EPD®

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

URBOS 100
for the City of Zaragoza
Environmental Product Declaration
according to ISO 14025

Technological Innovation in support of the **environment** to reach further with **less power consumption**. Based on a **catenary-free** innovative operating system, **Urbos 100** conforms to the strictest **environmental requirements**, for perfect integration in architectural environments while maintaining **high running performance**.

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:
Marcel Gómez Ferrer
www.marcelgomez.com
LCA study: Instituto Tecnológico de Aragón
www.itainnova.es

Registration number S-P-00284 V 2.0 / Date: 2015.03.05
Valid until 2018.03.05
UN CPC 495

EPDs within the same product category but from different programmes may not be comparable.

PCR review was conducted by:
The Technical Committee of the International EPD® System
Chair: Massimo Marino
Contact via info@environdec.com

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

CAF COMMITMENT

Railways and the environment. On track to efficiency.

CAF, CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. is an international leader in the in the design, manufacture, maintenance and supply of equipment and components for railway systems across the globe. The company was founded at the beginning of the 20th century and initially served primary industries in Northern Spain. Since then the company has grown into the international company it is today with over 7,000 qualified professionals, over 25% of whom are degree qualified. The company holds onto its roots with the company headquarters still being in the original site at Beasain.

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 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 hydro-electric 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 eco design methods in the engineering processes to optimise and control the environmental impact of products throughout their entire operating cycle.

As a result of this effort, CAF has developed this **world's first verified EPD®** of a tram: The **Urbos Tram for the city of Zaragoza**.

ZARAGOZA TRAM

The Zaragoza tram is a passenger urban transport vehicle belonging to the third generation Urbos redesigned to improve maintenance ease and lightness, reducing the consumption of both resources and energy during its entire operating life.

In 2009, CAF was awarded the production and delivery of 21 URBOS trams for the city of Zaragoza. These are 100% low floor and consist of 5 modules each. The units are fitted with an on-board energy storage system (ACR) which permits both catenary free LRV travel between stops, and energy saving via maximum braking energy recovery. The first unit was set into service in April, 2011.

The Zaragoza Tram Project was awarded “Best project in the world” in the “Light Rail Awards 2012”.

Technical Data

Composition	Mc-S-T-S-Mc
Train length (mm):	32.314
Maximum speed (km/h)	70

Equipment

Cab air conditioning
Passenger saloon air conditioning
Audio and visual information for passengers
Events recorder (black box)
Control and supervision system
On board passenger counting system
Video surveillance ACR

FREEDRIVE OPERATION

1. The vehicle starts running with the Freedrive system fully charged.

2. Between the stops the Freedrive system supplies energy to the traction system.

3. The kinetic energy generated during the braking phase is recovered in the Freedrive system starting the recharge process.

4. When the vehicle arrives at the stop, the Freedrive system is fully charged.

CAF Power & Automation GREENTECH FREEDRIVE
Free catenary movement

This is an on-board energy storage system which permits dispensing with the overhead electric lines (catenary) between stops in urban environments. The Rapid Charge Accumulator (ACR) is a groundbreaking technology, entirely unprecedented in revenue service, which contributes to improved integration of urban transport in the cities, reducing visual impact in heritage districts and increasing energy efficiency.

Accessibility

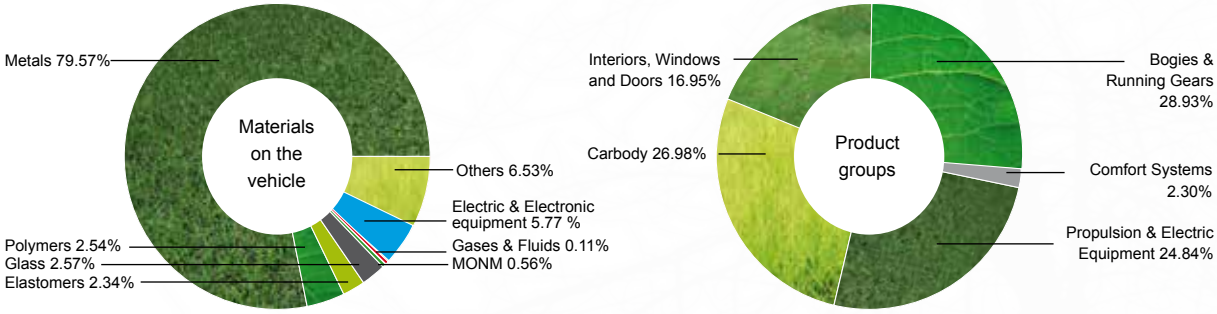
The Zaragoza tram has been carefully designed, in collaboration with persons with reduced mobility collectives, achieving a paramount comfort level for all passengers. The tram floor is low along the whole passenger saloon. In this way, the existing barriers are eliminated along the whole LRV and the entry and exit of passengers from platforms located at the level of the sidewalk is extremely comfortable.

