Zefiro™ Express high-speed train

Västtrafik X80
Environmental Product Declaration in accordance with ISO 14025

Programme operator: EPD International AB
Programme: The International EPD® System, www.environdec.com

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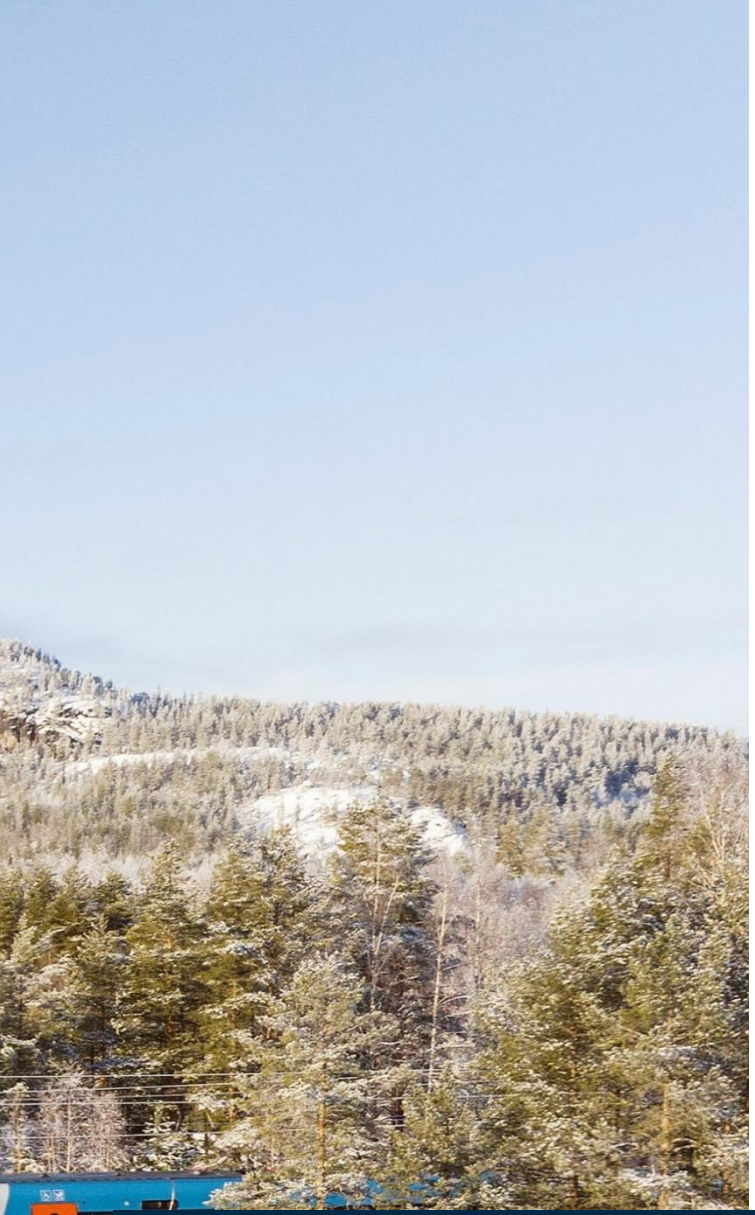
västtrafik
västtågen



Alstom, at the forefront of sustainability

Alstom develops and offers a range of systems, equipment and services for the rail sector and key to its mission is supporting the transition towards global sustainable transport systems that are inclusive, safe and efficient.

As a promoter of sustainable mobility, Alstom places environmental issues at the heart of its R&D strategy, constantly designing solutions and products which are less energy-consuming, quicker to install, cheaper to maintain, and with higher lifespan and reduced carbon footprint.

For more than 25 years, the company has worked systematically by introducing Ecodesign in its engineering procedures.

Today, Alstom can rely on a team of Ecodesign engineers to ensure the environmental performance of its portfolio and its ability to develop innovative solutions tackling key environmental challenges.

Sustainable mobility

Alstom's mission is to support the transition to sustainable transport systems by delivering mobility solutions that are safe, environmentally friendly, reliable and inclusive everywhere in the world.

