |
|---|---|---|---|
| **Electricity consumption (kWh)** | 262,8 | 262,8 | 481,8 |

The RIO UP devices do not have any batteries, instead, they are powered at 24Vdc provided by the Power Supply Battery Charger (PSBC) of the MV/LV SS at the installation site. In addition to that, it was assumed that no periodic or extraordinary maintenance works were required throughout the use phase because device failure is improbable thanks to the numerous quality control tests performed during and after assembling to ensure robustness. An additional environmental information is that during the installation and use stages, the RIO UP devices do not emit any pollutants or substances which are dangerous for the environment and health.

### End of life

At the end of the RSL of the products, the dismantling process and separation of the device components is done following guidelines given by the manufacturer, and the resulting wastes were assumed to be transported using a 7,5 - 16 tonne EURO5 lorry to a waste treatment plant located **50 km** away from the installation site.

## 6. LCA RESULTS

The environmental performance results of the RIO UP 1 Channel (Indoor and Outdoor) and RIO UP 4 Channels devices for the different lifecycle stages per FU accounting for all the mandatory environmental impact indicators **(Tables 7, 10, and 13)**, descriptive parameters for resource use **(Tables 8, 11, and 14)**, and waste production **(Tables 9, 12, and 15),** respectively, calculated as per Core PCR: EPDItaly007 and EN 50693 were automatically generated using the LCA TOOL "LCA-COL GROUP Tool 2.2" of 07/11/2024.



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## Environmental impacts for RIO UP 1 Channel Indoor

**Table 7.** LCA results for the environmental impact indicators

| Impact indicators | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **GWP-total** | kg $CO_2$ eq. | 4,66E+01 | 1,98E-02 | 4,27E-02 | 9,40E+01 | 1,50E+00 | 1,42E+02 |
| **GWP-fossil** | kg $CO_2$ eq. | 4,64E+01 | 1,98E-02 | 1,93E-02 | 9,35E+01 | 1,49E+00 | 1,42E+02 |
| **GWP-biogenic** | kg $CO_2$ eq. | 4,45E-02 | 6,76E-07 | 2,34E-02 | 4,03E-01 | 7,28E-05 | 4,71E-01 |
| **GWP-luluc** | kg $CO_2$ eq. | 6,49E-02 | 4,86E-07 | 7,19E-07 | 5,89E-03 | 1,40E-04 | 7,10E-02 |
| **ODP** | kg CFC-11 eq. | 2,08E-06 | 4,04E-10 | 6,78E-11 | 1,96E-06 | 1,26E-09 | 4,04E-06 |
| **AP** | mol $H^+$ eq. | 3,42E-01 | 4,93E-05 | 2,57E-05 | 3,05E-01 | 7,68E-04 | 6,48E-01 |
| **EP-freshwater** | kg P eq. | 7,94E-03 | 1,66E-08 | 2,30E-08 | 1,59E-03 | 3,74E-06 | 9,54E-03 |
| **EP-marine** | kg N eq. | 5,97E-02 | 1,89E-05 | 3,13E-05 | 4,71E-02 | 2,78E-04 | 1,07E-01 |
| **EP-terrestrial** | mol N eq. | 7,87E-01 | 2,07E-04 | 1,15E-04 | 5,38E-01 | 2,87E-03 | 1,33E+00 |
| **POCP** | kg NMVOC eq. | 2,17E-01 | 8,59E-05 | 4,17E-05 | 2,49E-01 | 7,81E-04 | 4,66E-01 |
| **ADP-min & met** | kg Sb eq. | 1,49E-02 | 6,54E-10 | 8,07E-10 | 1,36E-06 | 1,74E-08 | 1,49E-02 |
| **ADP-fossil** | MJ | 5,97E+02 | 2,61E-01 | 4,62E-02 | 1,54E+03 | 1,49E+00 | 2,14E+03 |
| **WDP** | $m^3$ eq. deprived | 1,23E+01 | 1,11E-04 | -8,03E-03 | 6,90E+01 | 3,22E-02 | 8,14E+01 |

