# ENVIRONMENTAL PRODUCT DECLARATION

In accordance with ISO14025 for

# AVENUE ELECTRON

## City Bus

Programme: The International EPD® System, www.environdec.com
Programme Operator: EPD International AB
Local Operator: EPD Türkiye
S-P Code: S-P-06804
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An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com.

# HOW TO READ THIS EPD?

An Environmental Product Declaration (EPD) is an ISO Type III Environmental Declaration based on ISO 14025 standard. An EPD transparently reports the environmental performance of products or services from a lifecycle perspective. The preparation of an EPD includes different stages, from acquiring raw materials to the end of life of the final product/service. EPDs are based on international standards and consider the entire value chain. Additionally, EPD is a third-party verified document. This EPD includes several sections described below.

## 1.General and Program Information

The 1. General and Program Information of an EPD has information about the name of the manufacturer and product/service and other general information such as the validity and expiration dates of the document, the name of the program operator, geographical scope, etc. The following page states the standards followed and gives information about the program operator, third-party verifier, etc.

## 2.Company and Product Information

Information about the company and the product is provided in this section. It summarizes the materials composition and as well as the information about the technical specifications of the product.

## 3.LCA Information

LCA information is one of the most important parts of the EPD as it describes the functional/declared unit, time representativeness of the study, database(s) and LCA software used, along with system boundaries. The assumptions and parameters used in determining the functional unit are given in this section.

## 4.LCA Results

The results of the Life Cycle Assessment are presented in a table format. The first column in each table indicates the name of the impact category and the second column for their relevant units. These tables show the values for impact indicators per each life cycle stage to see the impacts at different life cycle stages. For each impact category, the amount of its effects can be seen during the production of the product per functional unit, in this case, 1 passenger.km of Avenue Electron. The first impact indicator in the LCA results table is global warming potential (GWP), which indicates how much carbon dioxide ($CO_2$) and other greenhouse gases emissions is released at each stage measured in $CO_2$ eq. Other impacts include eutrophication potential, acidification potential, ozone layer depletion, land use related impacts and so on. The second table provides results for resource use and the third table is about the waste produced during production. The fourth and the final table shows the results for the GWP-GHG indicator, which is identical to GWP-Total in the LCA results table, with the only difference being the exclusion of the biogenic carbon content.

# PROGRAMME INFORMATION

The International EPD® System: EPD International AB Box 210 60 SE-100 31 Stockholm, Sweden, info@environdec.com

EPD Türkiye www.epdturkey.org info@epdturkey.org managed and run by SÜRATAM www.suratam.org NEF 09 B Blok No:7/15 34415 Kağıthane/Istanbul, Türkiye

Product Category Rules (PCR): PCR 2016:04 Public and private passenger buses and coaches (2.0.1) (valid until 2024-12-04)

CPC Code:  UN CPC 49112 & 49113

PCR review was conducted by: The Technical Committee of the International EPD® System

Chair: Maurizio Feschi Contact via: info@environdec.com
Independent third-party verification of the declaration and data, according to ISO 14025:2006, via:

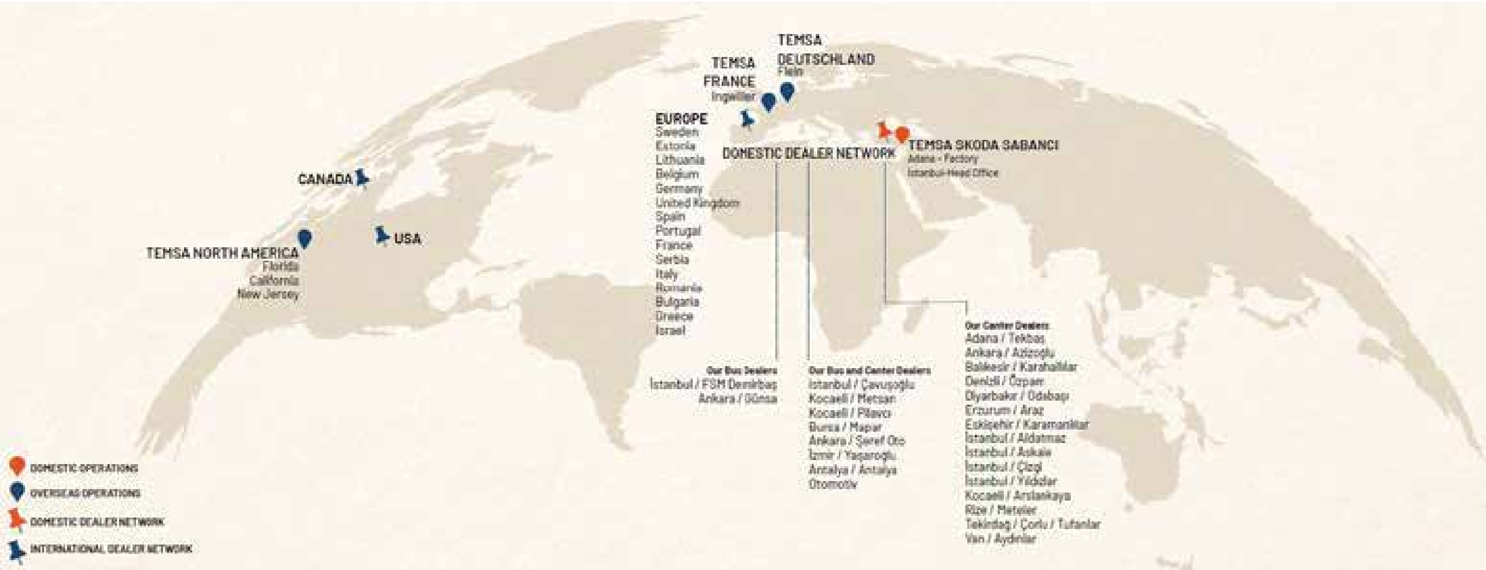
EPD verification by individual verifier
Third party verifier: Claudia A. Peña
Approved by: The International EPD® System

Procedure for follow-up of data during EPD validity involves third party verifier:

**Yes** ☐ **No** ☒

LCA accountability: Metsims Sustainability Consulting

# ABOUT TEMSA




## Owner of the EPD
## TEMSA SKODA SABANCI ULAŞIM ARAÇLARI A.Ş.
## SARIHAMZALI MAH. TURHAN CEMAL BERİKER BLV. / 563A
## ADANA / SEYHAN / TÜRKİYE

TEMSA ranks among the top global bus, minibus, and light-truck manufacturers. With 1 400 employees operating a single shift in a 500 000-square-meter factory in Adana, TEMSA produces up to 11 500 vehicles per year. To date, TEMSA has produced over 130 000 vehicles and exported over 15 000 vehicles to nearly 70 countries around the globe.