ISO 14001

Environmental Management

Alstom has an environmental management system fully in place and targets 100% of manufacturing sites and regional centers with over 200 employees to be certified according to ISO 14001:2015 Standard for Environmental management.

In the environmental management system, Alstom is including the life cycle perspective of products, from concept to recycling including maintenance and energy consumption. Alstom offers innovative solutions that respect the environment and meet the mobility needs according to a socially responsible model.

To continuously improve Alstom products and ways of working, environmental targets for sites and products are implemented and regularly evolved following return of experience and best practice.

Communicating Environmental Performance

Alstom communicate the environmental performance of products through Environmental Product Declarations (EPDs) following the International EPD® System. EPDs are developed in line with the Product Category Rules for Rolling Stock (PCR 2009:05 Rolling stock and parts thereof (4.0.2)) as well as the principles and procedures of ISO 14025:2006.

They are based on Life Cycle Assessment methodology and function as an externally validated communication tool, providing complete transparency to the benefit of customers and other stakeholders. The external validation is carried out by independent verifiers approved by the technical committee of the International EPD® System.

Life cycle assessment (LCA) is a technique assessing the environmental impacts associated with all stages of a product's life cycle from cradle to grave (i.e., from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling).

Zefiro Express X80

The Zefiro Express X80 train is part of Alstom's high-speed train platform, covering maximum operating speeds between 200 km/h and 350 km/h.

This Environmental product declaration provides a detailed insight into the environmental impact of the Zefiro Express X80 train for Västtrafik (VT) throughout its complete life cycle.

The three-car vehicle is designed to support the growth of the Västra Götaland region, with high passenger capacity and low operational costs. To offer high capacity as well as different seating and standing options, the width of the carbody has been optimized to fit a comfortable 2+3 seating arrangement as well as multi-functional areas.

Product information

The Zefiro Express X80 high-speed train is designed to operate in Scandinavia during all seasons of the year with outdoor temperatures ranging between -40 °C and + 35 °C. The trains will cover the Västra Götaland region at up to 200 km/h with space for 270 seated passengers, multi-purpose areas and Wi-Fi. The pressure-tight carbody design will deliver a smooth travel experience, minimizing vibrations and noise. Passengers with reduced mobility will benefit from the low-floor car with a dedicated accessibility area, offering a convenient and comfortable ride for everyone.

Key benefits with Zefiro Express X80

A safer environment

A vehicle developed with a strong emphasis on our commitment to eliminate hazardous substances in the product as well as during production providing a safer environment for our customers, passengers and employees.

A satisfactory working environment

A cab developed to provide a safe and satisfactory working environment for the driver by ensuring great visibility and automatic air-conditioning.

High energy efficiency

A vehicle equipped with energy-efficient solutions that are profitable from a life cycle perspective. The drive system is optimized for maximum regeneration with the electrodynamic brake and energy consumption is reduced through the design by a low vehicle weight and an optimized underframe for low running resistance.

A vehicle designed for all

A vehicle designed for all, Zefiro Express X80 provides a mix of quiet spaces- and social areas, suitable both for work and rest, and for those traveling with family or friends. The train is designed with extra wide doors to ensure easy access for all travelers including persons with disabilities and those traveling with small children and strollers. Optimized solutions for universal space inside the train is offered to ensure space for luggage, bicycles, etc.

Main characteristics	Vehicle data
Type of vehicle	Zefiro Express X80
Configuration	3-cars; low-floor and high-floor entrance
Expected service lifetime	30 years
Production site	Alstom Sifang Transportation Ltd Qingdao Alstom Transportation Hennigsdorf
Length over coupler covers	80.7 m
Width	3450 mm
Weight (empty)	173 ton
Bogies	FLEXX™ Compact bogie with radial steering capability
Wheel diameter (new wheels)	920 mm
Doors per side	4 doors
Door width	1400 mm
Seats	270 seats
Standing	320
Voltage	15 kV 16 2/3 Hz
Maximum operation speed	200 km/h
Features	Adapted for Scandinavian climate

Carbody

Aluminium structure

Comfort

Efficient air-conditioning ventilation systems that is automatically adjusted based on CO_2 levels in the passenger saloon.

Propulsion and electrical equipment

Energy recovery through braking.