**Caption: GWP-total** = Global Warming Potential – total; **GWP-fossil** = Global Warming Potential – fossil; **GWP-biogenic** = Global Warming Potential – biogenic; **GWP-luluc** = Global Warming Potential – land use and land use change; **ODP** = Ozone Depletion Potential; **AP** = Acidification Potential; **EP-freshwater** = Eutrophication potential, aquatic freshwater; **EP-marine** = Eutrophication potential, marine; **EP-terrestrial** = Eutrophication potential, terrestrial; **POCP** = Photochemical ozone formation; **ADP-min & met** = Depletion of abiotic resources – minerals and metals; **ADP-fossil** = Depletion of abiotic resources – fossil fuels; **WDP** = Water deprivation potential



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## Resource use for RIO UP 1 Channel Indoor

**Table 8.** LCA results for the environmental parameters describing resource use

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **PERE** | MJ | 7,08E+01 | 9,07E-04 | 5,74E-04 | 5,35E+02 | 1,12E-01 | 6,06E+02 |
| **PERM** | MJ | 2,07E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 2,07E+00 |
| **PERT** | MJ | 7,28E+01 | 9,07E-04 | 5,74E-04 | 5,35E+02 | 1,12E-01 | 6,08E+02 |
| **PENRE** | MJ | 5,92E+02 | 2,61E-01 | 4,62E-02 | 1,54E+03 | 1,49E+00 | 2,14E+03 |
| **PENRM** | MJ | 5,62E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 5,62E+00 |
| **PENRT** | MJ | 5,97E+02 | 2,61E-01 | 4,62E-02 | 1,54E+03 | 1,49E+00 | 2,14E+03 |
| **MS** | kg | 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 |
| **NRSF** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **FW** | $m^3$ | 4,22E-01 | 6,70E-06 | -1,74E-04 | 1,82E+00 | 1,16E-03 | 2,24E+00 |

**Caption: PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw material; **PERM** = Use of renewable primary energy resources used as raw material; **PERT** = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); **PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; **PENRM** = Use of non-renewable primary energy resources used as raw material; **PENRT** = Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials); **MS** = Use of secondary materials; **RSF** = Use of renewable secondary fuels; **NRSF** = Use of non-renewable secondary fuels; **FW** = Net use of fresh water



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## Waste production for RIO UP 1 Channel Indoor

**Table 9.** LCA results for the environmental parameters describing waste production

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **HWD** | kg | 1,47E-02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,47E-02 |
| **NHWD** | kg | 1,69E-06 | 0,00E+00 | 5,67E-02 | 0,00E+00 | 4,64E-01 | 5,21E-01 |
| **RWD** | kg | 9,95E-10 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 9,95E-10 |
| **CRU** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **MFR** | kg | 4,28E-02 | 0,00E+00 | 1,24E-01 | 0,00E+00 | 1,07E+00 | 1,24E+00 |
| **MER** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 5,30E-03 | 5,30E-03 |
| **ETE** | MJ | 0,00E+00 | 0,00E+00 | 9,00E-01 | 0,00E+00 | 0,00E+00 | 9,00E-01 |
| **EEE** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **Caption: HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed; **CRU** = Components for reuse; **MFR** = Material for recycling; **MER** = Materials for energy recovery; **ETE** = Exported thermal energy; **EEE** = Exported electricity energy | | | | | | | |



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## Environmental impacts for RIO UP 1 Channel Outdoor

