EPD®

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

METRO UNITS M300
for Helsinki Metro Transport
Environmental Product Declaration according to ISO 14025

CAF provides a sustainable development testimony, capitalizing knowledge to **lead and innovate** in the development of their own state-of-the-art technology which promotes **efficiency, safety and comfort** in our products.

A new generation of train that guarantees maximum power efficiency and full passenger ride comfort. **Versatile, with Personality and Environmentally Friendly.**

Environmental Product Declarations Programme:
The international EPD® System
operated by EPD International AB
www.environdec.com

Independent verification of the declaration and data, according to ISO 14025:2006:
□Internal ■External

Third Party Verifier:
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LCA study: IK Ingenieria www.ik-ingenieria.com

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PCR review was conducted by:
The Technical Committee of the International EPD® System
Chair: Massimo Marino
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CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

CAF'S COMMITMENT

**Railways and the environment.
On track for efficiency.**

Construcciones y Auxiliar de Ferrocarriles S. A., CAF, is one of the international benchmarks in the design and implementation of comprehensive rail solutions. Proximity and awareness of customers' needs allow CAF to design comprehensive and complete high added-value solutions, developed based on the company's own state-of-the-art technologies, tailored to meet the specific needs of each transport authority, minimising operating cycle costs. The CAF group employs a workforce of more than 8,000 worldwide.

This education level combined with a commitment to R+D+I and the know-how built up from over 100 years of experience, has meant that CAF has continued to lead and innovate their own state-of-the-art technology which has significantly improved efficiency, safety and comfort of its products and of the sector itself. This technology includes solutions such as the GREENTECH energy efficiency family with the EVODRIVE kinetic energy recovery system, the FREEDRIVE for catenary-free running, or the EDRIS energy consumption controller, and others for the control of fleets and their maintenance such as AURA, NAOS for traffic and energy control, together with AURIGA the ERTMS wayside and onboard system of the CAFs group.

CAF's group integrates Corporate Social Responsibility into the company's general policy, and is fully aware of the potential impact of industrial activities on the environment. For this reason the organisation includes Environmental protection as one of its primary objectives.
CAF's environmental management is aimed at controlling and minimizing environmental impact from emissions into the atmosphere, residues and energy consumption, with the principle aim of preserving natural resources. To achieve this CAF has implemented a sustainability function into the production processes, making the most of natural resources and generating energy via renewable methods. The CAF group operates photovoltaic solar, small scale wind and sustainable mobility business, with a hydroelectric plant, and photovoltaic panels at their facilities to meet the energy requirements: The implemented environmental management system has been certified in accordance with ISO 14001 since 2001.

In order to provide more efficient and more environmentally friendly means of transport, CAF is currently implementing the "Product Sustainability Function", introducing ecodesign methods in the engineering processes to optimise and control, the environmental impact of products throughout their entire operating cycle.

As a result, CAF has developed this verified EPD® of their Metro vehicle for the Helsinki City Transport (HKL)

M300 UNIT
For Helsinki Metro Transport

Bidirectional electric metro unit for Finnish track gauge (1,524 mm) consisting of four cars (three motor cars and one intermediate trailer car).

End cars (A) have a temporary driver cab at their free end and a gangway on the opposite end. Intermediate cars (B1 and B2) have gangways on both ends: this allows passengers to circulate freely between cars.

Motor cars (A and B1) are fitted with two motor bogies, each with two motor axles. The trailer car (B2) is identical to the intermediate motor car with regards to the interior design and the structure with the exception of the equipment mounted and the fact that it is not motorised.

The train is designed to be coupled with other units or with a locomotive for the rescuing and towing of units. Automatic couplers are provided for this purpose which permit rapid coupling/uncoupling of units.

The Helsinki Metro system terms for migration from a manual to fully automatic system have meant that the trains have been designed to house a temporary cab with an off-centre driver post with all the functions required for safe operation with a driver. Once the Helsinki Metro system has been fully developed, the temporary cab will be dismantled with the driver desk concealed and the cab becoming part of the passenger area.

The train has been designed such that minimal changes can provide for a safe and comfortable service in the various existing grades of automation (GoA1, GoA3 and GoA4).