Material selection

Materials selected to be recoverable at end-of-life.

Life cycle description

Environment impacts of Zefiro Express X80 trains have been characterized through the realization of a cradle-to-grave LCA in accordance with ISO 14040:2006 and ISO 14044:2006 methodology, and the requirements of the PCR 2009:05 Rolling stock and parts thereof (4.0.2). The GaBi Software System version 10.7.1.28 and the Database 2023.2 for Life Cycle Engineering were used to perform this life cycle impact assessment.

Functional unit

The functional unit for the performed LCA is 1 passenger over a distance of 1 km, using a 3-car rail vehicle in service for 30 years primarily in the Västra Götaland region with 270 seated passengers (AW1) and an average running distance of 300 000 km per year.

Cut-off rules

The exclusion rules applied are in line with the indications of the PCR 2009:05 Rolling stock and parts thereof (4.0.2).

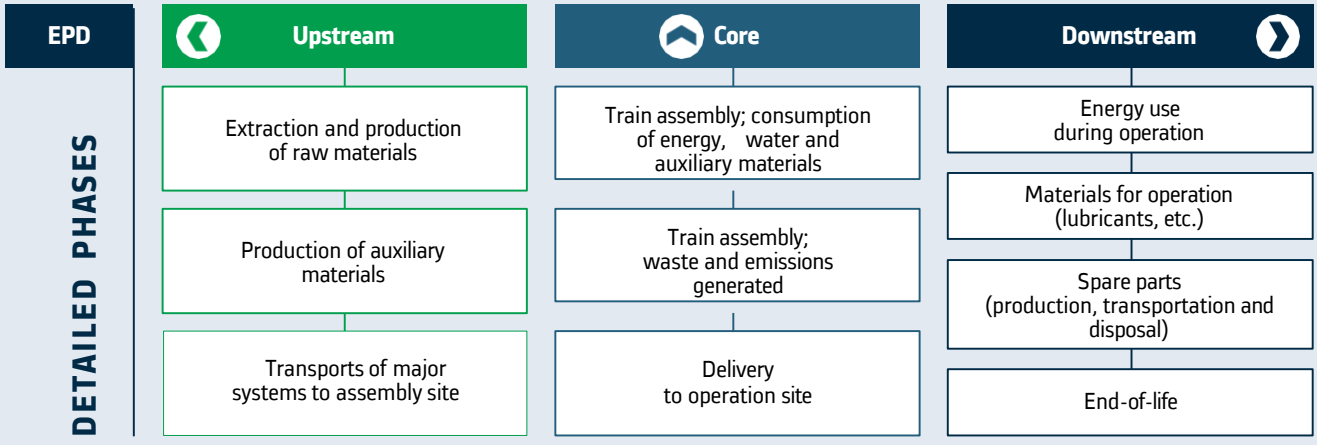
Life cycle boundaries

The material composition of the Zefiro Express X80 train is based on the Alstom engineering system and material information received from sub-suppliers. Energy consumption and production for the different material production processes is included in the datasets provided in GaBi.

Production data for the train have been collected from the assembly sites in Qingdao (China), Siegen (Germany), and Hennigsdorf (Germany). Resources and energy used within the core module are country specific data from the environmental reports from the production sites relevant for 2020 and 2021.

The power supply for the train operation is the specific mix of hydro and wind power, purchased by the Customer from the Swedish Transportation Authority. Data for used maintenance materials is based on the systematic and conditional preventive maintenance. The production of maintenance materials is assumed to be at the same location as for the material used for the initial production.

The end-of-life modelling of the Zefiro Express X80 train follows the steps based on the ISO 21106:2019 methodology. It is assumed that the train will be dismantled and disposed of in Sweden. The potential benefit from material recycling and energy recovery is not included in the environmental impact.



Allocations

In the upstream module, no allocation is required except the allocations built into the databases of the LCA software. For the train assembly in the core module, the impact of the production plant is allocated by number of cars produced, for the production sites in Qingdao and Hennigsdorf, and allocated by mass for the production site in Siegen.

Impacts and benefits of the recycling of waste are excluded from the scope of the study. Burden linked to incineration are included, but impact and benefits linked to the use of the energy from incineration are also excluded.