**Table 10.** LCA results for the environmental impact indicators

| Impact indicators | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **GWP-total** | kg $CO_2$ eq. | 1,38E+02 | 2,40E-02 | 4,27E-02 | 9,40E+01 | 1,86E+00 | 2,34E+02 |
| **GWP-fossil** | kg $CO_2$ eq. | 1,38E+02 | 2,40E-02 | 1,93E-02 | 9,35E+01 | 1,86E+00 | 2,33E+02 |
| **GWP-biogenic** | kg $CO_2$ eq. | 1,15E-01 | 8,18E-07 | 2,34E-02 | 4,03E-01 | 9,04E-05 | 5,41E-01 |
| **GWP-luluc** | kg $CO_2$ eq. | 1,82E-01 | 5,88E-07 | 7,19E-07 | 5,89E-03 | 1,74E-04 | 1,88E-01 |
| **ODP** | kg CFC-11 eq. | 8,17E-06 | 4,89E-10 | 6,78E-11 | 1,96E-06 | 1,56E-09 | 1,01E-05 |
| **AP** | mol $H^+$ eq. | 8,54E-01 | 5,97E-05 | 2,57E-05 | 3,05E-01 | 9,54E-04 | 1,16E+00 |
| **EP-freshwater** | kg P eq. | 2,60E-02 | 2,01E-08 | 2,30E-08 | 1,59E-03 | 4,65E-06 | 2,76E-02 |
| **EP-marine** | kg N eq. | 1,68E-01 | 2,29E-05 | 3,13E-05 | 4,71E-02 | 3,45E-04 | 2,15E-01 |
| **EP-terrestrial** | mol N eq. | 2,03E+00 | 2,50E-04 | 1,15E-04 | 5,38E-01 | 3,57E-03 | 2,57E+00 |
| **POCP** | kg NMVOC eq. | 5,59E-01 | 1,04E-04 | 4,17E-05 | 2,49E-01 | 9,70E-04 | 8,09E-01 |
| **ADP-min & met** | kg Sb eq. | 4,25E-02 | 7,91E-10 | 8,07E-10 | 1,36E-06 | 2,16E-08 | 4,25E-02 |
| **ADP-fossil** | MJ | 1,76E+03 | 3,16E-01 | 4,62E-02 | 1,54E+03 | 1,85E+00 | 3,31E+03 |
| **WDP** | $m^3$ eq. deprived | 3,12E+01 | 1,34E-04 | -8,03E-03 | 6,90E+01 | 4,00E-02 | 1,00E+02 |

**Caption: GWP-total** = Global Warming Potential – total; **GWP-fossil** = Global Warming Potential – fossil; **GWP-biogenic** = Global Warming Potential – biogenic; **GWP-luluc** = Global Warming Potential – land use and land use change; **ODP** = Ozone Depletion Potential; **AP** = Acidification Potential; **EP-freshwater** = Eutrophication potential, aquatic freshwater; **EP-marine** = Eutrophication potential, marine; **EP-terrestrial** = Eutrophication potential, terrestrial; **POCP** = Photochemical ozone formation; **ADP-min & met** = Depletion of abiotic resources – minerals and metals; **ADP-fossil** = Depletion of abiotic resources – fossil fuels; **WDP** = Water deprivation potential



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## Resource use for RIO UP 1 Channel Outdoor

**Table 11.** LCA results for the environmental parameters describing resource use

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **PERE** | MJ | 1,96E+02 | 1,10E-03 | 5,74E-04 | 5,35E+02 | 1,39E-01 | 7,31E+02 |
| **PERM** | MJ | 2,07E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 2,07E+00 |
| **PERT** | MJ | 1,98E+02 | 1,10E-03 | 5,74E-04 | 5,35E+02 | 1,39E-01 | 7,33E+02 |
| **PENRE** | MJ | 1,75E+03 | 3,16E-01 | 4,62E-02 | 1,54E+03 | 1,85E+00 | 3,30E+03 |
| **PENRM** | MJ | 5,86E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 5,86E+00 |
| **PENRT** | MJ | 1,76E+03 | 3,16E-01 | 4,62E-02 | 1,54E+03 | 1,85E+00 | 3,31E+03 |
| **MS** | kg | 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 |
| **NRSF** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **FW** | $m^3$ | 1,18E+00 | 8,11E-06 | -1,74E-04 | 1,82E+00 | 1,45E-03 | 2,99E+00 |