LIST OF MATERIALS

In the design of the Urbos 100 for the City of Zaragoza, 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 tram materials.

Materials Used	Carbody	Interiors, Windows and Doors	Bogies and Running Gears	Propulsion and Electric Equipment	Comfort Systems	TOTAL
Metals	23,84%	10,38%	28,34%	14,94%	2,07%	**79,57%**
Polymers	0,01%	0,43%	0,09%	2,00%	0,01%	**2,54%**
Elastomers	0,92%	0,80%	0,37%	0,25%	0,01%	**2,34%**
Glass	0,00%	2,52%	0,01%	0,04%	0,00%	**2,57%**
Gases & Fluids	0,01%	0,00%	0,01%	0,09%	0,00%	**0,11%**
MONM*	0,00%	0,56%	0,00%	0,0018%	0,00%	**0,56%**
Electric & Electronic equipment	0,00%	0,11%	0,00%	5,67%	0,0014%	**5,77%**
Others	2,21%	2,15%	0,11%	1,86%	0,21%	**6,53%**
TOTAL	**26,98%**	**16,95%**	**28,93%**	**24,84%**	**2,30%**	**100,00%**

* Modified organic natural materials



Values in % with respect to the vehicle total mass

In accordance with their policy, CAF meets the environmental requirements right from the very first stages of their projects. The use of materials related to high environmental impact values has been reduced to the bare minimum. Those materials which may involve a risk and which cannot be avoided using current technology are taken into account and controlled during the design and development stages.

PRODUCT ENVIRONMENTAL IMPACT

Noise

The main sources of noise emission involve the effects of the rolling gear, the HVAC unit and the vehicle's traction equipment. In accordance with standard ISO 3095, the unit's exterior noise emission is as follows:

Noise	dB(A)
Standstill	59
Constant Speed (40 km/h)	71

Energy Consumption

Energy consumption during operation has been calculated based on a simulation coherent with the reference document TecRec 100:001. Specification and verification of energy consumption for railway Rolling stock. and takes account of the route, timetables and frequency of the line the vehicle has been designed for (Valdespartera – Parque Goya), as well as its mechanical, electrical and auxiliary system characteristics. The considered vehicle occupation is for 200 passengers, corresponding to an occupied seat arrangement and 3.5 passengers/m2 of standing passengers in the assigned areas.
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).

Manufacturing Phase
Electric Consumption (kWh)

By Functional Unit	0.0133

Use Phase
Electric Consumption (kWh/Km)

0% Receptivity	4.22
100% Receptivity	3.93

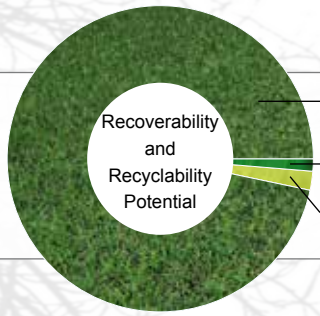
**The electric consumption for an average passenger ride, 2 km, is equivalent to approximately 2 and a half minutes of clothes ironing, 10 songs played on a stereo, or 6 minutes of playing videogames.*

POTENTIAL RECOVERABILITY AND RECYCLABILITY PROFILE

As a result of the studied design and modularity used during assembly and dismounting, high recyclability and recoverability potential ratios are achieved at the end of the trams' operating lives which, in accordance with UNI-LCA-001:00, are:

TZ Recoverability and Recyclability Potential

Recyclability Rate	93.0%
Recoverability Rate	98.6%



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 and Consumables	End of Life	0% Receptivity	100% Receptivity
			0% Receptivity	100% Receptivity				
RENEWABLE RESOURCES CONSUMPTION								
Materials [kg/ pass.km] (TOTAL)	1,86E-05	5,62E-06	4,34E-10	4,05E-10	1,80E-06	6,88E-09	2,60E-05	2,60E-05
Wood	5,98E-06	1,97E-06	1,53E-10	1,42E-10	5,50E-07	2,22E-09	8,51E-06	8,51E-06
Carbon dioxide	1,24E-05	3,65E-06	2,81E-10	2,62E-10	1,22E-06	4,65E-09	1,73E-05	1,73E-05
Peat	1,56E-07	3,69E-10	1,41E-14	1,31E-14	3,25E-08	1,39E-11	1,89E-07	1,89E-07
Water use (*) ([l/pass.km]	2,13E-02	2,36E-03	1,70E-07	1,58E-07	1,13E-03	1,37E-05	2,48E-02	2,48E-02
Energy [MJ/ pass.km] (TOTAL)	5,43E-04	2,24E-04	3,54E-02	3,30E-02	6,63E-05	5,59E-07	3,39E-02	3,16E-02
Hydropower	1,87E-04	7,70E-05	1,22E-02	1,13E-02	2,28E-05	5,27E-07	1,25E-02	1,16E-02
Windpower	2,52E-04	1,04E-04	1,64E-02	1,53E-02	3,08E-05	2,38E-08	1,68E-02	1,57E-02
Solar energy	5,78E-05	2,38E-05	3,77E-03	3,51E-03	7,06E-06	3,83E-09	3,86E-03	3,60E-03
NON RENEWABLE RESOURCES CONSUMPTION								
Materials[kg/ pass.km] (TOTAL)	3,60E-04	4,35E-06	2,25E-07	1,86E-10	1,17E-04	2,68E-06	4,84E-04	4,84E-04
Gravel	1,47E-04	2,19E-06	1,33E-10	1,24E-10	9,32E-05	2,31E-06	2,45E-04	2,45E-04
Calcite	7,91E-05	8,59E-07	3,84E-11	3,57E-11	6,50E-06	5,64E-08	8,65E-05	8,65E-05
Iron	4,82E-05	8,91E-07	1,53E-11	1,43E-11	1,38E-05	5,70E-08	6,30E-05	6,30E-05
Energy[MJ/ pass.km] (TOTAL)	6,80E-04	2,80E-04	4,44E-02	4,13E-02	8,30E-05	9,58E-07	4,62E-02	4,17E-02
Coal	1,62E-04	6,69E-05	1,06E-02	9,85E-03	1,98E-05	1,19E-07	1,08E-02	1,01E-02
Nuclear	2,41E-04	9,94E-05	1,57E-02	1,46E-02	2,94E-05	6,13E-07	1,61E-02	1,50E-02
NG Combined Cycle	1,24E-04	5,09E-05	8,06E-03	7,50E-03	1,51E-05	1,07E-07	8,25E-03	7,69E-03
WASTE [kg/ pass.km] (TOTAL)	2,85E-07	3,78E-06	1,45E-12	1,35E-12	7,57E-05	4,86E-06	8,46E-05	8,46E-05
Hazardous	2,11E-07	2,96E-06	1,03E-12	9,58E-13	0,00E+00	2,36E-07	3,41E-06	3,41E-06
Non Hazardous	7,45E-08	8,22E-07	4,22E-13	3,93E-13	7,57E-05	4,63E-06	8,12E-05	8,12E-05
ENVIRONMENTAL IMPACT [/pass.km]								
Global Warming Potential (kg CO2-Eq)	6,83E-04	8,93E-05	6,89E-03	6,43E-03	7,35E-05	2,18E-06	7,74E-03	7,28E-03
Acidifiying Potential (kg SO2-Eq)	5,53E-06	4,94E-07	4,67E-05	4,35E-05	5,79E-07	9,20E-09	5,33E-05	5,01E-05
Eutrophication Potential (kg PO4 -3 -Eq)	4,16E-06	4,78E-08	1,00E-05	9,36E-06	1,99E-07	2,09E-09	1,44E-05	1,38E-05
Photochemical Ozone Creation Potential (kg C2H4-Eq)	3,19E-07	2,04E-08	1,82E-06	1,70E-06	3,75E-08	3,38E-10	2,19E-06	2,07E-06
Ozone Depletion Potential (kg CFC-11-Eq)	6,14E-10	1,19E-11	8,01E-10	7,47E-10	2,69E-10	2,68E-13	1,70E-09	1,64E-09

(*) except the use in hidroelectric power generation

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 “extremely high” in the CAF train assembly process and in the Urbos AXL composition, and it is “high” quality for the environmental assessment basis data.