Technical datasheet

Composition:	Mc-M-T-Mc
Power supply voltage:	750 Vdc
Track gauge:	1,524 mm
Maximum speed:	100 km/h
Length:	88,220 mm
Exterior width:	3,200 mm
Vestibule area floor height:	1,110 mm
Total capacity:	1,028
Places for wheelchairs:	4
Number of doors per car and side:	3
Width:	1,400 mm
Height:	1,950 mm

Performance

Maximum design speed:	100 km/h
Maximum service speed:	90 km/h

DRIVERLESS METRO SOLUTIONS
For the cities of the future

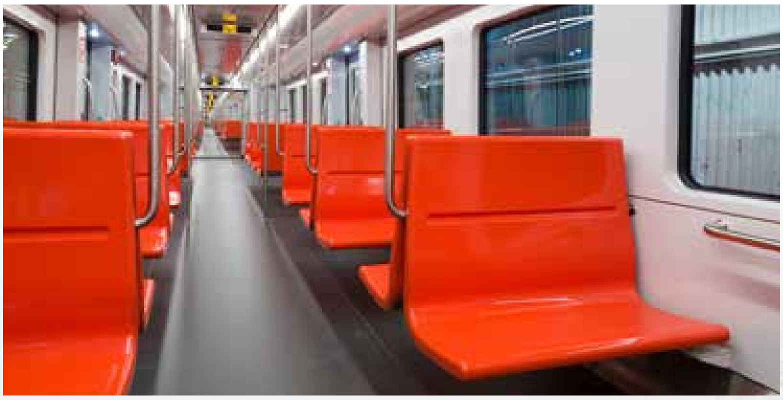
Future metropolitan environments will demand efficient metro solutions providing high comfort standards to the increasing volume of passenger transit. Metro network automation translates into reduced operating costs and yet it provides exacting punctuality and maximum passenger comfort.

Furthermore, this type of systems ensures maximum safety as a result of advanced technology applied to the monitoring of operation and the prevention of human error.

CAF has several metro project references designed to operate according to varying levels of automation, including driverless operation. This technology brings a good number of benefits both for the system operator and the final users alike:

- Higher transit capacity based on shorter headway.
- Less waiting time for higher user satisfaction.
- Higher fleet availability and reliability rates.
- Flexibility of design of line operation.
- Optimization of maintenance and life cycle costs.
- Reduction of operating costs

Main equipment



Traction and auxiliary systems

Third rail current collection by bogie-mounted current collectors.

Double traction converters, one per motor car, cooled by forced convection. Each converter has 2 independent inverters and each of them in turn supplies two traction motors.

Rheostatic dynamic brakes with forced convection brake resistor and the possibility of regenerative brakes with current return.

Each motor car has its own traction set (1 traction converter box with 2 traction inverters, brake resistors and 4 traction motors).

3-phase asynchronous squirrel-cage rotor type traction motors. These are self-ventilated and closed, protected by the thermal model.

The static converter

The static converters which produce the electrical energy required to supply all the auxiliary service loads at 230/400 Vac and 110 Vdc including battery charging, are integrated in the traction boxes.

Weather conditions

Taking account that the Helsinki Metro operates both outdoors and inside tunnels, the M300 series Metro Helsinki vehicle has been designed for commercial operation in extreme temperatures ranging from -40 ºC to +35 ºC.

The vehicle design has also taken account of other environmental factors such as snow accumulation, ice formation, low track adhesion and sharp shifts in temperature in short spaces of time.

Energy efficiency

HVAC

Each car is equipped with two separate units: an underframe-mounted heating unit and a roof-mounted cooling unit. Both units are centred on each car.

The heating box houses the brake resistors for enhanced energy efficiency. The heat dissipated on brake resistors is used to condition the air inside the car in winter. Additional heat resistors are used when the brake resistors do not provide enough heat for adequate interior air conditioning. All heating is discharged at floor level.

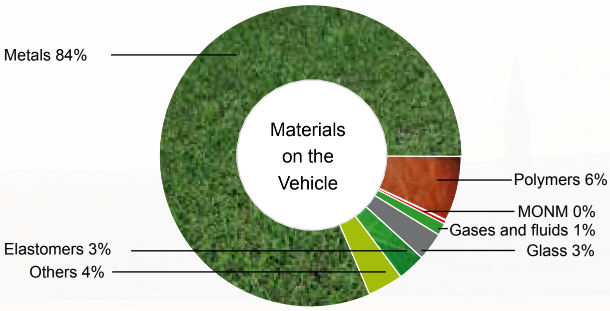
The roof-mounted air conditioning unit serves to cool the inside of the car. Cold air is distributed by means of two ceiling central ducts.

