HITACHI
Inspire the Next

Metro Leonardo

Environmental Product Declaration
Rev. 01 – Date: 2016/12/28
Approval date: 2017-01-17
Registration N. S-P-00836
UN CPC Code: 495
PCR 2009:05 version 2.11
Validity: 2020-01-15

Hitachi Rail Italy

Index

The Company

Hitachi Rail Italy, created by the evolution of AnsaldoBreda which is the most important Italian brand with more than 160 years of history in the rail and metro sector, has a wide range of products, ranging from high speed to driverless metros.
In the segment of local public transport Hitachi Rail Italy is the world leader for the driverless metros, holding about the 30% of the world market.
HRI is present in many countries of the world, among which - beyond Italy of course - in the Far East and in USA. Today Hitachi Rail Italy is organized in three Italian plants: Napoli, Pistoia and Reggio Calabria; furthermore, it can rely on some operating plants abroad, achieving an overall number of about 2,400 employees. All plants are involved in Metro Leonardo production: Napoli where the body components are built, Reggio Calabria and Pistoia, where carpentry, painting and assembly operations are performed.

The Product

Metro Leonardo is an HRV (Heavy Rail Vehicle) urban metro designed for transport passengers. Metro Leonardo consists of six car bodies with five articulations. The traction is supplied by sixteen electric engines, coupled on eight of the twelve boogies; the other four trucks are only trailers. Metro configuration is shown in the figure.

Technical information

Dimensions	
- Length	107 m (to coupler)
- Width	2.85 m (external)
- Height from railway plane	3.60 m
Net weight	201,044 kg
Weight with different configuration	
- Use test	216,969 kg
	228 passengers
- L3	287,112 kg
	All seats filled
	+ 6 passengers per m^2
Maximum speed	90 km/h
Maximum number of passengers	n. 1,232 whereof:
	- seat n. 410
	- standing n. 822
Power supply	Electric
Line voltage	750 L1÷1500 L2 V
Available power	283 kW x 16 = 4,528 kW

Use test is the configuration used for environmental impacts assessment.

The following table shows the distribution of materials the Metro is made of.

Product group	Quantity of materials (kg) per vehicle							
	Metals	Polymers no elastomers	Elastomers	Glass	Fluids	MONM	Other	Total
1 - Carbody	38,788	1,439	153	510	-	-	377	41,267
2 - Interior, windows and doors	20,774	560	1,830	4,013	4	1,473	1,305	29,961
3 - Bogies and running gears	89,073	28	3,673	41	135	21	103	93,075
4 - Propulsion and electric equipment	14,634	2,502	8,194	3,867	225	-	1,730	31,154
5 - Comfort systems	3,606	115	13	-	59	-	1,795	5,588
Total	***166,875***	***4,644***	***13,863***	***8,432***	***423***	***1,495***	***5,311***	***201,044***
	83.0%	***2.3%***	***6.9%***	***4.2%***	***0.2%***	***0.7%***	***2.6%***	***100.0%***

MONM = Modified Organic Natural Materials (i.e. leather. wood. cardboard. etc.)

The following table shows the distribution of materials Metro Leonardo is made of, referred to the functional unit.

Product group	Quantity of materials (g) per Functional Unit							
	Metals	Polymers no elastomers	Elastomers	Glass	Fluids	MONM	Other	Total
1 - Carbody	0.052	0.002	~ 0	0.001	-	-	0.001	0.056
2 - Interior. windows and doors	0.028	0.001	0.002	0.005	~ 0	0.002	0.002	0.040
3 - Bogies and running gears	0.120	~ 0	0.005	~ 0	~ 0	~ 0	~ 0	0.125
4 - Propulsion and electric equipment	0.020	0.003	0.011	0.005	~ 0	-	0.002	0.042
5 - Comfort systems	0.005	~ 0	~ 0	-	~ 0	-	0.002	0.008
Total	***0.225***	***0.006***	***0.019***	***0.011***	***0.001***	***0.002***	***0.007***	***0.271***
	83.0%	***2.3%***	***6.9%***	***4.2%***	***0.2%***	***0.7%***	***2.6%***	***100.0%***

MONM = Modified Organic Natural Materials (i.e. leather, wood, cardboard, etc.)

Following regulated hazardous material are present on the Metro.

Hazardous materials	kg	Where
Cadmium	479	Battery & Aux Equipment
Lubricants/oil/grease	139	Boogies
Gas refrigerants	59	HVAC
Nickel	719	Battery & Aux Equipment
KOH	794	Battery

The Metro doesn't contain SVHC (Substances of Very High Concern) as defined by the Regulation 1907/2006/EC (REACh).

