Environmental Product Declaration
according to ISO 14025

CAF

URBOS 100
for the City of **Kaohsiung**

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 trams that guarantees maximum power-efficiency and full passenger ride comfort.
Versatile, with Personality and Environmentally Friendly.

EPD®

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CAF COMMITMENT

Railways and the environment.
On track to efficiency.

Environmental Product Declarations Programme:
The international EPD® System
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PCR review was conducted by:
The Technical Committee of the International EPD® System
Chair: Massimo Marino
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Independent verification of the declaration and data,
according to ISO 14025:2006:
□Internal ☒External

Individual verifier approved by the International EPD® System:
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LCA study:
Instituto Tecnológico de Aragón / www.itainnova.es

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UN CPC 495

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

CAF, CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. is an international leader 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 8,000 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.

02 / Kaohsiung Tram

URBOS 100
TRAMS

For Mass Rapid Transit Bureau,
Kaohsiung City (KMRT)

This is an international gauge, bidirectional tram vehicle with two driver cabs, made up of 5 articulated modules resting on two motor bogies and one trailer bogie under the central module.

The trams are fitted with Greentech Freedrive system based on ultracapacitors and regenerative electric brake making it possible to run between two stations without catenary on the route.

Technical Datasheet

Composition:	Mc-S-T-S-Mc
Power supply voltage:	750 Vdc
Track gauge:	1,435 mm
Max. speed (ACR/catenary):	50/70 km/h
Length:	34,166 mm
Exterior width:	2,650 mm
Vestibule area floor height:	350 mm
Total capacity:	250
Places for wheelchairs:	2

Equipment

- Saloon and cab air conditioning
- Passenger Audio and Visual Information: station announcer and broadcasts, exterior and interior LED displays
- Exterior side cameras with rear-view mirror function
- Event Recorder and “Dead Man”
- Closed circuit TV train surveillance
- Sanders and Flange Lubrication
- Height adjustable front pedestrian protection system
- Crashworthiness device
- Smoke detectors
- Radio-communication System
- OSS: Operation Support System
- Ticketing
- Traffic light priority system
- Signalling
- Greentech Freedrive

Advantages of the Greentech Freedrive system:

- It allows vehicles to operate in catenary-free sections.
- Variable autonomy: from a typical distance of hundreds of metres to many kilometres thanks to lithium batteries.
- Reduction in infrastructure investment.
- Elimination of catenaries in sections, reducing visual intrusion in urban environments.
- Non-proprietary system, applicable to any new or existing manufacturer and infrastructure.

URBOS

Versatile, with Personality and Environmentally Friendly

Urban design
Environmentally sustainable CAF’s long-standing experience in the production and implementation of urban transport systems has led to the creation of the Urbos solution, a range of trams with the potential to respond to the most demanding requirements of users and operators alike. The Urbos family includes trams, LRVs and tram-trains, a whole range of innovative, high-quality products, specifically designed to offer the end user a unique traveling experience.

On-board comfort

The Urbos design is focussed on passenger comfort and safety. With this aim in mind, this tram is fitted with seats that have been specially designed for daily use on urban and tram transport. The seats are comfortable, modular, individual, interchangeable, vandal-proof and lightweight.

Accessibility

The Urbos 100 tram has been carefully designed, in collaboration with persons with reduced mobility collectives, achieving a paramount comfort level for all passengers. It is 100% low floor along the entire passenger saloon. This dispenses with any passenger obstacles along the whole tram. In addition, boarding and alighting of passengers from / to platforms at a similar level to sidewalks is extremely comfortable.

Catenary-free trams

Greentech Freedrive is an on-board energy storage system that allows **catenary-free movement.** This system, based on lithium-ion supercapacitors and batteries, includes Evodrive technological advantages, being easily integrated into new or existing railway systems, regardless of their make and structure.

CAF has the ability to adapt to different operational scenarios with catenary-free tram operations, through the hybrid combination of lithium-ion supercapacitors and batteries. In this way, parameters such as performance, autonomy, cost and traffic type are optimised.