Data quality

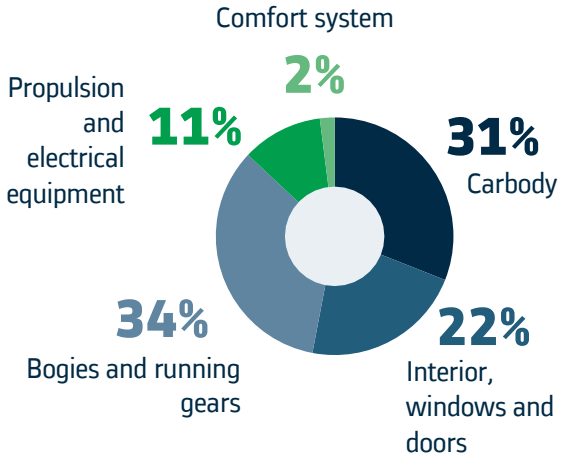
Whenever possible, specific data was used. In particular, 99.65% of the mass of the train and the spare parts were inventoried with specific data, the rest being modelled according to the PCR for Rolling stock (PCR 2009:05 Rolling stock and parts thereof (4.0.2)).

Specific transportation data was collected for 68% of the delivery of components to sites, the rest is modelled with a truck transport for 500 km, in line with the PCR for Rolling stock (PCR 2009:05 Rolling stock and parts thereof (4.0.2)).

Content declaration

Rolling stock manufacturing

Share of mass by PCR categories



Rolling stock composition

Top four metals for manufacturing (metric tons)

21%

of recycled (post-consumer) content included in the train. This number is based on specific supplier data and global average values of recycled content within materials.

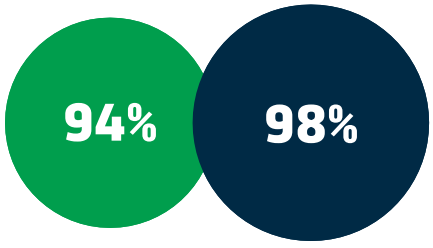
Bill of materials (mass in kg)	Upstream (vehicle)	Downstream (spare parts)*	TOTAL
Metals	141 951.63	173 087.15	315 038.78
Electric and Electronic Equipment (EEE)	4 067.00	1 588.17	5 655.17
Polymers – filled and unfilled	8 060.88	439.37	8 500.25
Glass / Safety Glass	4 270.79	0.80	4 271.59
Elastomers	2 407.51	2 603.87	5 011.38
Composites	670.25	367.00	1 037.25
Modified Organic Natural Materials (MONM)	1 037.90	0.17	1 038.07
Oil, grease, etc.	1 203.48	326.52	1 530.01
Mineral Wool	648.24	0.00	648.24
Acids, cooling agents, etc.	33.80	0.00	33.80
Other	9 124.67	829.46	9 954.13
TOTAL	**172 827.91**	**179 242.52**	**352 070.43**

* The mass of materials in the downstream module is larger than in the upstream module to the change of spare parts, i.e. wheelsets, brake pads, and other components occurring several times during the vehicle's lifetime.

Hazardous substances

Alstom's standard for hazardous substances management considers European regulation (REACH) and railway sector principles through the RISL (Railway Industry Substances List), which has been considered during the design of the train as well as for chemicals used during maintenance.

In some areas, use of hazardous substances according to RISL has not been avoidable due to functional and safety requirements, including lead in electronics as well as the refrigerant gas mix used for the air conditioning system. However, no hazardous substances are used in any prohibited application at the time of production of the Zefiro Express X80 train.



Recyclability rate **Recoverability rate**

A recyclable solution

Using materials featuring high recyclability and considering disassembly early in the design phase maximise the overall recoverability of the Zefiro Express X80. Material recycling and energy recovery aggregate to a 98% recoverability rate by applying ISO 22628:2002 methodology. This methodology has been used as per the customer request.

Additional information

Energy consumption during operation

The energy consumption of the Zefiro Express X80 train for Västra Götaland region is 4.91 kWh/km. The energy consumption data is based on a simulated run between station Göteborg-Skövde-Göteborg with 2 intermediate stops and a roundtrip distance of 288 km. The assumption is that the vehicle is fully loaded with seated passengers (AW1), and all auxiliary and passenger comfort systems operating at normal conditions. Regenerative braking is included depending on the environmental conditions and drivers' operations.