The Line L1 is the Milan subway marked by red colour that starting from Sesto Primo Maggio allows passengers moving to Rho Fiera or Bisceglie stops. Its length is about 27 km and it joins the north east part of Milan to the West one. It was the first subway built in Milan since its works started in 1957 and finished in 1964.
The Line L2 is the Milan subway marked by green colour that starting from Abbiategrasso or from Assago Mirafiori Forum allows passengers moving to Gessate or Cologno Nord stops. Its length is about 39.4 km and recently the construction of the new branch from Famagosta to Assago Mirafiori has been completed.

Environmental Performance Declaration

Methodology

The environmental performance of the considered product has been quantified by Life Cycle Assessment (LCA) approach in accordance with ISO 14040 and ISO 14044. Data used for the study refers to years 2014 for Napoli and Pistoia site plant, while 2015 for Reggio Calabria. Specific and generic data fulfil General Program Instruction criteria for EPD as well as PCR for preparing EPD for rail vehicle. Contribution given by generic data is less than 1% of the total. The use phase has been modelled using real data obtain by ATM (Azienda Trasporti Milanesi), the transport company owned by the Milan Municipality:

- Average speed (commercial)
- Energy measuring system installed on board Leonardo train
- Normal load November 2015 - January 2016
- Length of the route L1
- Average number of runs per day and year

The adopted model is coherent with *"Specification and verification of energy consumption for railway rolling stock - Railenergy WP 2.2: Input to future UIC/UNIFE Technical Recommendation"* (EC contract N°FP6-031458)
For the use phase impacts calculation the following assumption has been adopted:

- Length of route on which energy consumption has been measured (L1): 88.397 km
- Life span of the Metro: 35 years
- Maximum number of Metros in exercise on the route: 30
- Average number of passengers transported: 228
- Load factor: 18.5

The Italian electricity energy mix LV has been assumed for the use phase.
The Ecoinvent database has been used for all processes, for base materials production, for waste treatment processes, for electronic parts production and as a source for the Italian electric mix.
The characterization factors used are the default ones available on www.environdec.com site.

Functional Unit

According to relating PCR, the functional unit is the transport of **1 passenger for 1 km.**