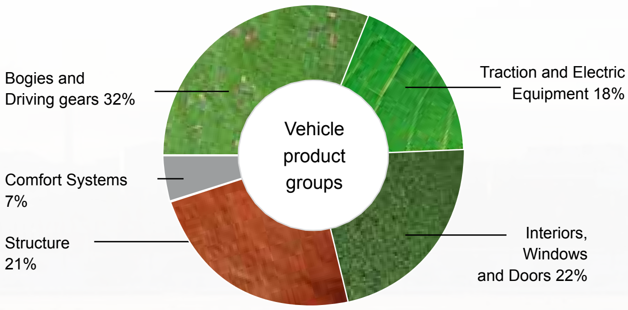
LIST OF MATERIALS

In the design of the M300 Units, materials have been selected, according to the functional, technical and regulatory requirements, as well as considering their recyclability and ease of dismantling at the end of their operating life. The following table shows the summarised inventory of the train materials, according to the ISO 22628 standard categories and the product groups of the EN 15380-2.

Materials used M300 units	Vehicle materials (UPSTREAM)					
	Structure	Interior, windows and doors	Bogies and running gears	Traction and electric equipment	Comfort systems	TOTAL
Metals	20,61%	10,71%	30,72%	15,50%	6,30%	**83,84%**
Polymers	0,46%	3,92%	0,02%	1,10%	0,15%	**5,65%**
Elastomers	0,03%	2,06%	0,84%	0,33%	0,05%	**3,30%**
Glass	0,04%	2,78%	0,00%	0,03%	0,19%	**3,04%**
Gas & Fluids	0,00%	0,00%	0,02%	0,25%	0,02%	**0,30%**
MNOM*	0,00%	0,12%	0,00%	0,05%	0,02%	**0,18%**
Others	0,02%	2,16%	0,16%	1,20%	0,17%	**3,69%**
TOTAL	**21,15%**	**21,74%**	**31,76%**	**18,46%**	**6,89%**	**100,00%**

* Modified natural organic materials





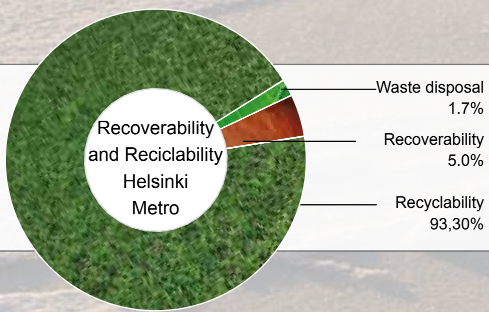
In accordance with their policy, CAF meets the environmental requirements right from the very first stages of their projects. When designing the M300 Unit, CAF has observed and demanded that their suppliers apply the "Railway Industry Substance List" (www.unife-database.org) to eliminate the use of regulated materials that could affect the environment or people's health.

CAF has also taken into account specific material and chemical products restriction demanded by the customer. Disassembling is foreseen right from the design stage to enhance material separation and recycling of the vehicle when its end of life is reached.

POTENTIAL RECOVERABILITY AND RECYCLABILITY PROFILE

The recyclability potential has been assessed according to the methodology of standard ISO 22628. The M300 Unit train reaches high recyclability and recoverability rates: material recycling and energy recovery results on more than 98% recoverability rate.

Recoverability and recyclability potential according to ISO 22628	
Reciclability Rate	93,26%
Energy recovery	98,26%



PRODUCT ENVIRONMENTAL IMPACT

Noise

The noise level measurements are carried out according to the conditions defined in the standard ISO 3095 and the contract.