1. The vehicle starts to run with the Freedrive system fully charged.

2. While it travels from one stop to another the Freedrive powers the traction system.

3. During the braking process the kinetic energy generated is stored in the Freedrive, starting its recharging process.

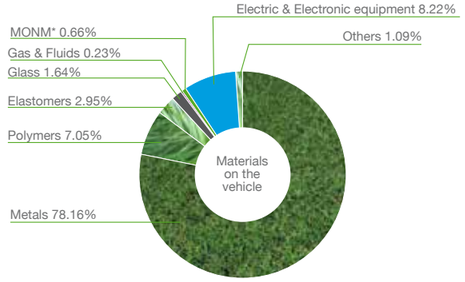
4. When the vehicle arrives at the stop the Freedrive system recharging process is completed.

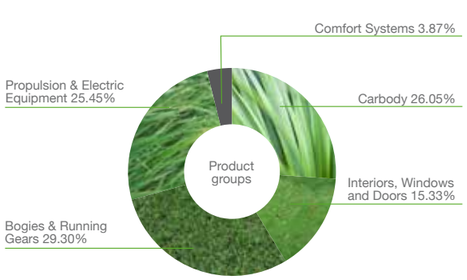
LIST OF **MATERIALS**

In the design of the Urbos 100 for the City of Kaohsiung, 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.

In accordance with their policy, CAF meets the environmental requirements right from the very first stages of their projects. When designing the Kahosiung tram units, CAF has observed and demanded that their suppliers apply the “Railway Industry Substance List” (www.unife-database.org) to reject the content of regulated materials that could affect the environment or people’s health.

Disassembling is foreseen right from the design stage to enhance material separation and recycling of the vehicle when its end of life is reached. The following figures show the summarised inventory of the tram materials.



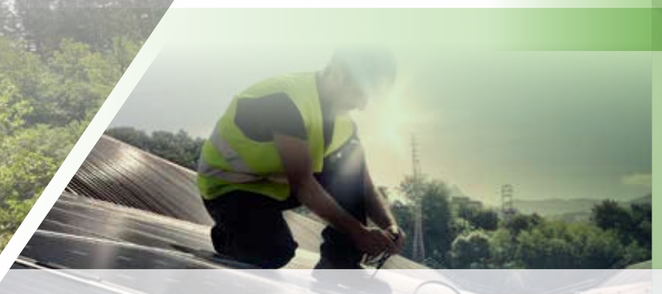


* Modified organic natural materials
Values in % with respect to the vehicle total mass

Commitment with clean energy

The CAF group owns two hydroelectric plants, preserved heritage of the origins of the company for over 100 years, which were subject to a comprehensive modernization a decade and a half ago.

CAF has also undertaken an ambitious project to install solar panels on the roofs of its plant in Beasain offering optimum utilization conditions.



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 contractual noise emission is as follows:

Noise	dB(A)
Stationary noise	≤ 64
Pass-by noise (40 km/h)	≤ 78
Pass-by noise (60 km/h)	≤ 80

Recoverability and recyclability potential 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 tram operating life.equipment. In accordance with standard ISO 22628 the recoverability and recyclability profile is as follows:

Recoverability and Recyclability Potential according to ISO 22628	
Recyclability Rate	92.7%
Recoverability Rate	98.7%

Energy Consumption

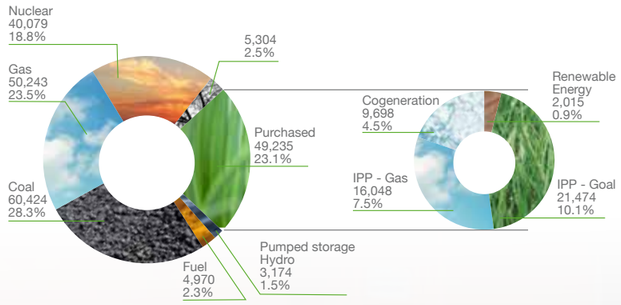
Energy consumption during the use stage takes into account the route and timetables of the line the vehicle has been designed for (Yisin Rd – Hamasing Kaohsiung Port, 100% catenary free) and it has been calculated based on a simulation coherent with the reference document TecRec 100:001 -Specification and verification of energy consumption for railway rolling stock. A vehicle occupation capacity of 250 passengers (all seated and 5 passengers per sqr-meter standing) has been considered in accordance with the operational mass defined in standard EN 15663.