System Boundaries

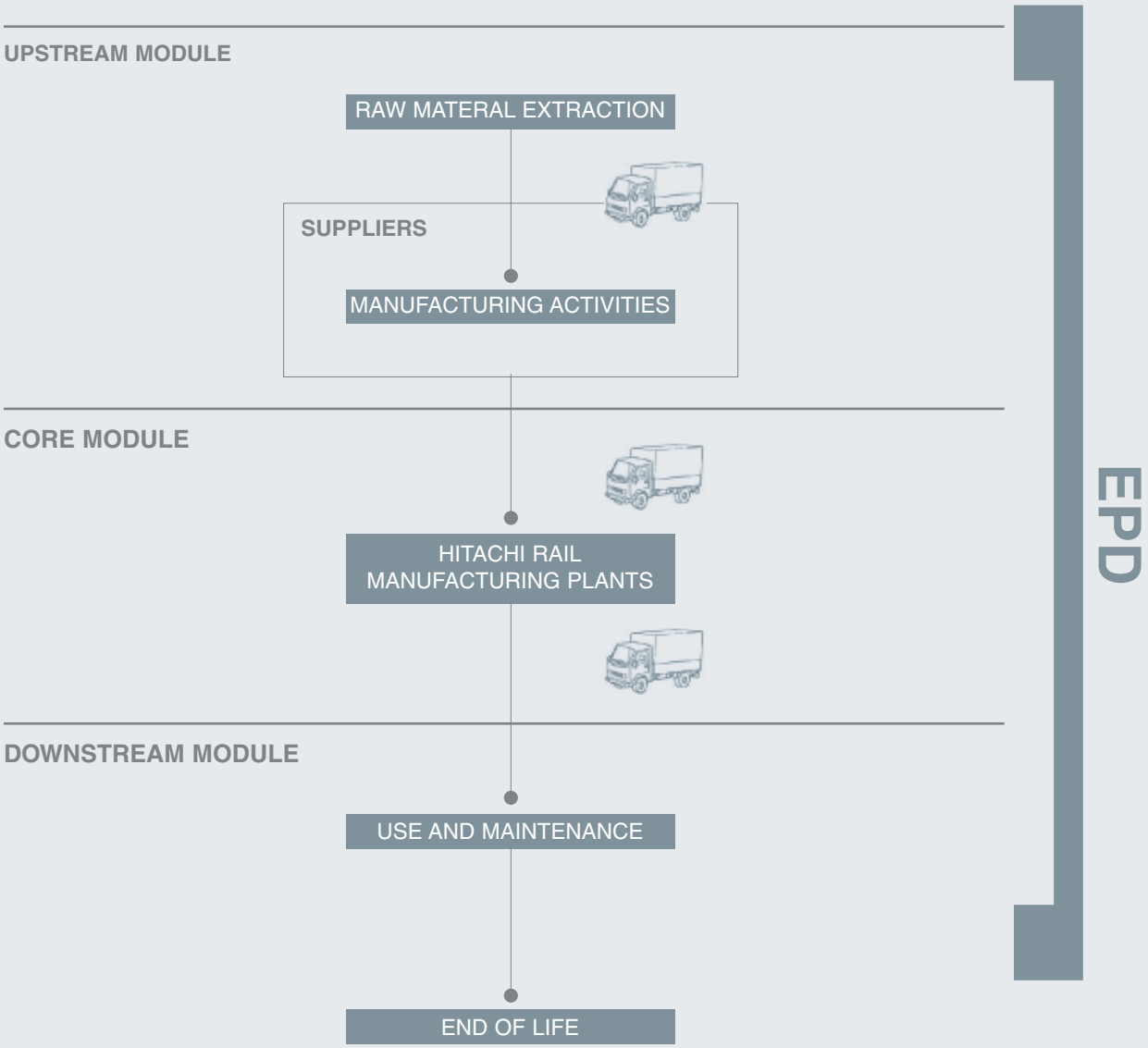


Figure 1 – System boundaries. All main module from the extraction of natural resources to the end of life are included

The considered System is split into three phases according to the following hypothesis.

• MATERIAL & ENERGY PRODUCTION • TRANSPORT OF MATERIAL & PARTS	UPSTREAM	Material & Energy Production Infrastructure Transport Infrastructure
• VEHICLE MANUFACTURING including energy and auxiliary materials and waste • TRANSPORT OF VEHICLE TO USE LOCATION	CORE	Manufacturing Facilities Transport Infrastructure
• VEHICLE ENERGY & MAINTENANCE MATERIALS • VEHICLE DISMANTLING AN DISPOSAL	DOWN STREAM	Railways Infrastructure (Railroad, Station and Depots) Dismantling & Treatment Facilities

Exclusions (Cut off)
Cut off rules applied are consistent with the PCR requirements.

Environmental Results

Resources consumption

Non Renewable Resorces data for transport of 1 passenger for 1 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Material (kg)					
Gravel	0.0001932	0.0000754	0.0011983	0.0000094	0.0014763
Iron	0.0001398	0.0000022	0.0002665	0.0000002	0.0004086
Calcite	0.0000765	0.0000048	0.0002611	0.0000003	0.0003427
Others	0.0004041	0.0000964	0.0008381	0.0000124	0.0013511
Total	***0.0008136***	***0.0001787***	***0.0025639***	***0.0000223***	***0.0035786***
Energy (MJ)					
Natural gas	0.0000850	0.0000463	0.0040381	0.0000002	0.0041696
Hard Coal	0.0004260	0.0000591	0.0057905	0.0000005	0.0062761
Crude oil	0.0000713	0.0000334	0.0008435	0.0000026	0.0009509
Others	0.0000000	0.0000000	0.0000001	0.0000000	0.0000001
Total	***0.0005823***	***0.0001388***	***0.0106723***	***0.0000033***	***0.0113967***

Renewable Resorces data for transport of 1 passenger for 1 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Material (kg)					
Wood	0.0000100	0.0000019	0.0002141	0.0000000	0.0002261
Total	***0.0000100***	***0.0000019***	***0.0002141***	***0.0000000***	***0.0002261***
Energy (MJ)					
Hydropower	0.0010335	0.0002206	0.0337376	0.0000008	0.0349925
Biomass	0.0004466	0.0000615	0.0068069	0.0000008	0.0073158
Wind power	0.0000471	0.0000532	0.0088021	0.0000001	0.0089024
Others	0.0000004	0.0000000	0.0003607	0.0000000	0.0003611
Total	***0.0015275***	***0.0003353***	***0.0497072***	***0.0000017***	***0.0515718***