Outside noise emited	dB(A)
Stationary noise ***(1)***	< 75
Starting noise ***(2)***	< 77

(1) *In continuous mode at 1 m from the car at a height of 1,5 m from the top of the rail.*
(2) *At a distance of 7,5 m from the track centre line at a height of 1,2 m from the top of the rail.*

Energy Consumption

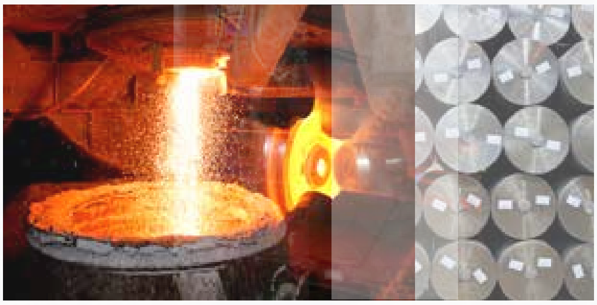
The M300 Units consumption during operation has been simulated in accordance with standard TS 50591_2013. A vehicle occupation capacity of 564 passengers has been considered in accordance with the Operational Mass in standard EN 15663.

The energy consumption results are calculated with catenary reception extreme values. Two possible scenarios are considered: One where the required energy during braking is regenerated on the catenary (100% receptivity) and another where all the energy is dissipated (0% receptivity). To calculate the environmental impact of the electricity consumption during the entire service life of the train, the routes and operating days specified in the contract have been considered (Ruoholahti-Mellunmäki-Ruoholahti route). HKL customer specific purchased electricity Mix has been taken as reference.

Electric consumption per functional unit	[Kwh/1pass.1km]
Manufacturing Phase	0,00011
Use Stage 0% receptivity	0,021
Use Stage 100% receptivity	0,012

The electric consumption for a passenger travelling 10 km is equivalent to approximately drinking 2,3 coffe cups or ironing 1 shirt.

Parts for bogie, wheels and axels made of steel are manufactured by CAF in its own foundry where recycled scrap is employed as core material. The benefit for the environment of recycling material has not been taken into acoount in this assessment.



ENVIRONMENTAL PROFILE OF THE PRODUCT LIFE CYCLE

Environmental profile for the functional unit [1pass.1km]	Material and component production [UPSTREAM]	Transport and vehicle assembly [CORE]	Vehicle use [DOWNSTREAM]				TOTAL	
			Energy consumption		Maintenance	End of Life	0% Receptivity	100% Receptivity
			0% Receptivity	100% Receptivity				
RENEWABLE RESOURCES CONSUMPTION								
Materials [kg/pass.1km]								
Water*	8,01E+00	7,38E-01	1,97E+02	1,15E+02	2,50E+00	2,45E-03	2,08E+02	1,27E+02
Carbon Dioxide	5,54E-06	7,80E-07	1,58E-06	9,27E-07	2,02E-06	8,19E-09	9,93E-06	9,28E-06
Wood	4,43E-06	5,04E-07	1,35E-06	7,89E-07	1,66E-06	6,81E-09	7,95E-06	7,39E-06
Others	6,18E-03	1,16E-03	1,27E+00	7,45E-01	1,78E-03	5,74E-06	1,28E+00	7,54E-01
Energy [MJ/pass.1km]								
Hydroelectric	8,18E-04	8,62E-05	4,29E-02	2,52E-02	2,51E-04	3,20E-07	4,41E-02	2,63E-02
Biomass	5,74E-05	8,68E-06	1,85E-05	1,08E-05	1,96E-05	7,98E-08	1,04E-04	9,66E-05
Wind	1,17E-05	8,95E-05	3,30E-02	1,93E-02	4,42E-06	2,47E-08	3,31E-02	1,94E-02
Solar	2,03E-07	2,15E-05	6,79E-08	3,98E-08	9,93E-08	4,49E-10	2,19E-05	2,18E-05
Geothermic	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NON RENEWABLE RESOURCES CONSUMPTION								
Materials [kg/pass.1km]								
Limestone	3,77E-05	2,60E-06	5,28E-05	3,09E-05	1,55E-05	9,81E-08	1,09E-04	8,69E-05
Iron	2,25E-05	8,33E-07	2,11E-05	1,23E-05	2,10E-05	4,96E-08	6,55E-05	5,67E-05
Resources from ground	1,31E-04	1,24E-05	4,33E-04	2,54E-04	4,61E-05	2,00E-06	6,25E-04	4,45E-04
Others	6,02E-08	2,30E-06	1,28E-03	7,47E-04	4,22E-06	2,04E-08	1,28E-03	7,54E-04
Energy [Kg/pass.1km]								
Uranium	2,13E-09	6,94E-10	5,56E-10	3,26E-10	6,79E-10	3,58E-12	4,06E-09	3,83E-09
Fuel Oil	4,20E-05	4,03E-06	1,17E-05	6,86E-06	1,43E-05	3,80E-07	7,24E-05	6,76E-05
Coal	7,63E-05	1,40E-05	3,09E-05	1,81E-05	3,55E-05	7,58E-08	1,57E-04	1,44E-04
Lignite	4,71E-05	3,42E-06	1,07E-05	6,28E-06	1,53E-05	6,09E-08	7,67E-05	7,22E-05
Natural Gas	3,51E-05	1,82E-05	1,32E-05	7,74E-06	1,17E-05	6,88E-08	7,82E-05	7,28E-05
WASTE [kg/pass.1km]								
Hazardous	1,41E-05	2,11E-06	3,03E-06	1,77E-06	2,94E-04	1,79E-04	4,93E-04	4,92E-04
Non Hazardous	9,52E-04	7,83E-06	1,20E-04	7,05E-05	3,88E-03	7,81E-03	1,28E-02	1,27E-02
Total	9,66E-04	9,94E-06	1,23E-04	7,23E-05	4,17E-03	7,99E-03	1,33E-02	1,32E-02
ENVIRONMENTAL IMPACT [/pass.1km]								
Global warming potential (kg CO2 eq.)	4,28E-04	9,08E-05	5,09E-04	2,97E-04	1,48E-04	1,29E-05	1,19E-03	9,76E-04
Acidification potential (kg SO2 eq.)	3,68E-06	4,36E-07	6,95E-07	4,05E-07	1,20E-06	6,94E-09	6,01E-06	5,72E-06
Eutrophication potential (kg PO4 eq.)	2,98E-06	1,08E-07	3,32E-07	1,93E-07	8,90E-07	2,28E-09	4,31E-06	4,17E-06
Photochemical oxidation power (kg C2H4 eq.)	2,10E-07	2,07E-08	1,27E-07	7,38E-08	7,63E-08	2,32E-10	4,34E-07	3,81E-07
Ozone depletion potential (kg CFC-11 eq.)	9,57E-11	9,93E-12	8,59E-12	5,00E-12	1,16E-11	1,98E-13	1,26E-10	1,22E-10