**Caption: PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw material; **PERM** = Use of renewable primary energy resources used as raw material; **PERT** = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); **PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; **PENRM** = Use of non-renewable primary energy resources used as raw material; **PENRT** = Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials); **MS** = Use of secondary materials; **RSF** = Use of renewable secondary fuels; **NRSF** = Use of non-renewable secondary fuels; **FW** = Net use of fresh water



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## Waste production for RIO UP 1 Channel Outdoor

**Table 12.** LCA results for the environmental parameters describing waste production

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **HWD** | kg | 1,65E-02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,65E-02 |
| **NHWD** | kg | 1,69E-06 | 0,00E+00 | 5,67E-02 | 0,00E+00 | 5,48E-01 | 6,04E-01 |
| **RWD** | kg | 9,95E-10 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 9,95E-10 |
| **CRU** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **MFR** | kg | 4,79E-02 | 0,00E+00 | 1,24E-01 | 0,00E+00 | 1,36E+00 | 1,53E+00 |
| **MER** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 6,60E-03 | 6,60E-03 |
| **ETE** | MJ | 0,00E+00 | 0,00E+00 | 9,00E-01 | 0,00E+00 | 0,00E+00 | 9,00E-01 |
| **EEE** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **Caption: HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed; **CRU** = Components for reuse; **MFR** = Material for recycling; **MER** = Materials for energy recovery; **ETE** = Exported thermal energy; **EEE** = Exported electricity energy | | | | | | | |



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## Environmental impacts for RIO UP 4 Channels

**Table 13.** LCA results for the environmental impact indicators

| Impact indicators | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **GWP-total** | kg $CO_2$ eq. | 4,55E+01 | 3,90E-02 | 8,55E-02 | 1,72E+02 | 2,92E+00 | 2,21E+02 |
| **GWP-fossil** | kg $CO_2$ eq. | 4,53E+01 | 3,90E-02 | 3,86E-02 | 1,72E+02 | 2,91E+00 | 2,20E+02 |
| **GWP-biogenic** | kg $CO_2$ eq. | 5,83E-02 | 1,33E-06 | 4,69E-02 | 7,38E-01 | 1,42E-04 | 8,44E-01 |
| **GWP-luluc** | kg $CO_2$ eq. | 7,44E-02 | 9,58E-07 | 1,44E-06 | 1,08E-02 | 2,75E-04 | 8,55E-02 |
| **ODP** | kg CFC-11 eq. | 1,02E-06 | 7,95E-10 | 1,36E-10 | 3,59E-06 | 2,46E-09 | 4,61E-06 |
| **AP** | mol $H^+$ eq. | 4,06E-01 | 9,71E-05 | 5,15E-05 | 5,59E-01 | 1,50E-03 | 9,66E-01 |
| **EP-freshwater** | kg P eq. | 6,46E-03 | 3,27E-08 | 4,60E-08 | 2,92E-03 | 7,35E-06 | 9,39E-03 |
| **EP-marine** | kg N eq. | 6,09E-02 | 3,72E-05 | 6,25E-05 | 8,63E-02 | 5,42E-04 | 1,48E-01 |
| **EP-terrestrial** | mol N eq. | 9,01E-01 | 4,08E-04 | 2,29E-04 | 9,86E-01 | 5,60E-03 | 1,89E+00 |
| **POCP** | kg NMVOC eq. | 2,34E-01 | 1,69E-04 | 8,34E-05 | 4,56E-01 | 1,52E-03 | 6,91E-01 |
| **ADP-min & met** | kg Sb eq. | 1,42E-02 | 1,29E-09 | 1,61E-09 | 2,49E-06 | 3,39E-08 | 1,42E-02 |
| **ADP-fossil** | MJ | 5,88E+02 | 5,15E-01 | 9,24E-02 | 2,83E+03 | 2,93E+00 | 3,42E+03 |
| **WDP** | $m^3$ eq. deprived | 1,40E+01 | 2,19E-04 | -1,61E-02 | 1,27E+02 | 6,29E-02 | 1,41E+02 |