Västtrafik uses an energy mix consisting of 83% hydro power and 17% wind power, the energy mix is provided by the Swedish Transport Administration (Trafikverket). The environmental impact from the electricity generation has been modelled based on information provided by internal resources at Trafikverket for the year 2022. The calculated environmental impact per functional unit of the Operation phase for the "Climate Change – total" category is 2.65E-04 kgCO2 eq.

Electricity net losses are accounted for in the model within the datasets used for the upstream and core modules. For the downstream module, the electricity net losses are considered by modelling the "as delivered" amount of electricity, and not the impact for the "as produced" amount (according to the Vattenfall EPDs for hydro power and wind power). The vehicle electricity net losses are part of the energy calculation.

	Operation
Energy consumption while running	4.91 kWh/km
Distance travelled per year	300 000 km
Roundtrip distance (for energy calculation)	288 km
Operation time	30 years
Number of passengers (for energy calculation)	270

Noise emissions

	Unit	dB(A)
Stationary noise	LpAeq	≤ 65
Pass-by at 80 km/h	LpAeq	≤ 80
Pass-by at 200 km/h	LpAeq	≤ 92
Acceleration	LpAfmax	≤ 80

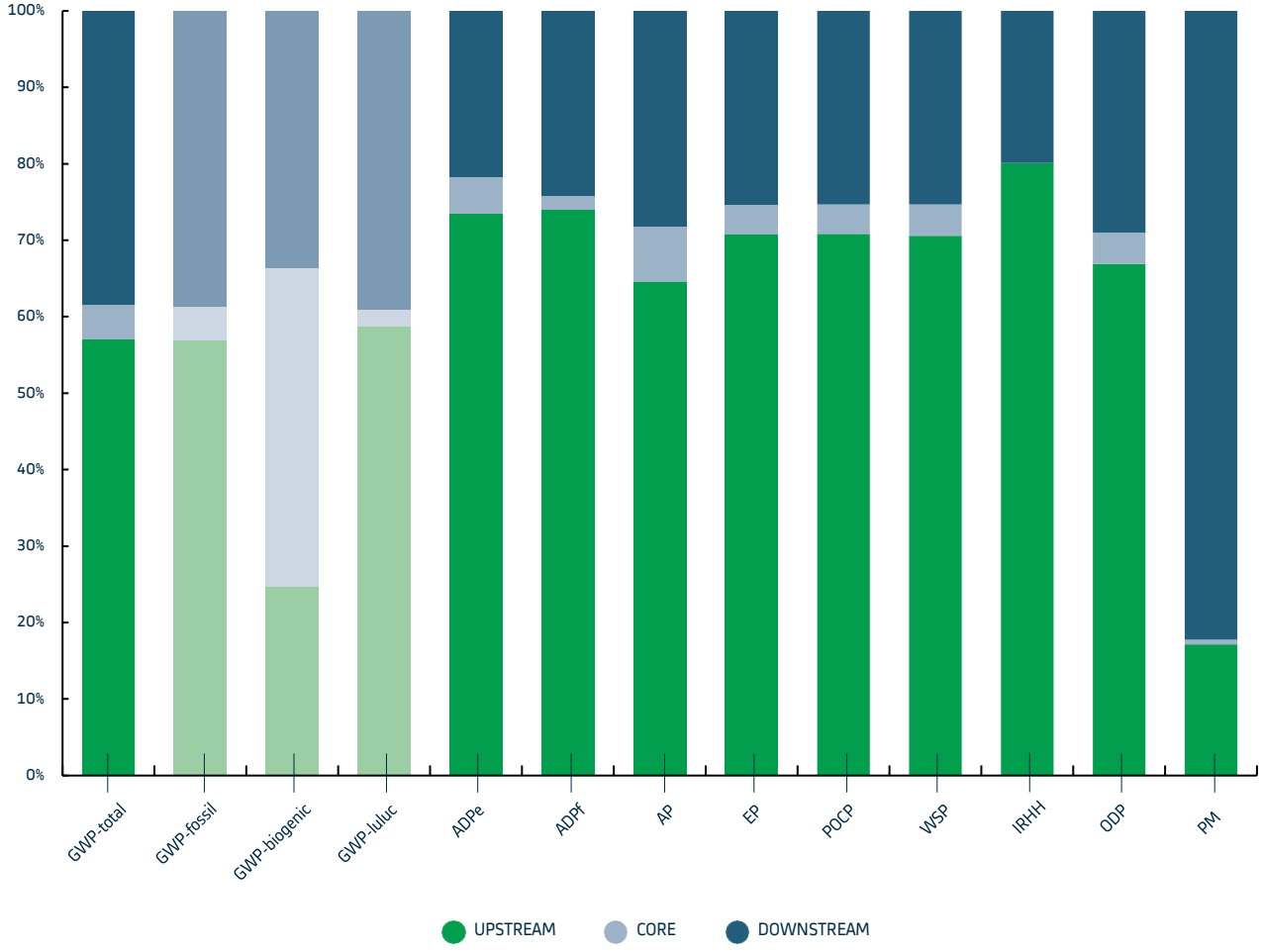
The exterior noise limits for the Zefiro Express X80, based on the TSI NOI. Exterior noise is measured in accordance with the ISO 3095:2013.

