

HITACHI
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Caravaggio Train



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The Company

Hitachi Rail is the most important railway company in Italy. Since November 2015, it is under the control of Hitachi Rail Europe. Hitachi Rail was born from the merge of two historical companies, Ansaldo Trasporti and Breda Costruzioni Ferroviarie which, during their 160 years, have marked the urban and the extra-urban mobility sector.

Hitachi Rail produces railway and metropolitan vehicles, concerning designing and manufacturing both mechanical parts and electrical equipment. Another distinguishing element of HR's profile is the maintenance service including spare parts

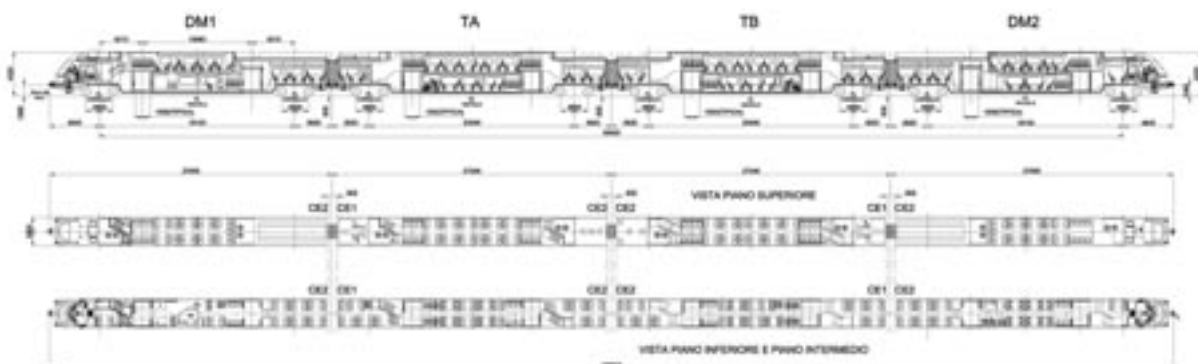
supply, substitution and upgrading.

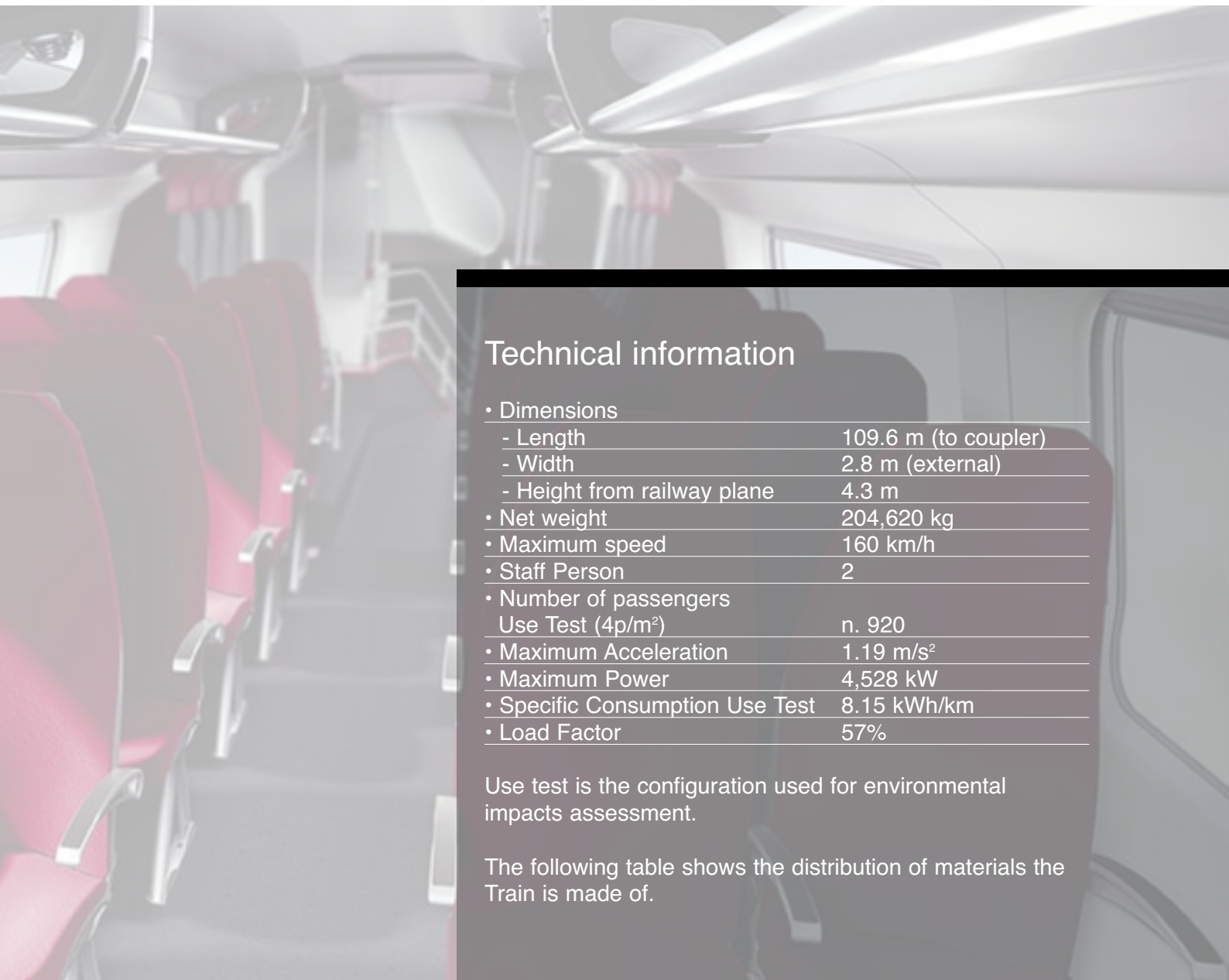
Among the leading products of Hitachi Rail there are the new high-speed train currently in operation in Italy, the ETR1000, the innovative driverless metros for the cities of Milan, Rome, Taipei, Riyadh, Copenhagen, Honolulu, Thessaloniki and Lima, the traditional metros with driver for Milan, Fortaleza, Miami and moreover in the near future, for Baltimore too. HR has great experience in the regional transport which Vivalto and TSR, double high-capacity trains, are just examples of success in Italy.