Headquartered in Turkey, TEMSA has subsidiaries in United States, France and Germany and provides sales and aftersales services in main European, Middle Eastern and North African markets. With a mission to provide sustainable mobility solutions, TEMSA continues to develop its know-how in zero emmission vehicles. In line with this vision, TEMSA has successfully exported its first electric vehicle to Sweden, one of the most advanced countries in this field.

TEMSA has developed Europe's first electric intercity bus and successfully completed the testing process of its electric coach, the TS45E, tailored specially for the North American market in Silicon Valley. Additionally, TEMSA has embarked on a significant project in collaboration with ASELSAN, resulting in the delivery of Turkey's very first domestically manufactured electric bus. These accomplishments highlight TEMSA's commitment to advancing sustainable transportation solutions.

Aside from developing 5 unique electric buses for mass production, TEMSA has also established an in-house production line for battery packs. Embracing the principles of circular business models, the company is actively working towards achieving a net-zero greenhouse gas emission target by the year 2050. By 2025, TEMSA aims to sell 50% of city bus segment vehicles powered by alternative fuels, reflecting their commitment to sustainable and environmentally-friendly transportation solutions.

For more information and read to our sustainability report, please scan or click the QR code.

# AVENUE ELECTRON

The Avenue Electron is a TEMSA Tech product designed to take transportation to the next level. With its different battery alternatives, this silent and ultra-comfortable citybus is ready to hit the road. Order your Avenue Electron now and get ready for the new perspective of mobility.

Human-centered design is one of the core principles of TEMSA. We wanted to create a vehicle belongs to the city and its people. Therefore, we've wanted Electron to look like young and self-confident but also quiet and peaceful. Avenue Electron is responsive to its surroundings. It's a hundred percent electric bus to ensure a better future. For the first time in a bus, we are able to offer one pedal drive to our customers. We simply call it driving pedal. It's an remarkable technology that has the ability to regenerate more control on power, lower maintenance cost and provide comfort to the driver and the passengers. Regenerated power increased the range up to fifteen percent. Temsa battery management system is used to maximize the battery's capacity and prevent undercharging or overcharging. It ensures all the cells that compose the battery are kept at the same voltage or stayed off charged through balancing. It guarantees the energy efficiency and extra range in Avenue Electron.

## TEMSA TECH EV SOLUTIONS

As TEMSA, we are using our own batteries and TEMSA BMS (Battery Management System)

We are taking the transportation to the next step by introducing the newly facelifted version of 100% electric: Avenue Electron. The quiet, powerful, and modern design of Avenue Electron is reflected in TEMSA's experience with electric vehicle technology combined with proven characteristics of the Avenue LF diesel.

## LOWERING YOUR TOTAL COST OF OWNERSHIP

Avenue Electron will meet all your needs with its engine, battery and range features.

The CCS Type-2 compatible battery system offers convenient and fast charging as 2 hours with 150 kWh DC Charger, 3 hours with 90 kWh DC Charger, and 5 hours with 45 kWh DC Charger. There are three battery capacity options to choose -240 kWh, 300 kWh and 360 kWh- depending on your preference up to 400 km. Also with its 250 kW 2 885 Nm Torque engine power, the Avenue Electron offers maximum driving experience.

## OUTSTANDING DESIGN

The Avenue Electron's durable and simple character makes quite the first impression with its appearance. It's always ready to make a difference to your business with its aesthetic, modern stance and user-friendly design. Avenue Electron's new front and back facelift integrates TEMSA's powerful classic design with cutting edge technologies. The body integrates bold colors, superior quality, and long-term perfection. By enhancing the design with renewed face, Avenue Electron is ready to be one step ahead in its segment.

New LED lights, LED Front Fog Light and LED Daytime Running Light, offer remarkable durability, safety, and also effectiveness for cost via innovations in LED light technology.

## WHERE UNIQUE EXPERIENCES BEGIN: DRIVER'S CABIN

The ergonomic driver seat, right armrest and heater for driver seat makes every part of the journey a joy to drive even during prolonged driving. All operating positions of the driver are at ease without physical changes.

The full digital dashboard, which is designed to offer a variety of crucial information during the journey and easy to-use driving equipment ensure easy access.

## A COMFORTABLE JOURNEY

The comfortable spacious interior design and powerful air conditioning system of Avenue Electron means that every single passenger can enjoy their journey.

The Avenue Electron's interior design features also ensure uninterrupted experiences for passengers. Users can access all relevant information easily on the multifunctional information displays. Depending on the number of seats, the number of standing passengers can be adjusted in line with your requirements. The 37 kW air conditioner keeps the interior of the vehicle cool and fresh even in the hottest weather conditions.

## ENHANCED SAFETY SYSTEMS

The most comfortable journeys begin with a safe driving experience. The Avenue Electron incorporates a number of safety systems to provide the highest level of support, such as ESP, LDWS, LDWS, Blind Spot Information System, Pedestrian & Cyclist Collision Warning System, Forward Collision Warning System, Reversing Detection System.

Thus, Avenue Electron considers the safety of the surrounding area as much as it thinks about the safety of its own passengers in urban transportation.