Environmental performance

Contribution of each phase to the environmental impacts

The relative contribution per functional unit from each phase of the life cycle of Zefiro Express X80.

The main impact comes from the Upstream module and the Downstream module. The Core module including production and assembly in Qingdao (China), Siegen (Germany) and Hennigsdorf (Germany) contributes the least to all impact categories analysed. The impact categories follow EN15804 + A2 as required by the PCR for Rolling Stock (PCR 2009:05 Rolling stock and parts thereof (4.0.2)).



Configuration

Life cycle description information and environmental performance results published in this EPD correspond to the one of the design configurations developed by Alstom. To know the performance associated to other possible configurations of the solution, please contact Alstom.

Environmental impacts (indicator per functional unit*)	Unit	Upstream	Core	Downstream	TOTAL
Climate Change - total	[kgCO2 eq.]	7.55E-04	6.61E-05	5.25E-04	**1.35E-03**
Climate Change, fossil	[kgCO2 eq.]	7.55E-04	6.54E-05	5.24E-04	**1.34E-03**
Climate Change, biogenic	[kgCO2 eq.]	4.55E-07	6.19E-07	6.87E-07	**1.76E-06**
Climate Change, land use and land use change	[kgCO2 eq.]	1.55E-07	6.41E-09	1.13E-07	**2.75E-07**
Ozone depletion	[kg CFC-11 eq.]	4.72E-15	1.32E-17	1.40E-15	**6.14E-15**
Acidification	[Mole of H+ eq.]	4.04E-06	1.04E-07	1.33E-06	**5.48E-06**
Eutrophication, freshwater	[kg P eq.]	7.08E-10	1.57E-11	3.25E-10	**1.05E-09**
Eutrophication, marine	[kg N eq.]	5.95E-07	3.41E-08	2.17E-07	**8.47E-07**
Eutrophication, terrestrial	[Mole of N eq.]	6.47E-06	3.70E-07	2.35E-06	**9.19E-06**
Photochemical ozone formation, human health	[kg NMVOC eq.]	1.85E-06	1.13E-07	6.71E-07	**2.63E-06**
Resource use, mineral and metals	[kg Sb eq.]	1.30E-08	4.11E-13	3.23E-09	**1.62E-08**
Resource use, fossils	[MJ]	7.56E-03	5.68E-04	3.34E-03	**1.15E-02**
Water use	[m³ world equiv.]	1.91E-04	6.49E-06	9.18E-04	**1.12E-03**

* To convert the results to one unit of product, a conversion factor of 2.43E+09 shall be used.