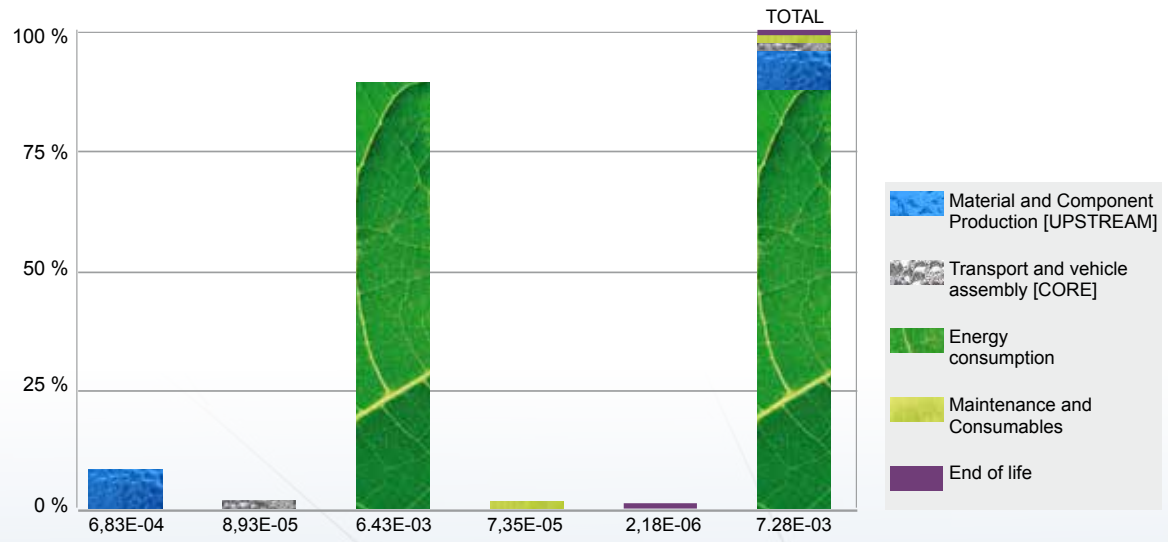
ENVIRONMENTAL PROFILE OF THE PRODUCT LIFE CYCLE

Under a Life Cycle approach, cost and environmental impacts reduction of the operation use have been core targets of the Urbos platform design process. 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 materials, as a result of the reliability and durability of the components, and the modularity and standardisation of the solutions employed.

Consumption during use, particularly energy consumption during the 30 years of operating life, causes the main environmental effects of an Urbos tram, as shown in the adjoining graph which uses the reference environmental indicator "Global Warming Potential", for a 100% catenary receptivity scenario.

The ACR on board energy storage system allows for a reduction of energy consumption during operation of the tram and minimises the difference of impacts between the extreme receptivity scenarios. In this way, the tram units fitted with this system are much less sensitive to the availability of the catenary for receiving energy and therefore, the energy consumption during the use stage is less than on vehicles which are not fitted with this technology.

Total Global Warming Potential (kg CO2 eq.)



"In 2010 Spanish CO2 emissions were 5.8 metric tons per capita. (Source: http://data.worldbank.org)"

INFORMATION ABOUT THE ENVIRONMENTAL DECLARATION

This environmental declaration was made following the requirements of the reference document “PCR 2009:05 Version 2.11 Product category rules for preparing an environmental product declaration for Rail Vehicles. UNCPC CODE: 495” published by Environdec (www.environdec.com) and is based on the data of the URBOS 100 tram units for the City of Zaragoza, for all the stages of the product’s life cycle (production of raw materials and components, assembly of the vehicle, distribution, use and end of life). The functional unit in this study is the transport of 1 passenger over 1km and the operating life of the vehicle analyzed has been set at 30 years.

The Urbos 100 environmental 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 characterization of the environmental impact of the compiled operating life inventory was CML 2001. 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. Data from the Ecoinvent database (version 2.0) has been used for the environmental definition of the processes and materials. Those processes not available in Ecoinvent database were generated using first hand data.

For vehicle assembly, the effect of the procurement of materials and components making it up have been considered, as well as the transport of materials (over 80% of the tram weight) to the assembly plant, the assembly itself, handling of the waste from both the assembly and dismantling of the vehicle and the transport of the vehicle from CAF’s Zaragoza plant to Valdesparatera depot during year 2009.

For the environmental impact of the energy consumption during assembly, the 2009 Spanish electricity production mix has been taken into account, with data provided by the Spanish Ministry for Industry. For environmental impact characterization of the energy consumption during use phase an average of 66,500 km per year has been considered and electricity mix supplied for operation during year 2013 has been considered.