# AVENUE ELECTRON

## DIMENSIONS AND WEIGHTS

| | |
|---|---|
| Length | 12 095 mm |
| Width | 2 550 mm |
| Height (incl. air conditioner) | 3 237 mm |
| Floor-To-Ceiling Height | Front:2 420 mm / Rear: 2 389 mm |
| Wheelbase | 5 805 mm |
| Front Overhang | 2 757 mm |
| Rear Overhang | 3 533 mm |
| Turning Diameter | 21 160 |
| Wheel Lock(°) | 56°-1° |
| Approach Angle | 7° |
| Gross Vehicle Weight | 19 000 kg |
| Max Passenger Capacity | 98 (35 Seated + 63 Standing) |
| Chassis Length and With | 12 095 x 2 550 mm |
| Turning Circle (Ø) | 21 160 mm |

## POWER

| | |
|---|---|
| Maximum Motor Power | 250 kW |
| Maximum Torque | 2 700/2 885 Nm |
| Gradeability | 18% |

## BATTERY

| | |
|---|---|
| Type | Li-Ion NMC |
| Battery Capacity | 240/300/360 kWh |
| Charging System | CCS Type 2 |
| Charging Time | 2 hours with 150 kWh DC Charger |
| | 3 hours with 90 kWh DC Charger |
| | 5 hours with 45 kWh DC Charger |
| Location | Roof |

## AXLES

| | |
|---|---|
| Front Axle Type | ZF Independent |
| Front Axle Capacity | 8 200 kg |
| Rear Axle Type | ZF Rigid |
| Rear Axle Capacity | 13 000 kg |

## RIMS & TIRES

| | |
|---|---|
| Rim | 8.25 x 22.5 |
| Tire | 275/70 R22.5 |

## ELECTRICAL SYSTEM

| | |
|---|---|
| System Voltage | 24 V |
| Battery | 2 x 12 V 240Ah |

## STEERING WHEEL

| | |
|---|---|
| Electro Hydraulic Steering | Standard |
| Steering Wheel Tilt and Telescopic | Standard |

## BRAKES

| | |
|---|---|
| Service Brake | Standard |
| Parking Brake | Standard |
| ASR (Anti-Slip Regulation) | Standard |
| EBS (Electronic Braking System) | Standard |

## INTERIOR

| | |
|---|---|
| Handle, Dashboard | Standard |

## EXTERIOR AND BODY

| | |
|---|---|
| Body Lifting | Standard |
| Body Kneeling | Standard |
| Body Side Kneeling | Standard |
| Opaque-White Exterior Colour | Standard |
| Metallic Exterior Colour | Optional |

## DRIVER'S AREA

| | |
|---|---|
| Sunvisor | Standard |
| Interior Mirror for Driver | Standard |
| Sliding Front Heated Driver Window | Standard |
| 3 Point Safety Belt for Driver Seat | Standard |
| Left Armrest for Driver Seat | Optional |
| Right Armrest for Driver Seat | Optional |

## SECURITY

| | |
|---|---|
| ESP (Electronic Stability Programme) | Standard |
| Safety Hammers | Standard |
| Low Voltage Warning | Standard |
| Fire Extinguisher | Standard |
| Bus Stop Brake | Standard |
| Circuit Separator on Battery | Standard |
| LDWS (Lane Departure Warning System) | Optional |
| Blind Spot Information System | Optional |
| Pedestrian & Cyclist Collision Warning System | Optional |
| Forward Collision Warning System | Optional |
| Reversing Detection System | Optional |
| Intelligent Speed Assistance | Optional |
| Headway Monitoring & Warning System | Optional |

## WINDOWS AND CLIMATIZATION

| | |
|---|---|
| Double Glazed Side Windows | Standard |
| Air Conditioner | 37 kW |
| Preheater | Standard |
| Driver's Defroster | Standard |

## ELECTRONIC EQUIPMENTS

| | |
|---|---|
| Interior Display | Optional |
| WiFi | Optional |
| Reverse Gear Buzzer | Standard |
| Rear Parking Sensor | Optional |
| Electrically Adjustable Exterior Mirrors | Standard |
| Front Destination Plates | Standard |
| Video Record System | Optional |

## OTHER EQUIPMENTS

| | |
|---|---|
| Fog Lights | Standard |
| Random Coded Lock | Standard |
| Electrical Horn | Standard |
| Ticket Machine Preparation | Standard |
| Manual Ramp | Standard |

## NOISE

| | |
|---|---|
| ECE Regulation N°51 | 72 dB(A) |

Table 1. Technical Specifications

# CONTENT INFORMATION

The total weight of the vehicle was analyzed by using the material weight list. The types and weight distribution of the materials used in the production of the vehicle are also shown in the tables and graphics below. The weights given are the empty weight of the vehicle.

| Materials Category | Weight, kg | % |
|---|---|---|
| Metals | 7 891 | 59,3 |
| Elastomers | 449 | 3,3 |
| Fluids | 98 | 0,7 |
| Polymers | 897 | 6,7 |
| Electrical Equipment (EEQ) | 2 551 | 19,0 |
| Glass | 449 | 3,3 |
| Others | 704 | 5,2 |
| (Modified Organic Natural Materials) MONM | 330 | 2,5 |
| Total | 13 459 | 100 |