* Direct amount of water used by the core process: 3,55E-05 l/pass.km

The quality of the compiled data has been analysed with a Pedigree Matrix analysis (Pedigree Matrix - Weidema and Suhr Wesnaes, 1996). It has been verified that the quality of the data is “very high” in the CAF train assembly process and in the Civity train composition, and it is “high” quality for the environmental assessment basis data.

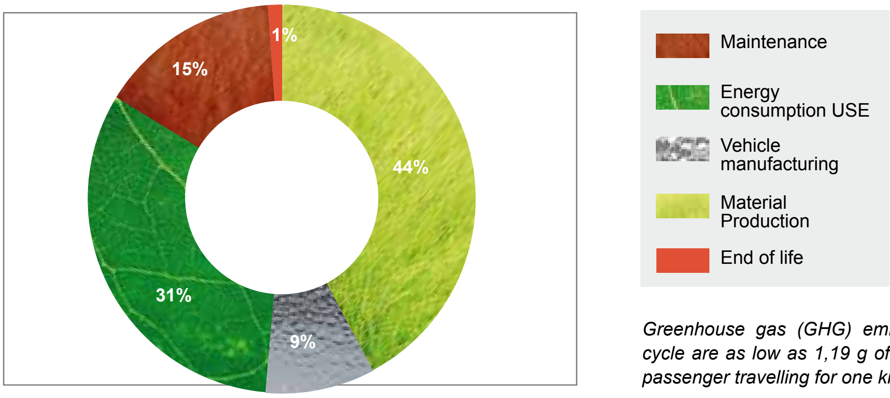
ENVIRONMENTAL PROFILE OF THE PRODUCT LIFE CYCLE

Consumption during the 20 years of operating life, thanks to the renewable electricity mix used by HKL vehicle operator and a low specific energy consumption per passenger, is not the main environmental impact during the all Life Cycle, as shown in the adjoining graph which uses the reference environmental indicator “Global Warming Potential”, for a 100% catenary receptivity scenario.