Use of resources		Unit	Upstream	Core	Downstream	TOTAL
RENEWABLE RESOURCES (per functional unit*)						
Primary energy resources	Used as energy carrier	MJ, net calorific value /pass. km	2.52E-06	3.02E-05	9.23E-02	9.23E-02
	Used as raw materials	MJ, net calorific value /pass. km	6.39E-04	1.54E-06	3.10E-04	9.50E-04
	TOTAL	**MJ, net calorific value /pass. km**	**6.41E-04**	**3.18E-05**	**9.26E-02**	**9.33E-02**
NON-RENEWABLE RESOURCES (per functional unit*)						
Primary energy resources	Used as energy carrier	MJ, net calorific value /pass. km	5.05E-06	5.57E-04	5.99E-04	1.16E-03
	Used as raw materials	MJ, net calorific value /pass. km	7.56E-03	4.62E-06	2.69E-03	1.03E-02
	TOTAL	**MJ, net calorific value /pass. km**	**7.57E-03**	**5.62E-04**	**3.28E-03**	**1.14E-02**

* To convert the results to one unit of product, a conversion factor of 2.43E+09 shall be used.

Global warming potential

These indicators calculate the contribution to global warming of the planet by the emission of greenhouse gases. GWP is expressed as: GWP-fossil, GWP-biogenic, GWP-land use and land use change (luluc),and GWP-Total (the sum of the other three GWP indicators).

The result is expressed in kg CO_2 equivalents.

Depletion of abiotic resources-elements*

This indicator calculates the depletion of non-fossil resources, i.e., mineral and metallic resources.

The result is expressed in kg Sb equivalents.

Depletion of abiotic resources-fossil fuels*

This indicator calculates the depletion of fossil energetic resources (gas, coal, etc.)

The result is expressed in MJ.

Acidification potential

This indicator calculates the potential atmospheric acidification caused by the emission of gas with an acidifying effect.

The result is expressed in kg SO_2 equivalents.

Eutrophication potential

This indicator calculates the eutrophication potential of water caused by the emission of specific substances (discharge of phosphoric, nitrogenous and organic matter).

The result is expressed in kg phosphate equivalents.

Photochemical ozone creation potential

This indicator calculates the potential of certain gases (NOx, CO, VOCs, etc.) to create ozone in the troposphere under the effect of solar radiation.

The result is expressed in kg ethylene equivalents.

Water scarcity potential*

The indicator represents the potential to deprive human or ecosystem when consuming water in a considered area, considering both availability and demand.

The result is expressed in m^3 equivalents deprivation.

Ionizing radiation – human health

This indicator represents the emissions of radionuclides with damage to human health and ecosystems (generally linked to use of nuclear power in an electricity mix)

The result is expressed in kg U235 equivalents.

Emission of ozone-depleting gases

This indicator calculates the contribution made by the discharge of specific gases responsible for ozone layer depletion.

The result is expressed in kg CFC-11 equivalents.

Particulate matter

Health impact of emissions of small particles and liquid droplets (e.g., organic chemicals, soil or dust particles)

The result is expressed in disease incidence.

* The results of this environmental impact indicator shall be used with care as the uncertainties of the results are high and as there is limited experience with the indicator.

Programme information

This Environmental Product Declaration (EPD) is based on a product Life-Cycle Assessment according to ISO 14040:2006/ISO 14044:2006 and is compliant with the requirements set in ISO 14025:2006. Alstom, owner of the EPD, has the sole ownership, liability and responsibility of the EPD.

EPDs within the same product category but from different programmes may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison.

Accountabilities for PCR, LCA and independent, third-party verification

Product category rules (PCR)

Product Category Rules (PCR) 2009:05 Rolling stock and parts thereof (4.0.2)
PCR review was conducted by: The Technical Committee of the International EPD® System. Chair: Nasser Ayoub.
The PCR review panel may be contacted via info@environdec.com.

Life cycle assessment (LCA)	**LCA accountability**	Railify AB Vasagatan 12 Stockholm, Sweden	**EPD owner** Alstom 48, rue Albert Dhalenne 93482 Saint-Ouen, Cedex France

Third party verification

Independent verification of the declaration and data, according to ISO 14025:2006 via:

■ EPD verification by individual verifier

Third party verifier	Martin Erlandsson IVL Swedish Environmental Research Institute Stockholm martin.erlandsson@ivl.se	**Approved by**	The International EPD® System

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

☐ Yes ■ No

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