Table 2. Materials Breakdown and Composition of Temsa Avenue Electron

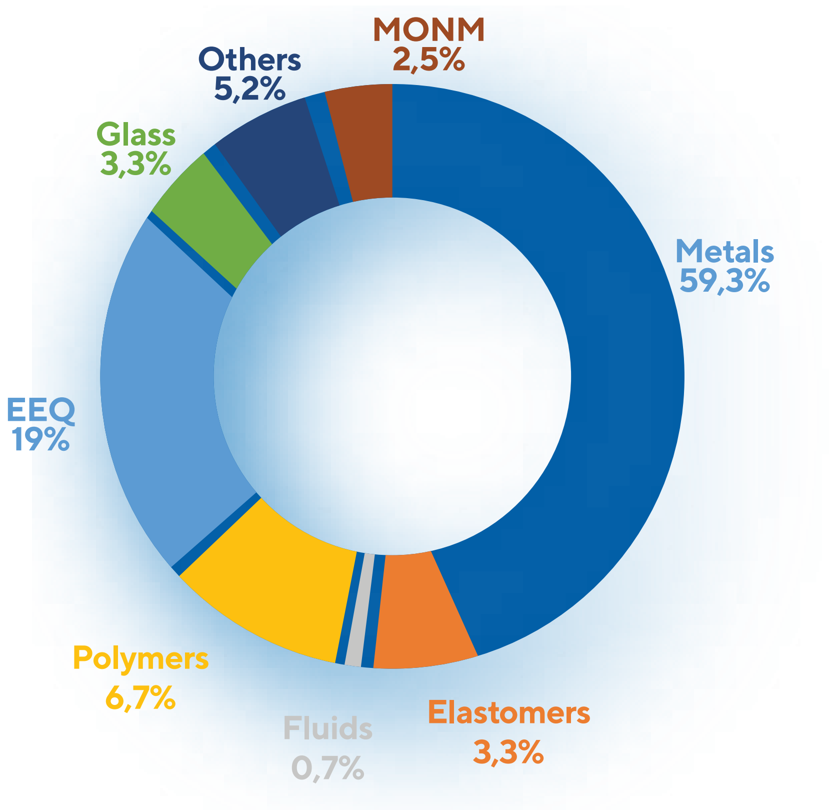



Figure 1. Distribution of Materials Breakdown of Temsa Avenue Electron

The vehicle's recyclability and recoverability rates are calculated as defined in the ISO 22826:2002 standard - "Road vehicles - Recyclability and recoverability - Calculation method". The ratios are shown in the figure below.

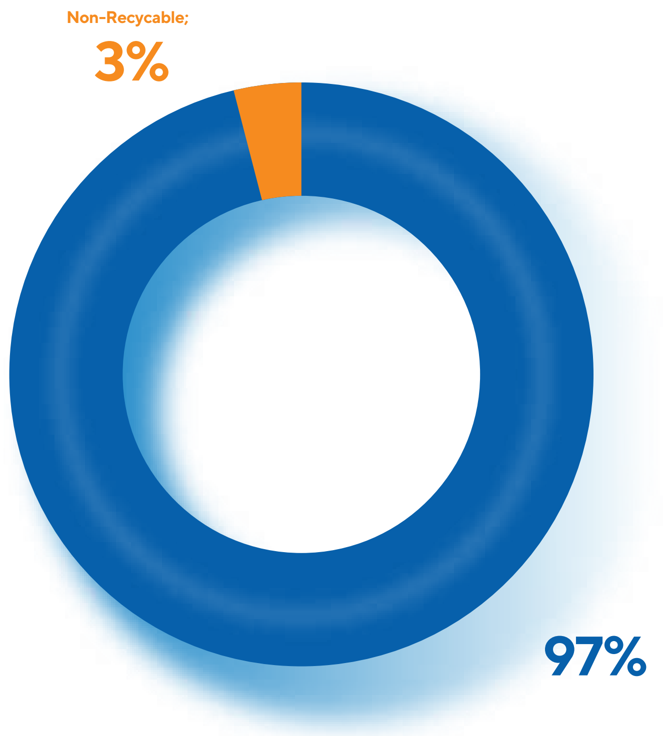



Figure 2. Recyclability rate for Temsa Avenue Electron

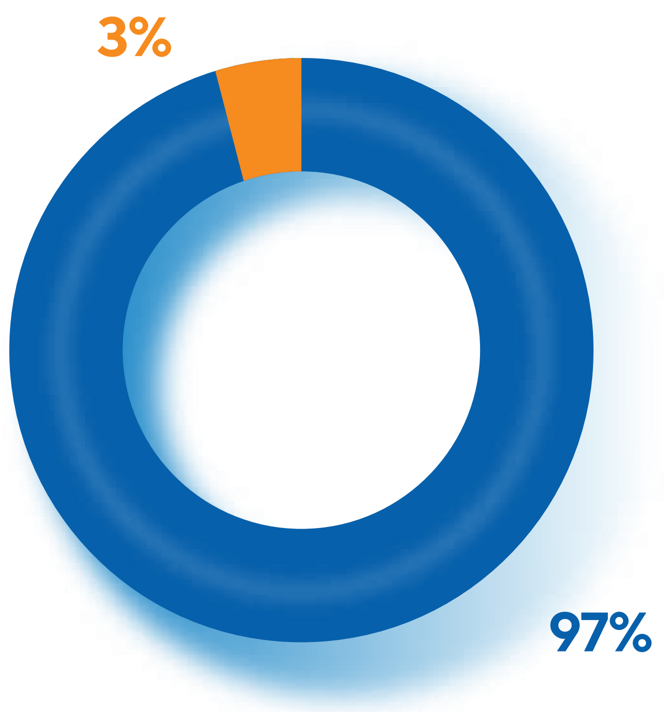



Figure 3. Recoverability rate for Temsa Avenue Electron

# LCA INFORMATION

## Functional Unit

The functional unit is the transport of 1 passenger for 1 km. The bus or coach capacity will be calculated according to available seats and space for standing at 100% load factor. The lifetime year of the bus is assumed 12 years and the annual travelled millage is assumed 100 000 km as stated by Temsa.

| Passenger Capacity, passenger | 90 (35 Seated + 55 Standing) |
|---|---|
| Annual milliage, km | 100 000 |
| Reference Service Life, year | 12 |
| Lifetime milliage, km | 1 200 000 |
| Passenger.km | 108 000 000 |

Table 2. Details of functional unit figures.

## Time Representativeness

Primary LCA data covers January to December of 2022.

## Database(s) and LCA Software:

Ecoinvent 3.9.1 and SimaPro 9.5

## Geographical Scope

The geographical scope of this LCA is Europe

## Allocations

Water consumption, energy consumption and raw material transportation were weighted according to 2022 production figures. In addition, hazardous and non-hazardous waste amounts were also allocated from the 2022 total waste generation. There is no co-product allocation.

## Cut-Off Criteria

1% cut-off is applied. Data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts have been included.

## REACH Regulation

No substances included in the Candidate List of Substances of Very High Concern for authorization under the REACH regulations are present in this product either above the threshold for registration with the European Chemicals Agency or above 0,1% (wt/wt). You can contact TEMSA sales consultants for detailed information about SVHC (substances of very high concern) and REACH.

## LCA Modelling, Calculation and Data Quality

The results of the LCA with the indicators as per EPD requirement are given in the LCA result tables. All energy calculations were obtained using Cumulative Energy Demand, Low Heating Values (LHV) methodology, while freshwater use is calculated within selected inventory flows in SimaPro according to the PCR. Corresponding regional energy datasets were used for all energy related activities. While calculating the LCA results of Avenue Electron, the impact categories and impact assessment requirements have been followed in PCR of Public and Private Buses and Coaches PCR.