Under a Life Cycle approach, cost and environmental impacts reduction of the operation use have been core targets of the M300 Units design process to achieve one of the most environmental friendly metro units in the market nowadays.

A low specific energy consumption per passenger has been achieved, thanks to the lightness and large capacity of the train, together with a low consumption of maintenance material, as a result of the reliability and durability of the components, and the modularity and standardisation of the solutions employed.

Global warming potential (kg CO2 eq.) 100% receptivity



Greenhouse gas (GHG) emissions throughout the M300 Unit life cycle are as low as 1,19 g of CO2 equivalents when allocated to one passenger travelling for one km.

INFORMATION REGARDING THE ENVIRONMENTAL DECLARATION

This environmental declaration was made following the requirements of the reference document “Product Category Rules 2009:05 version 2.11 - UN CPC 495 Rolling Stock” published by Environdec (www.environdec.com) and is based on the data of the Helsinki Metro unit, for all the stages of the vehicle life cycle (production of raw materials and components, assembly of the vehicle, distributionuse and end of life).

The functional unit in this study is the transport of 1 passenger over 1 km and the operating life of the vehicle analysed has been set at 20 years.

The Helsinki Metro unitenvironmental impact study has been quantified by means of an Life Cycle Analysis in accordance with standards ISO 14040 and ISO 14044. The method of the characterisation of the environmental impact of the compiled operating life inventory was CML.

The LCAManager software was used to handle the operating life cycle inventory and to calculate the environmental impact.

Information regarding the materials and production of the vehicle has been obtained directly from the Management Systems of CAF and the information provided by the suppliers themselves for the year 2014. Data from the Ecoinvent database (version 2.2) has been used for the environmental definition of the processes and materials.

For bogie manufacturing in CAF-Beasain plant and vehicle assembly in CAF-Zaragoza plant, the effect of the procurement of materials and constituent components have been considered, as well as their transport to the plant (80,30% by weight of transport from suppliers have been measured and analyzed) and handling of the waste from both the assembly and dismantling of the vehicle. Transport ofthe vehicle from CAF-Zaragoza plantplant to the commissioning location in Helsinki has been considered also.

For the environmental impact of the energy consumption during assembly, the Spanish electricity production Mix has been taken into account, with data provided by the Spanish Electrical Grid (Red Eléctrica Española) for the year 2014 (year on which the train was manufactured).

For the environmental impact characterization of the energy consumption during use phase an average of 135 000 km per year has been considered, and the HKL specific purchased electricity 100% renevable Mix has been taken as reference (43% wind and 57% Hidroelectric).

The maintenance of the train has been considered for the entire operating life, with inventories for the materials and spare parts of a Life Cycle Cost (LCC) of Helsinki Metro unit study, which includes operation related consumables, but not those involved in train cleaning operations or passenger waste treatment and disposal.

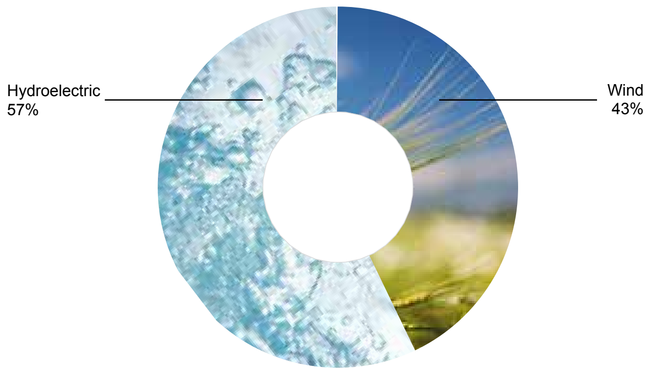
End of life, and vehicle dismantling stage has been modelled according to UNI-LCA-001:00 Railway Rolling Stock - Recyclability and Recoverability Calculation Method and the ISO 22628 has been used to perform the calculation of the recyclability potential. The potential advantage of recycling and recovery of the energy from incineration processes has not been accounted for in the study.