Electric Consumption (*)	
Manufacturing [kWh/pass.km]	1.43E-04
Use Stage [kWh/pass.km]	2.14E-02
Stand-by [kWh/pass.km]	1.98E-03

(*) Data valid according to established simulation criteria. On real operation, depending on operational conditions, these values may vary.

The electric consumption for a passenger travelling 5 km is equivalent to approximately 6 minutes of clothes ironing, 27 songs played on a stereo, or 16 minutes of playing videogames.

Taiwan Electricity Mix 2014



Source: http://www.taipower.com.tw

Bogie, wheels and axels

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 and Consumables	End of Life	
Renewable resources consumption						
Materials [kg/ pass.km] (TOTAL)	2,54E-05	4,79E-06	1,77E-03	2,47E-06	1,27E-10	1,80E-03
Carbon dioxide	1,71E-05	3,17E-06	1,17E-03	1,63E-06	8,31E-11	1,19E-03
Wood	8,12E-06	1,59E-06	5,99E-04	7,96E-07	4,29E-11	6,10E-04
Others	1,82E-07	2,72E-08	5,92E-07	3,60E-08	8,71E-13	8,37E-07
Water (natural resource*) ([l/pass.km]	9,20E+00	2,22E-02	2,06E+01	2,26E-01	5,33E-06	3,00E+01
Energy [MJ/ pass.km] (TOTAL)	1,50E-03	3,06E-04	1,79E-02	5,41E-05	1,81E-09	1,97E-02
Hydropower	1,29E-03	1,29E-04	1,86E-03	3,27E-05	8,15E-10	3,31E-03
Eolic power	1,48E-05	1,13E-04	3,17E-03	2,64E-06	6,68E-11	3,30E-03
Others	1,97E-04	6,32E-05	1,28E-02	1,88E-05	9,26E-10	1,31E-02
Non renewable resources consumption						
Materials [kg/ pass.km] (TOTAL)	3,03E-04	3,18E-05	5,89E-04	9,23E-05	1,43E-08	1,02E-03
Gravel	1,39E-04	1,67E-05	4,37E-04	7,18E-05	1,38E-08	6,65E-04
Calcite	3,72E-05	4,56E-06	8,22E-05	5,08E-06	2,33E-10	1,29E-04
Iron	4,39E-05	7,09E-06	3,81E-05	1,15E-05	1,33E-10	1,01E-04
Others	8,27E-05	3,39E-06	3,11E-05	3,84E-06	1,13E-10	1,21E-04
Energy [Kg/ pass.km] (TOTAL)	2,35E-04	7,41E-05	7,44E-03	3,31E-05	3,16E-09	7,78E-03
Coal	1,15E-04	2,51E-05	5,31E-03	1,80E-05	3,80E-10	5,47E-03
Oil, Crude	4,41E-05	1,02E-05	2,77E-04	7,51E-06	2,53E-09	3,38E-04
Natural Gas	3,93E-05	3,64E-05	1,77E-03	4,96E-06	1,82E-10	1,85E-03
Others	3,67E-05	2,40E-06	7,63E-05	2,68E-06	6,79E-11	1,18E-04
Waste [kg/ pass.km] (TOTAL)	1,44E-04	3,67E-05	6,22E-04	2,83E-05	1,86E-07	8,31E-04
Hazardous	1,81E-07	1,87E-08	1,92E-08	2,38E-08	4,16E-11	2,43E-07
Non Hazardous	1,44E-04	3,66E-05	6,22E-04	2,83E-05	1,86E-07	8,31E-04

(EDIP 2003 method)

Environmental impact [/pass.km]