**Caption: GWP-total** = Global Warming Potential – total; **GWP-fossil** = Global Warming Potential – fossil; **GWP-biogenic** = Global Warming Potential – biogenic; **GWP-luluc** = Global Warming Potential – land use and land use change; **ODP** = Ozone Depletion Potential; **AP** = Acidification Potential; **EP-freshwater** = Eutrophication potential, aquatic freshwater; **EP-marine** = Eutrophication potential, marine; **EP-terrestrial** = Eutrophication potential, terrestrial; **POCP** = Photochemical ozone formation; **ADP-min & met** = Depletion of abiotic resources – minerals and metals; **ADP-fossil** = Depletion of abiotic resources – fossil fuels; **WDP** = Water deprivation potential



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## Resource use for RIO UP 4 Channels

**Table 14.** LCA results for the environmental parameters describing resource use

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **PERE** | MJ | 6,85E+01 | 1,79E-03 | 1,15E-03 | 9,81E+02 | 2,21E-01 | 1,05E+03 |
| **PERM** | MJ | 4,13E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 4,13E+00 |
| **PERT** | MJ | 7,26E+01 | 1,79E-03 | 1,15E-03 | 9,81E+02 | 2,21E-01 | 1,05E+03 |
| **PENRE** | MJ | 5,77E+02 | 5,15E-01 | 9,24E-02 | 2,83E+03 | 2,93E+00 | 3,41E+03 |
| **PENRM** | MJ | 1,13E+01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,13E+01 |
| **PENRT** | MJ | 5,88E+02 | 5,15E-01 | 9,24E-02 | 2,83E+03 | 2,93E+00 | 3,42E+03 |
| **MS** | kg | 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 |
| **NRSF** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **FW** | $m^3$ | 4,38E-01 | 1,32E-05 | -3,47E-04 | 3,33E+00 | 2,28E-03 | 3,77E+00 |

**Caption: PERE** = Use of renewable primary energy excluding renewable primary energy resources used as raw material; **PERM** = Use of renewable primary energy resources used as raw material; **PERT** = Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); **PENRE** = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw material; **PENRM** = Use of non-renewable primary energy resources used as raw material; **PENRT** = Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials); **MS** = Use of secondary materials; **RSF** = Use of renewable secondary fuels; **NRSF** = Use of non-renewable secondary fuels; **FW** = Net use of fresh water



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## Waste production for RIO UP 4 Channels

**Table 15.** LCA results for the environmental parameters describing waste production

| Parameters | Unit of measurement | Manufacturing | Distribution | Installation | Use | End of life | TOTAL |
|---|---|---|---|---|---|---|---|
| **HWD** | kg | 1,47E-02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,47E-02 |
| **NHWD** | kg | 0,00E+00 | 0,00E+00 | 1,13E-01 | 0,00E+00 | 9,48E-01 | 1,06E+00 |
| **RWD** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **CRU** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| **MFR** | kg | 4,28E-02 | 0,00E+00 | 2,49E-01 | 0,00E+00 | 2,08E+00 | 2,37E+00 |
| **MER** | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,50E-06 | 1,50E-06 |
| **ETE** | MJ | 0,00E+00 | 0,00E+00 | 1,80E+00 | 0,00E+00 | 0,00E+00 | 1,80E+00 |
| **EEE** | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |

**Caption: HWD** = Hazardous waste disposed; **NHWD** = Non-hazardous waste disposed; **RWD** = Radioactive waste disposed; **CRU** = Components for reuse; **MFR** = Material for recycling; **MER** = Materials for energy recovery; **ETE** = Exported thermal energy; **EEE** = Exported electricity energy



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