# SYSTEM BOUNDARIES & DESCRIPTION

In this LCA study, the cradle-to-grave approach was followed, and the entire life cycle of the bus was evaluated. The construction of the bus production facility, machinery and equipment used in manufacturing, employee commuting and business travels are excluded from the system boundaries. The system boundaries are summarized in the diagram below. Explanation and details for each LCA module are given in the following section.

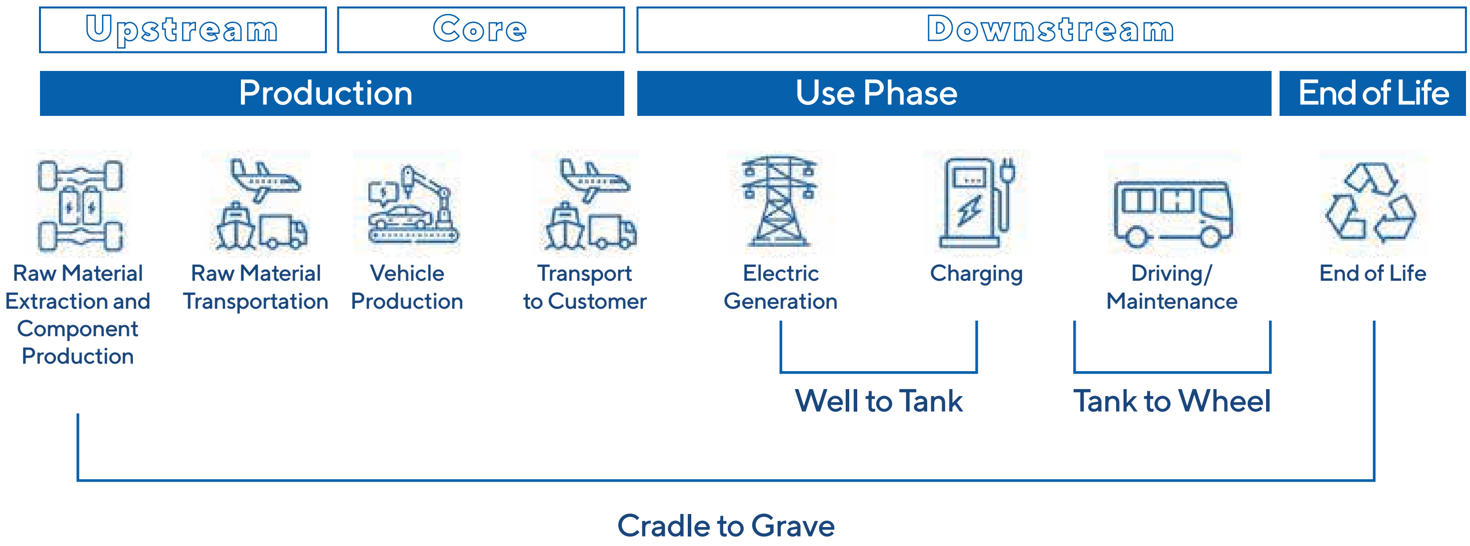



Figure 4. System Boundary

## Upstream Processes

In this module, the processes from the extraction and processing of raw materials such as steel, aluminium, copper, plastic, electronic parts, glass and battery materials used in vehicle production and raw material acquisition are evaluated. The mass list was used to determine the components and weights of the vehicle. Material types and weights are arranged according to the information received from the tier-1 suppliers. At the same time, the transportation of these parts from the suppliers' production facility to the TEMSA production facility is assessed under this module. The piece's weight and the transport mode are considered when modelling the shipping.

## Core Process

The core process module covers the vehicle's assembly and production stages and the vehicle's transportation to the customer after production. The production phase of the vehicle begins with the assembly and welding of the body and chassis parts. Combining other body parts, such as the door and ceiling, completes the body process and the painting process. After painting, mechanical parts such as the motor, cable, pipe, and battery are assembled. The production process is completed by combining electronics, glasses, and other parts. Electricity, natural gas, diesel and water are used in production. At the same time, waste is generated during production. Waste and energy consumption were shared with the vehicles in proportion to their production time and size. Produced vehicles are shipped to customers by road or sea. While LCA modelling the transport module to the customer, sales in 2022 are taken as a basis.

## Downstream Process

The energy consumed during the use of the vehicle and generation of electricity, maintenance and end-of-life stages are evaluated in this LCA module. While calculating the environmental impacts of the electricity consumed during vehicle use, the geographical region has been stated as Europe according to the  common clients countries. Average European grid electricity was used for electricity generation. While calculating the energy consumption, the efficiency loss of the battery is included. The battery is assumed to be changed after eight years of use and 70% efficiency. The energy consumption value is based on the SORT-2 test. Electricity consumption of the vehicle, driver behavior, use of air-conditioning tools, number of passengers, etc. may differ according to the variables.

During the maintenance phase, it was considered that the oil, tires, lighting, some plastic parts and the battery were replaced. The breakdown and disposal of the vehicle at end-of-life is modelled following the ISO 22826:2002 standard.

# ENVIRONMENTAL PERFORMANCE

For the assessment of the environmental performance, the latest update of the default list was made on 2022-03-29, referred to as Version 2.0 is used. The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

LCA results for 1 pkm are given in the table below. The downstream process dominates in all environmental impacts.