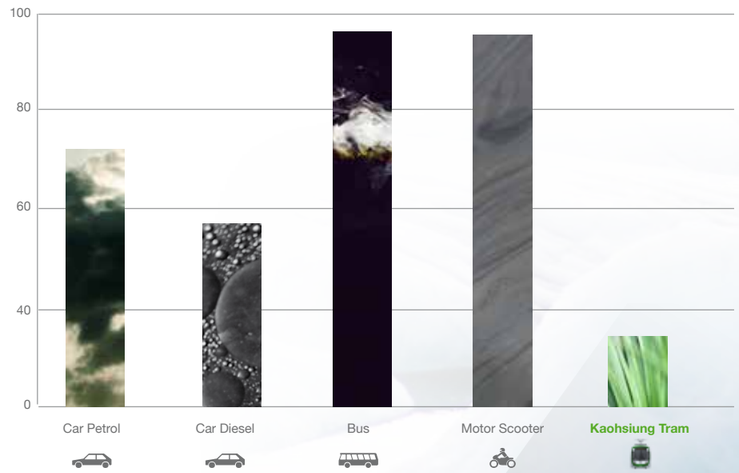
Global Warming Potential (kg CO2-Eq)	5,74E-04	1,72E-04	1,70E-02	7,77E-05	1,72E-06	1,78E-02
Acidifiying Potential (kg SO2-Eq)	7,88E-06	1,16E-06	6,32E-05	8,28E-07	6,84E-09	7,31E-05
Eutrophication Potential (kg PO4 -3 -Eq)	3,94E-06	2,13E-07	1,68E-05	2,35E-07	1,95E-09	2,12E-05
Photochemical Ozone Creation Potential (kg C2H4-Eq)	4,43E-07	5,30E-08	2,88E-06	4,67E-08	2,99E-10	3,43E-06
Ozone Depletion Potential (kg CFC-11-Eq)	6,11E-10	3,40E-11	8,43E-10	1,90E-10	3,05E-13	1,68E-09

(*) except the use in hidroelectric power generation
Direct amount of water used by the core process: 7,53E-06 l/pass km

Low Energy Consumption

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.

Tramway, key to a sustainable future



g CO2-eq / passenger.km
Source: Ecoinvent v3

INFORMATION ABOUT THE **ENVIRONMENTAL DECLARATION**

This environmental declaration was made following the requirements of the reference document “PCR 2009:05 v.2.11 - UN CPC 495 Rolling Stock” published by Environdec (www.environdec.com) and is based on the data of the URBOS 100 tram units for the City of Kaohsiung, 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 25 years.

The Urbos 100 environmental impact study has been quantified by means of a 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 3.1) 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.

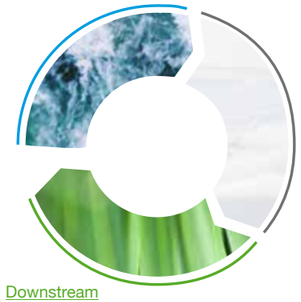
For vehicle assembly, the effect of the procurement of materials and components making it up have been considered, as well as the transport of materials (over 56% of the tram weight) to the assembly plant, the assembly itself, handling of the waste from both the assembly and dismantling of the vehicle and the transport of the vehicle from CAF’s Zaragoza plant to Kaohsiung during year 2014.

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 environmental impact characterization of the energy consumption during use phase an average of 80.000 km per year and 2014 Taiwan electricity mix (http://www.taipower.com.tw) has been considered.

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 (91.8% recyclability / 97.1 % recoverability). The potential advantage of recycling and recovery of the energy from incineration processes has not been accounted for in the study.

Rolling Stock System Boundaries



Upstream
- Material & Energy Production
- Transport of Materal & Parts

Core
- Vehicle Manufacturing (including energy and auxiliary materials and waste)
- Transport of Vehicle to Use Location

Downstream
- Vehicle Energy & Maintenance Materials
- Vehicle Dismantling and Disposal

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 (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.

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.

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_2H_4).

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 2.1
- 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.

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