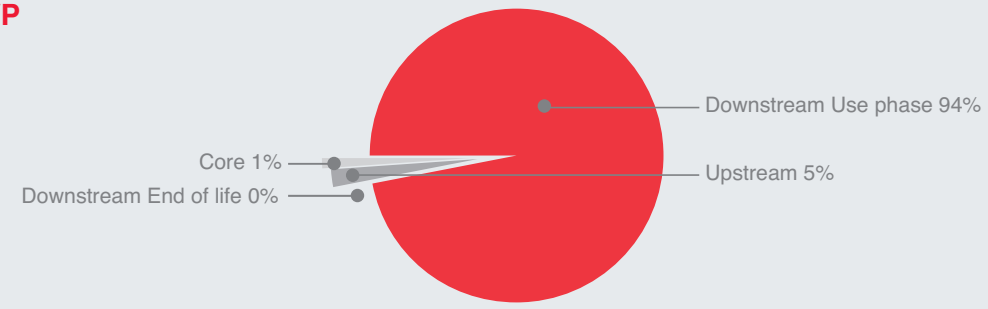
OTHER INFORMATIONS data for transport of 1 passenger for 1 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Water use (kg) escluding turbine use	0.0122055	0.0028397	0.0981254	0.0000419	0.1132125
Electricity consumption manufacturing (kWh)	-	0.0002194	-	-	0.0002194
Use of Material Secondary resources (kg)	-	-	-	-	-
Use of Energy Secondary resources (kg)	-	-	-	-	-
Recovered Energy flows (MJ)	-	-	0.1095376	-	0.1095376

WASTES GENERATION data for transport of 1 passenger for 1 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
(kg)					
Hazardous	0.0000004	-	0.0000009	-	0.0000012
Non hazardous	0.0002604	0.0001038	0.0010618	0.0000258	0.0014519
Total	*0.0002607*	*0.0001038*	*0.0010627*	*0.0000258*	*0.0014531*

Polluttant emissions expressed in terms of potential environmental impact

ENVIRONMENTAL IMPACT data for transport of 1 passenger for 1 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
GWP (kg CO2eq)	0.0012717	0.0003064	0.0244938	0.0000132	0.0260851
ODP (kg CFC-11eq)	-	-	-	-	-
AP (kg SO2eq)	0.0000127	0.0000013	0.0001035	-	0.0001175
EP (kg PO4eq)	0.0000033	0.0000001	0.0000096	-	0.0000131
POCP (kg C2H4eq)	0.0000007	0.0000001	0.0000053	-	0.0000061

GWP



About 94% of GWP is caused by the “Downstream Use Phase” of the train due to the emissions caused by electric energy production plants supplying electric energy for the operational phase.

Additional Information

Metro energy consumption

Metro Leonardo electricity consumption for using phase has been evaluated taking electric energy consumption directly measured during service activity of one train on L1 line, for about 6 months and for an overall coverage of about 88,400 km, resulting in a specific electricity consumption of 10.39 kWh/km.
The number of passengers used to refer the results to the functional unit has been estimated in 228. This value has been obtained as weighted average of the calculated number of passengers carried by each one of 21 trains during their corresponding service activities on L1 and L2 lines in different periods; each service period having a duration of some weeks between the end of 2015 and the beginning of 2016.
The number of transported passengers has been calculated using measures of loads carried by each train and assuming an average weight for each person of about 75 kg. The load factor resulting in about 18.5%.

Noise emissions

Apart from wheels, among the main sources of noise and vibrations systems installed on board are the following: HVAC, air compression circuit, traction engine, reducer, auxiliary converter, traction converters, compressed air system, trumpets.
Following table represents the internal and external noise levels in different operating conditions of the train.
The noise analysis was conducted on the vehicle according to ISO 3095 and ISO 3381.

	U.M.	Stationary conditions	Constant speed (60 km/h)	Acceleration
External Noise	LpAeq,T [dB(A)]	68±4	75±4	Measures not available

Potential recyclability and recoverability

	Recovery		Undefined residue
Reuse (Component Parts) 0	Recycling (Materials) 187,874 kg	Energy recovery (Materials) 3,732 kg	Waste (Materials) 9,437 kg
Recyclability rate 93.4%			
Recoverability rate 95.3%			
Vehicle mass 201,044 kg			

	Recyclability	Recoverability
End of life	93.4%	95.3%
Maintenance	96.3%	98.0%
Total life cycle	**94.7%**	**96.5%**

Other environmental information

Hitachi Rail Italy has developed and certified environmental (ISO 14001) and health and safety (OHSAS 18001) management systems.

Hitachi Rail Italy recognises as its strategic objectives:

- the satisfaction of customer's needs, both from product and service point of view;
- the health and safety of its employees;
- the health, the reliability and the quality of its products.

The use of materials that can be cause of allergic reactions has been completely avoided.