Reference Documentation

- ISO14040:2006. Environmental management. Life cycle assessment. Principles and framework
- ISO14044:2006. Environmental management. Life cycle assessment. Requirements and guidelines
- ISO 14025:2006 Environmental labels and declarations. Type III environmental declarations. Principles and procedures
- Product Category Rules 2009:05 version 2.11 - UN CPC 495 Rolling Stock
- General Programme Instructions for environmental product declarations, EPD, version 2.01
- ISO 22628:2002. Road vehicles. Recyclability and recoverability. Calculation method.
- TS 50591_2013 Specification and verification of energy consumption for railway Rolling stock.
- EN 15663:2009. Railway applications. Definition of vehicle reference masses.
- TSI Noise requirements. 2011/229/CE
- Railway Industry Substance List, versión 2011-03-01
- UNI-LCA-001:00 Railway Rolling Stock - Recyclability and Recoverability Calculation Method.

DEFINITIONS:

Vehicle operator (HKL) electricity Mix



Global warming (potential):

Greenhouse effect emissions into the atmosphere absorb some of the infrared solar radiation reflected on the earth's surface resulting in a troposphere temperature increase. The global warming potential is an index, in equivalent kg of CO_2, to measure the global warming contribution of a substance released into the atmosphere in a span of 100 years.

Acidification (potential):

Acidification results from the emission of sulphur dioxide and nitrogen oxides. In the atmosphere, these oxides react with the existing steam, forming acids which fall back to the earth in the form of rain or snow, or as dry deposits. Its effect on the earth generally shows itself in the form of reduced forest development and in aquifer ecosystems, such as lakes, acidification is apparent in the disappearance of some living organisms. Other objects such as constructions, monuments and buildings may also be damaged as a result of the effects of acid rain. Acidification potential measures an emitting substance's contribution to acidification expressed in sulphur dioxide equivalents (SO_2).

Eutrophication (potential):

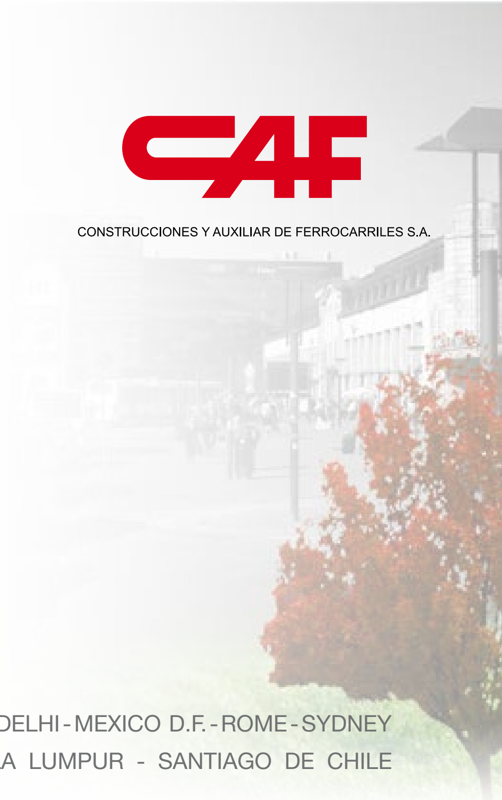
Eutrophication results in the enrichment of water ecosystems with organic compounds and nutrients, which give rise to an increased production of plankton, algae and other water plants with the resulting reduction in water quality. In this case the main sources related to this phenomenon are nitrogen and phosphorous. A secondary effect is the decomposition of dead organic material, a process which consumes oxygen and may result in anaerobic environments. The eutrophication potential, expressing in equivalent PO-43, quantifies nutrient enrichment via the release of a substance in water or land.

Ozone photochemical formation/ Photochemical oxidation (potential):

The photo-chemical formation of the ozone in the troposphere is mainly provoked by the decomposition of volatile organic compounds (VOCs) in the presence of nitrogen oxides (Nox) and light. The formation of ozone by means of this process can be quantified by using the so-called ozone photochemical formation potentials (POCPs) expressed in equivalent kg of ethane (C 2H4).

Ozone depletion (potential):

The ozone layer in the atmosphere protects the flora and fauna from harmful ultraviolet radiation from the sun. Some substances emitted into the atmosphere deplete this layer resulting in a higher level of UV radiation on the earth. The ozone layer depletion potential is the contribution of a substance compared with the impact caused by CFC-11.



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