## Environmental impacts per passenger kilometre

| Indicator | Unit | Upstream Process | Core Process | Downstream Process | Total |
|---|---|---|---|---|---|
| GWP-fossil | kg $CO_2$ eq. | 774E-6 | 88,2E-6 | 4,51E-3 | 5,37E-3 |
| GWP-biogenic | kg $CO_2$ eq. | 3,56E-6 | 5,26E-6 | 298E-6 | 307E-6 |
| GWP-luluc | kg $CO_2$ eq. | 1,30E-6 | 412E-9 | 10,5E-6 | 12,2E-6 |
| GWP-total | kg $CO_2$ eq. | 778E-6 | 93,8E-6 | 4,82E-3 | 5,69E-3 |
| ODP | kg CFC 11 eq. | 82,3E-12 | 2,21E-12 | 98,2E-12 | 183E-12 |
| AP | mol $H^+$ eq. | 8,13E-6 | 329E-9 | 28,9E-6 | 37,4E-6 |
| EP | kg $PO_4^{3}$ eq. | 11,8E-6 | 819E-9 | 48,5E-6 | 61,2E-6 |
| POCP | kg NMVOC eq. | 3,43E-6 | 263E-9 | 14,2E-6 | 17,9E-6 |
| ADP-minerals&metals** | kg Sb eq. | 61,0E-9 | 87,4E-12 | 97,2E-9 | 158E-9 |
| ADP-fossil** | MJ | 9,99E-3 | 1,11E-3 | 96,9E-3 | 108E-3 |
| WDP** | $m^3$ | 1,13E-3 | 107E-6 | 1,87E-3 | 3,10E-3 |
| Acronyms | GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption | | | | |

Table 3. Environmental Impacts

*Disclamier-1: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
**Disclaimer-2: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

## Resource use indicators per passenger kilometre

| Indicator | | Unit | Upstream Process | Core Process | Downstream Process | Total |
|---|---|---|---|---|---|---|
| Primary energy resources | Use as energy carrier | MJ, net calorific value | 3,6E-3 | 124E-6 | 19,6E-3 | 23,3E-3 |
| | Use as raw material | | 000,0E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| | Total | | 3,58E-3 | 124E-6 | 19,6E-3 | 23,3E-3 |
| Primary energy resources - Non-renewa ble | Use as energy carrier | MJ, net calorific value | 9,30E-3 | 1,11E-3 | 84,6E-3 | 95,0E-3 |
| | Use as raw material | | 000,0E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| | Total | | 9,30E-3 | 1,11E-3 | 84,6E-3 | 95,0E-3 |
| SM | | kg | 000,0E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| RSF | | MJ, net calorific value | 000,0E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| NRSF | | MJ, net calorific value | 000,0E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| FW | | $m^3$ | 8,74E-6 | 2,62E-6 | 28,9E-6 | 40,3E-6 |
| Acronyms | | SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water | | | | |

Table 4. Resource Use Indicators

## Waste indicators per passenger kilometre

| Indicator | Unit | Upstream Process | Core Process | Downstream Process | Total |
|---|---|---|---|---|---|
| HWD | MJ | 214E-9 | 1,71E-06 | 28,4E-6 | 30,4E-6 |
| NHWD | MJ | 000,0E+0 | 3,44E-06 | 14,3E-6 | 17,8E-6 |
| RWD | MJ | 000E+0 | 000,0E+0 | 000,0E+0 | 000,0E+0 |
| Acronyms | HWD: Hazardous waste disposed, NHWD: Non-hazardous waste disposed, RWD: Radioactive waste disposed | | | | |

Table 5. Waste Indicators

## Output flow indicators indicators per passenger kilometre

| Indicator | Unit | Upstream Process | Core Process | Downstream Process | Total |
|---|---|---|---|---|---|
| Components for re-use | kg | 000E+0 | 000E+0 | 000E+0 | 000E+0 |
| Material for recycling | kg | 000E+0 | 3,44E-06 | 1,18E-04 | 1,21E-4 |
| Materials for energy recovery | kg | 000E+0 | 1,71E-06 | 2,44E-07 | 1,95E-6 |
| Exported energy, electricity | MJ | 000E+0 | 000E+0 | 000E+0 | 000E+0 |
| Exported energy, thermal | MJ | 000E+0 | 000E+0 | 000E+0 | 000E+0 |

Table 6. Output Flow Indicators

# INTERPRETATION

According to the LCA results, the environmental impacts of 1 passenger travelling 1 km with Temsa Avenue Electron were calculated. As a result of the system boundary and assumptions detailed in the EPD document, the GWP (Global Warming Potential) impact of 1 passenger travelling 1 km with Temsa Avenue Electron was calculated as 5,69 g $CO_2$eq. 85% of this impact is due to the downstream phase, 14% to the upstream phase, and the remaining amount is due to the core processes phase. The vehicle's electricity consumption comes to the fore during the usage phase. The energy consumption per km of the bus is modelled according to the SORT-2 test results. SORT (Standardised On-Road Test cycles) aims to provide the bus sector with a standardized means of comparing the energy consumption of different buses and to design reproducible test cycles for on-road tests of buses to measure their energy consumption. While calculating the energy consumption over the years, the efficiency loss and life of the battery are considered. As secondary data, it was assumed that the vehicle was used in Europe, and the European grid electricity mix was used in modelling. The impacts of the other stages are visualized in the graphs below.