Glossary

Acidification Potential (AP): phenomenon by which atmospheric rainfall has a pH which is lower than average. This may cause damage in forests and cultivated fields, as well as in water ecosystems and objects in general. This phenomenon is due to the emissions of SO_2, of NO_x, and NH_3, which are included in the Acidification Potential (AP) index expressed in masses of SO_2 produced.

Eutrophication Potential (EP): enrichment of the watercourses by the addition of nutrients. This causes imbalance in water ecosystems due to the overdevelopment encouraged by the excessive presence of nourishing substances. In particular, the Eutrophication Potential (EP) includes phosphorous and nitrogen salts and it is expressed in grams of oxygen (kg O_2).

Global Warming Potential (GWP): phenomenon by which the infrared rays emitted by the earth's surface are absorbed by the molecules in the atmosphere as a result of solar warming and then re-emitted in the form of heat, thus giving rise to a process of global warming of the atmosphere. The indicator used for this purpose is GWP (Global Warming Potential). This mainly includes the emissions of carbon dioxide, the main greenhouse gas, as well as other gases with a lower degree of absorption of infrared rays, such as methane (CH_4), nitrogen protoxide (N_2O), chlorofluorocarbons (CFC), which are expressed according to the degree of absorption of CO_2 (kg CO_2).

HVAC: Heating, Ventilating, and Air Conditioning

HRV: Heavy Rail Vehicle

LV: Low Voltage

MONM: Modified Organic Natural Materials

Ozone Depletion Potential (ODP): degradation and depletion of the ozone layer in the stratosphere, which has the property of blocking the ultraviolet components of sunlight thanks to its particularly reactive compounds, originated by chlorofluorocarbons (CFC) or by chlorofluoromethanes (CFM). The substance used as a point of reference for assessing the ODP (Ozone Depletion Potential) is trichlorofluoromethane, or CFC-11.

Photochemical Ozone Creation Potential (POCP): production of compounds which by the action of light are capable of encouraging an oxidising reaction leading to the production of ozone in the troposphere. The indicator POCP (Photochemical Ozone Creation Potential) includes especially VOC (volatile organic compounds) and is expressed in grams of ethylene (kg C_2H_4).

SVHC: Substances of Very High Concern

References

- Life cycle assessment of Metro Milano Leonardo Rev 01 - Final report, Altran Italia and Hitachi Rail Italy, 28th December 2016
- Use Phase - Piattaforma Metropolitana di Milano Leonardo - Sistema di misura dell'energia installato a bordo dei treni, 2016/09/16
- Product Category Rules (PCR 2009:05) v. 2.11 for preparing an Environmental Product Declaration (EPD) for rolling stock- UN CPC: 495
- General Programme Instructions For Environmental Product Declarations, EPD, Version 2.5, 2015-05-11
- ISO 22628:2002 Road vehicles- Recyclability and recoverability - Calculation method
- EN 15380-2:2006 Railway applications-Designation system for railway vehicles- Part 2 Product Groups
- EN 12663:2000 Railway Applications - Structural Requirements Of Railway Vehicle Bodies
- Database Ecoinvent, software SimaPro 8.2.0 and suppliers' data used for calculation, including database required by PCR
- (1) Reference laws about hazardous substances
  - Regulation 1907/2006 "REACh" (Annex XVII)
  - Directive 94/62/EC on packaging and packaging waste and subsequent updates
  - Regulation (CE) 1005/2009 on ozone depletion substances
  - RoHS Directive 2002/95/CE
  - Regulation (CE) n. 648/2004
  - Directive 2002/72/CE
  - Directive 2001/41/CE
  - Directive 67/548/CEE

Verification information

Product Category Rules (PCR) review was conducted by:
The Technical Committee of the International EPD® System.
Chair: Filippo Sessa
Contact via info@environdec.com.
Independent verification of the declaration and data, according to ISO 14025:2006:
EPD process certification X EPD verification
Third parts verifier:
Adriana Del Borghi
(adriana.delborghi@unige.it)

Approved by:
The International EPD® System
Validity until: 2020-01-15

For further information visit www.environdec.com site.

EPD®s within the same product category but from different programmes may not be comparable.

Contacts

Davide Bonaffini
Hitachi Rail Italy S.p.A.
Via Ciliegiole 110b
51100 – Pistoia (PT) – Italy (IT)
Tel +39 0573 3701
Fax + 39 0573 370616
Davide.Bonaffini@hitachirail.com

HITACHI
Inspire the Next

Hitachi Rail Italy

Hitachi Rail Italy
Via Ciliegiole 110 b

51100 - Pistoia (PT
Italy (IT)

Tel +39 0573 3701
Fax + 39 0573 370616