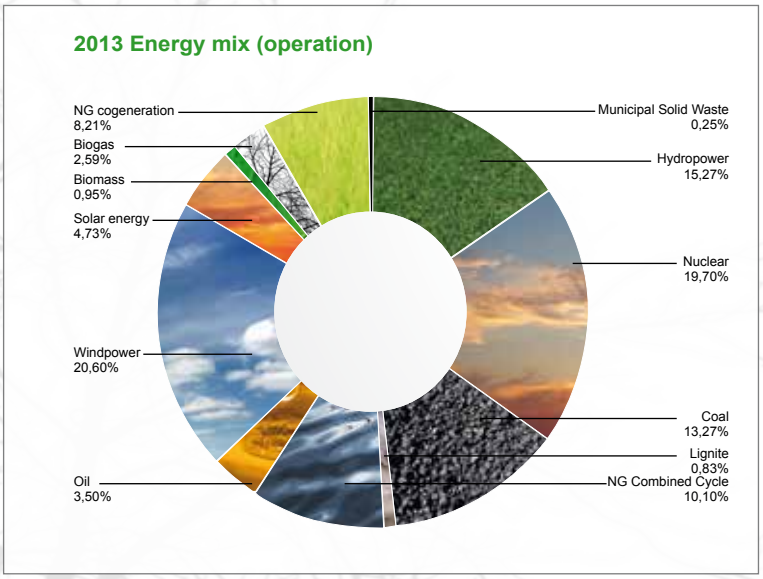
The maintenance of the train has been considered for the entire operating life, with inventories for the materials and spare parts of a Life Cycle Cost (LCC) of Urbos 100 study, including operation related consumables, such as traction sand or brake pads, but not those involved in train cleaning operations or passenger waste treatment and disposal.

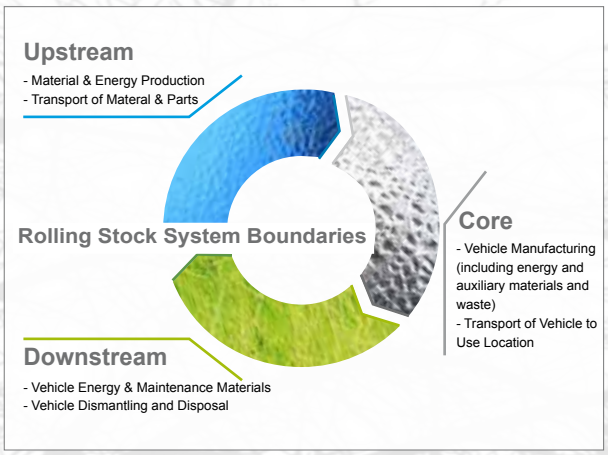
In the end of life, and vehicle dismantling stage, has been modelled according to UNI-LCA-001:00 Railway Rolling Stock - Recyclability and Recoverability Calculation Method (89.4% recyclability / 92.7 % recoverability). The potential advantage of recycling and recovery of the energy from incineration 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.
- PCR 2009:05. Product category rules for preparing an environmental product declaration for Rail Vehicles.
- General Programme Instructions for environmental product declarations, EPD, version 2.1
- ISO 22628:2002. Road vehicles. Recyclability and recoverability. Calculation method.
- TecRec 100:001. Specification and verification of energy consumption for railway Rolling stock.
- EN 15663:2009. Railway applications. Definition of vehicle reference masses.
- ISO 3085. Railway applications - Acoustics - Measurement of noise emitted by railbound vehicles.
- Railway Industry Substance List, (www.unife-database.org).
- UNI-LCA-001:00 Railway Rolling Stock - Recyclability and Recoverability Calculation Method.

DEFINITIONS:





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 (SO2).

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.

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 CO2, to measure the global warming contribution of a substance released into the atmosphere in a span of 100 years.

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.

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 photo-chemical formation potentials (POCPs) expressed in equivalent kg of ethane (C 2H4).

Registered office

JM Iturrioz 26
20200 Beasain (Gipuzkoa)
Spain

Administration offices

Padilla, 17
28006 Madrid
Spain

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

PRODUCTION PLANTS: SPAIN - FRANCE - U.S. - BRAZIL - MEXICO

OFFICES: MADRID - PARIS - LONDON - MUNICH - WASHINGTON DC - NEW DELHI - MEXICO DF - ROME - SYDNEY WARSAW - SAO PAULO - BUENOS AIRES - ISTANBUL - ROTTERDAM - DOHA - KUALA LUMPUR - SANTIAGO DE CHILE

www.caf.net

Versión impresa: en papel Cyclus Offset