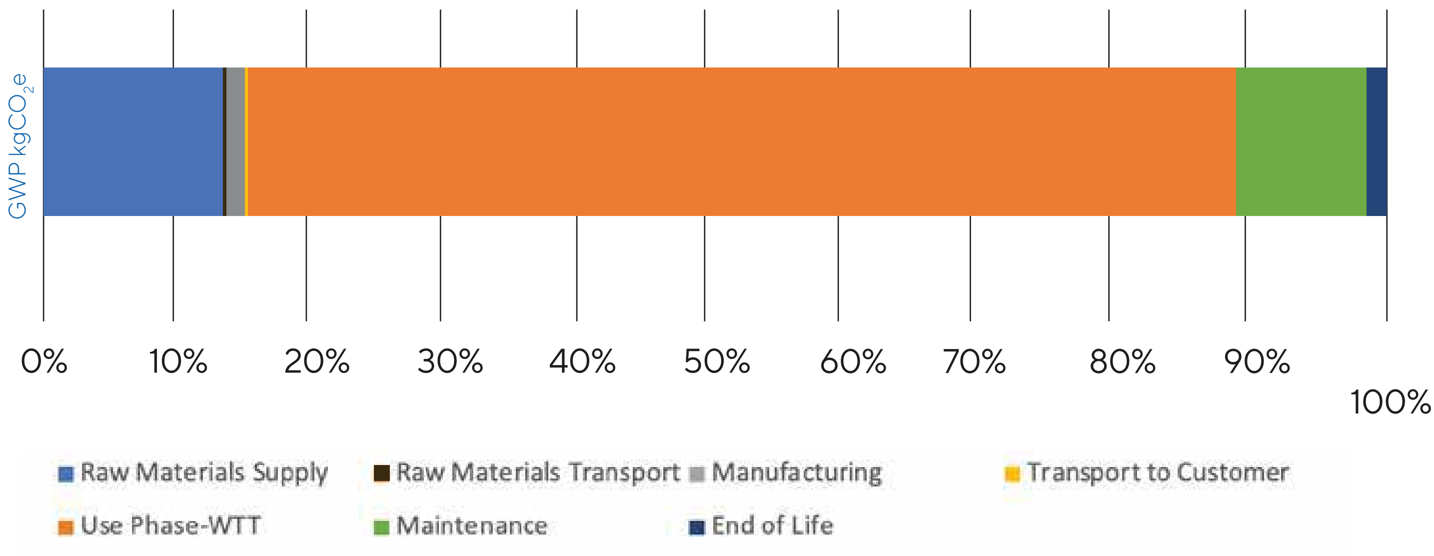



Figure 5. GWP Contributions of LCA of Avenue Electron, %

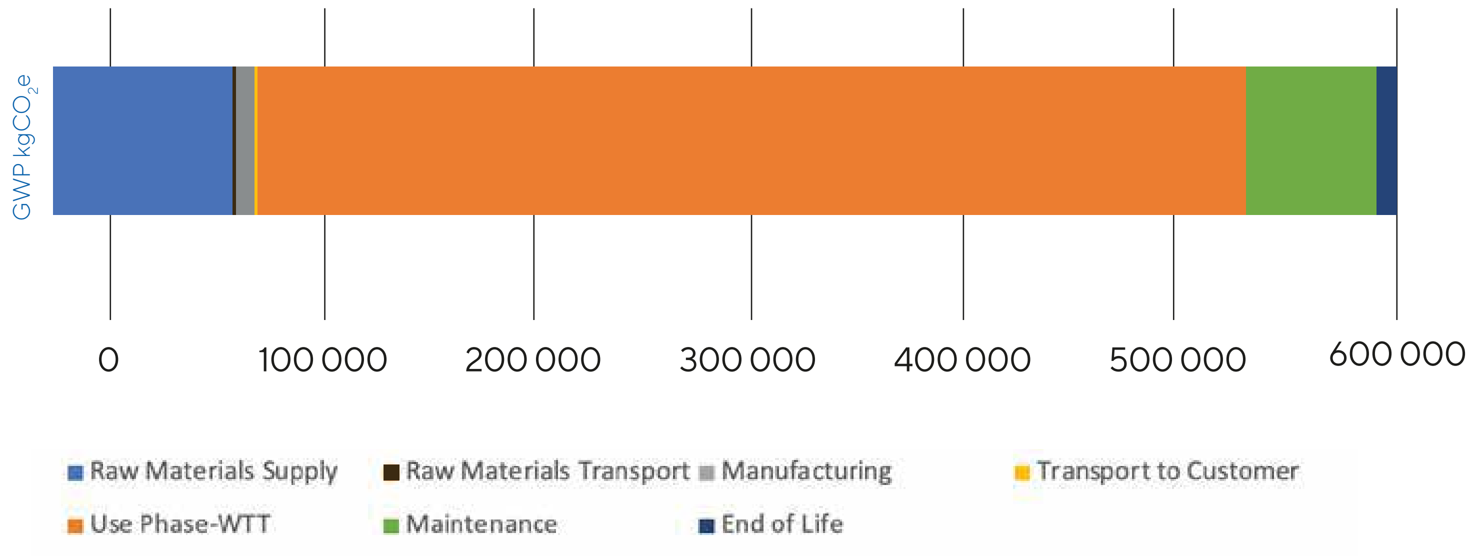



Figure 6. GWP Contributions of LCA of Avenue Electron, kg $CO_2e$

After the usage phase, the most environmental impact is caused by the production of the raw materials of the bus. Similarly, during the maintenance phase, parts of the vehicle such as tires, headlights, fluids and batteries are changed periodically. The impacts caused by the production of these parts are at a significant level. In particular, the production of the battery has a more dominant share in terms of the impact it causes among all the parts.

| Impact category | Unit | Raw Materials | Raw Materials Transport | Manufacturing | Transport to Customer | Use Phase-WTT* | Maintenance | End of Life |
|---|---|---|---|---|---|---|---|---|
| **GWP** | kg $CO_2$ eq. | 13% | <1% | 1% | <1% | 73% | 10% | 2% |
| **Ozone depletion** | kg CFC 11 eq. | 45% | <1% | 1% | <1% | 40% | 10% | 3% |
| **Photochemical ozone formation** | kg NMVOC eq. | 18% | 1% | 1% | <1% | 58% | 21% | 1% |
| **Acidification** | mol $H^+$ eq. | 21% | <1% | 1% | <1% | 59% | 18% | 1% |
| **Eutrophication, freshwater** | kg $PO_4^{3}$ eq. | 9% | <1% | 1% | <1% | 82% | 7% | 1% |
| **Water use** | $m^3$ | 36% | <1% | 3% | <1% | 32% | 27% | 1% |
| **Resource use, fossils** | MJ | 9% | <1% | 1% | <1% | 80% | 9% | 1% |
| **Resource use, minerals and metals** | kg Sb eq. | 39% | <1% | <1% | <1% | 29% | 32% | <1% |

Table 7. Selected Environmental Impacts Contributions of LCA of Avenue

*This stage represents WTT (Well to Tank) emission. For electricity vehicles, WTT emissions cover the generation of electricity.

In the environmental performance stage, the results of all environmental impacts, outputs and resource use are given in the tables. For a more detailed analysis, the percentage distributions according to LCA stages are shown in the table above for some environmental impact categories. While the usage phase-WTT is the most dominant in the GWP category, this situation may differ in other parameters. For example, in the ozone depletion, water scarcity and resource use categories, different LCA stages predominate. This is because the value of these parameters increases depending on resource consumption andit is dominant rather than process emission or energy consumption at the raw material extraction stage.

# GLOSSARY

- PERE (Use of Renewable Primary Energy Excluding Resources Used as Raw Materials): PERE quantifies the consumption of renewable primary energy sources during the product's life cycle, excluding energy derived from raw materials used in the product itself. It focuses on energy from renewable sources like solar, wind, hydro, etc., that are not part of the product's composition.

- PERM (Use of Renewable Primary Energy Resources Used as Raw Materials): PERM assesses the consumption of renewable primary energy sources that are inherent in the raw materials used to create the product. It accounts for the energy embedded in the materials themselves.

- PERT (Total Use of Renewable Primary Energy): PERT represents the overall consumption of renewable primary energy sources throughout the life cycle of the product. It includes both the energy used as raw materials (PERM) and energy used beyond raw materials (PERE).

- PENRE (Use of Non-Renewable Primary Energy Excluding Resources Used as Raw Materials): PENRE quantifies the consumption of non-renewable primary energy sources during the product's life cycle, excluding energy associated with raw materials used in the product's composition.

- PENRM (Use of Non-Renewable Primary Energy Resources Used as Raw Materials): PENRM assesses the consumption of non-renewable primary energy sources that are embodied in the raw materials used to create the product.

- PENRT (Total Use of Non-Renewable Primary Energy): PENRT represents the total consumption of non-renewable primary energy sources throughout the product's life cycle. It encompasses both energy used in raw materials (PENRM) and energy used beyond raw materials (PENRE).

- SM (Secondary Material): SM refers to materials that have been previously used and then re-introduced into the production process. These are materials recycled or recovered from waste streams.

- RSF (Renewable Secondary Fuels): RSF represents fuels derived from renewable sources that are used as secondary fuels. These are fuels used for energy recovery that come from sustainable sources.

- NRSF (Non-Renewable Secondary Fuels): NRSF refers to non-renewable fuels used as secondary fuels for energy recovery purposes.

- FW (Net Use of Fresh Water): FW quantifies the difference between freshwater withdrawals and discharges during the product's life cycle. It considers the potential impact on freshwater resources.

- HWD (Hazardous Waste Disposed): HWD quantifies the amount of hazardous waste that is disposed of during the product's life cycle. It considers waste materials that pose risks to human health or the environment.

- NHWD (Non-Hazardous Waste Disposed): NHWD represents the amount of non-hazardous waste that is disposed of during the product's life cycle. It includes waste materials that do not pose significant risks.

- RWD (Radioactive Waste Disposed): RWD quantifies the amount of radioactive waste that is disposed of during the product's life cycle. It addresses waste materials containing radioactive substances.

- CRU (Components for Reuse): CRU identifies components of the product that are intended for reuse after the end of the product's life cycle. These components can be reconditioned and used again.

- MFR (Material for Recycling): MFR identifies materials within the product that are suitable for recycling. These materials can be recovered and used as raw materials for new products.

- MER (Materials for Energy Recovery): MER refers to materials within the product that can be used for energy recovery through processes like incineration or other energy conversion methods.

- EE (Electrical) Exported Energy: This refers to the amount of electrical energy generated by the product that is exported to the grid or used for other purposes outside the product's own operation.

- EE (Thermal) Exported Energy: Similar to electrical exported energy, this indicator represents the amount of thermal energy generated by the product that is exported or used for external purposes.

- GWP (Global Warming Potential): GWP quantifies the total greenhouse gas emissions over the product's life cycle, expressed in terms of their equivalent impact on global warming, usually in $CO_2$ equivalents.

- ODP (Ozone Depletion Potential): ODP quantifies the potential of a substance to contribute to the depletion of the ozone layer in the stratosphere. It helps assess the environmental impact of substances that can harm the ozone layer.

- AP (Acidification Potential): AP evaluates the potential of emissions to cause acidification of the environment, which can harm ecosystems and aquatic life by altering pH levels.

- EP (Eutrophication Potential): EP measures the potential of emissions to contribute to eutrophication, which is the excessive growth of algae and plants in water bodies due to nutrient enrichment, leading to ecological imbalances.

- POCP (Photochemical Ozone Creation Potential): POCP assesses the potential of emissions to contribute to the formation of ground-level ozone, a harmful air pollutant that affects air quality and human health.

- ADPE (Abiotic Depletion Potential- Elements): ADPE quantifies the potential depletion of abiotic resources, specifically elements, due to the product's life cycle. It considers the impact on the availability of elements required for various purposes.

- ADPF (Abiotic Depletion Potential- Fossil Fuels): ADPF focuses on the potential depletion of fossil fuel resources due to the product's life cycle, highlighting the impact on non-renewable energy sources.

- WDP (Water Depletion Potential- Water Scarcity): WDP assesses the potential depletion of water resources in regions where water scarcity is a concern. It quantifies the impact of water consumption on the availability of freshwater resources in areas where water scarcity may be exacerbated by human activities.

- PM (Particulate Matter- Respiratory Inorganics): PM assesses the potential harm to human health due to the release of fine particulate matter containing respiratory inorganic substances. It focuses on the impact of airborne particles on respiratory systems and related health effects.

- IR (Ionizing Radiation): IR evaluates the potential exposure of individuals to ionizing radiation during the life cycle of the product. It considers both the emissions of ionizing radiation and the associated health risks to humans and the environment.

- ETP-FW (Ecotoxicity- Freshwater): ETP-FW assesses the potential harm to freshwater ecosystems due to the release of ecotoxic substances. It considers the impact on aquatic organisms, aquatic habitats, and the overall health of freshwater ecosystems.

- HTP-c (Human Toxicity Potential - Cancer Effects): HTP-c quantifies the potential impact of emissions on human health, specifically focusing on cancer-related effects. It considers the exposure to substances that may cause cancer and the associated health risks.

- HTP-nc (Human Toxicity Potential - Non-Cancer Effects): HTP-nc evaluates the potential impact of emissions on human health, focusing on non-cancer-related effects. It considers the exposure to substances that may lead to non-cancer health issues and associated risks.

- SQP (Spatial Quality of Land- Soil Quality): SQP assesses the potential impact of land use on soil quality in the surrounding environment. It considers the potential degradation of soil due to land use changes and associated environmental consequences.

# VERSIONS

V1.01, 2024-01-25:
Editorial and typo improvements, some tables were modified in format, correction in total results and percentages.

# REFERENCES

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The International EPD® System/ The International EPD® System is a programme for type III environmental declarations, maintaining a system to verify and register EPD®s as well as keeping a library of EPD®s and PCRs in accordance with ISO 14025. www.environdec.com

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