HR fundamental commitment toward safety, reliability and responsibility is expressed in the maximum accuracy during the whole production process, from design to manufacturing, from precise quality controls to static and dynamic tests, from the choice of materials to the enhancement of resources. Hitachi Rail employs approximately 2,000 employees, divided among Naples, Pistoia and Reggio Calabria plants. The company has subsidiaries in USA and Spain.

The Product

Caravaggio is a Regional Train designed for transport passengers and belongs to the category of passenger transport vehicles classified as "Regional" – "Single- and double-deck electric multiple units". Caravaggio Train consists of four carbodies with three articulations. The traction is supplied by eight electric engines, coupled on four motor boogies, two for motor boogie; the other four trucks are only trailers. Train configuration is shown in the following figure.





Technical information

• Dimensions

- Length	109.6 m (to coupler)
- Width	2.8 m (external)
- Height from railway plane	4.3 m
• Net weight	204,620 kg
• Maximum speed	160 km/h
• Staff Person	2
• Number of passengers	
Use Test (4p/m ²)	n. 920
• Maximum Acceleration	1.19 m/s ²
• Maximum Power	4,528 kW
• Specific Consumption Use Test	8.15 kWh/km
• Load Factor	57%

Use test is the configuration used for environmental impacts assessment.

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



Product group	Materials (kg) vehicle							
	Metals	Polymers	Elastomers	Glass	Fluids	MONM	Other	Total
1 - Carbody	54,084	37	33	-	1	-	11	54,167
2 - Interior, windows and doors	23,544	5,001	2,825	4,307	0	5,007	1,260	41,943
3 - Bogies and running gears	72,360	200	2,341	2	-	-	461	75,364
4 - Propulsion and electric equipment	20,726	2,331	1,474	207	100	-	568	25,406
5 - Comfort systems	7,625	13	22	0	59	-	20	7,740
Total	178,340	7,581	6,695	4,515	161	5,007	2,321	204,620
	87.2%	3.7%	3.3%	2.2%	0.1%	2.4%	1.1%	100%

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

The following table shows the distribution of Caravaggio Train materials referred to the functional unit.

Product group	Materials (mg) U.F.							Total
	Metals	Polymers	Elastomers	Glass	Fluids	MONM	Other	
1 - Carbody	11.757	0.008	0.007	-	-	-	0.002	11.775
2 - Interior, windows and doors	5.118	1.087	0.614	0.936	-	1.088	0.274	9.118
3 - Bogies and running gears	15.731	0.044	0.509	-	-	-	0.100	16.384
4 - Propulsion and electric equipment	4.506	0.507	0.320	0.045	0.022	-	0.123	5.523
5 - Comfort systems	1.658	0.003	0.005	-	0.013	-	0.004	1.683
Total	38.770	1.648	1.455	0.982	0.035	1.088	0.505	44.483
	87.2%	3.7%	3.3%	2.2%	0.1%	2.4%	1.1%	100%

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

Following regulated hazardous material are present on the Train.

Hazardous Materials	kg	Where
Lubricants/oil/grease	148	Propulsion and electric equipment
Gas refrigerants	59	HVAC
Nickel	124	Propulsion and electric equipment
KOH	7	Battery

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





Environmental Performance Declaration

Methodology

The environmental performance of the Train has been quantified using Life Cycle Assessment (LCA) method in accordance with ISO 14040 and ISO 14044. The data handled for the study were carried out in Pistoia plant during 2018, distributed over the product unit. Specific and proxy data fulfil General Program Instruction criteria for EPD as well as PCR for preparing EPD for rail vehicle.

Contribution given by proxy data is less than 10% of the total.

The Use phase has been modelled using data obtained by HR in compliance with the CEI CLC/TS_50591:2014-05 and TECREC 100_001 2010-03-11.

For the use phase impacts' calculation, the following assumption has been adopted:

- Length of route on which energy consumption has been measured: 70 km
- Life period of the Train: 25 years
- Number of passengers transported: 920 as a source for the Italian electric mix MV.

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 per 1 km**.

System Boundaries

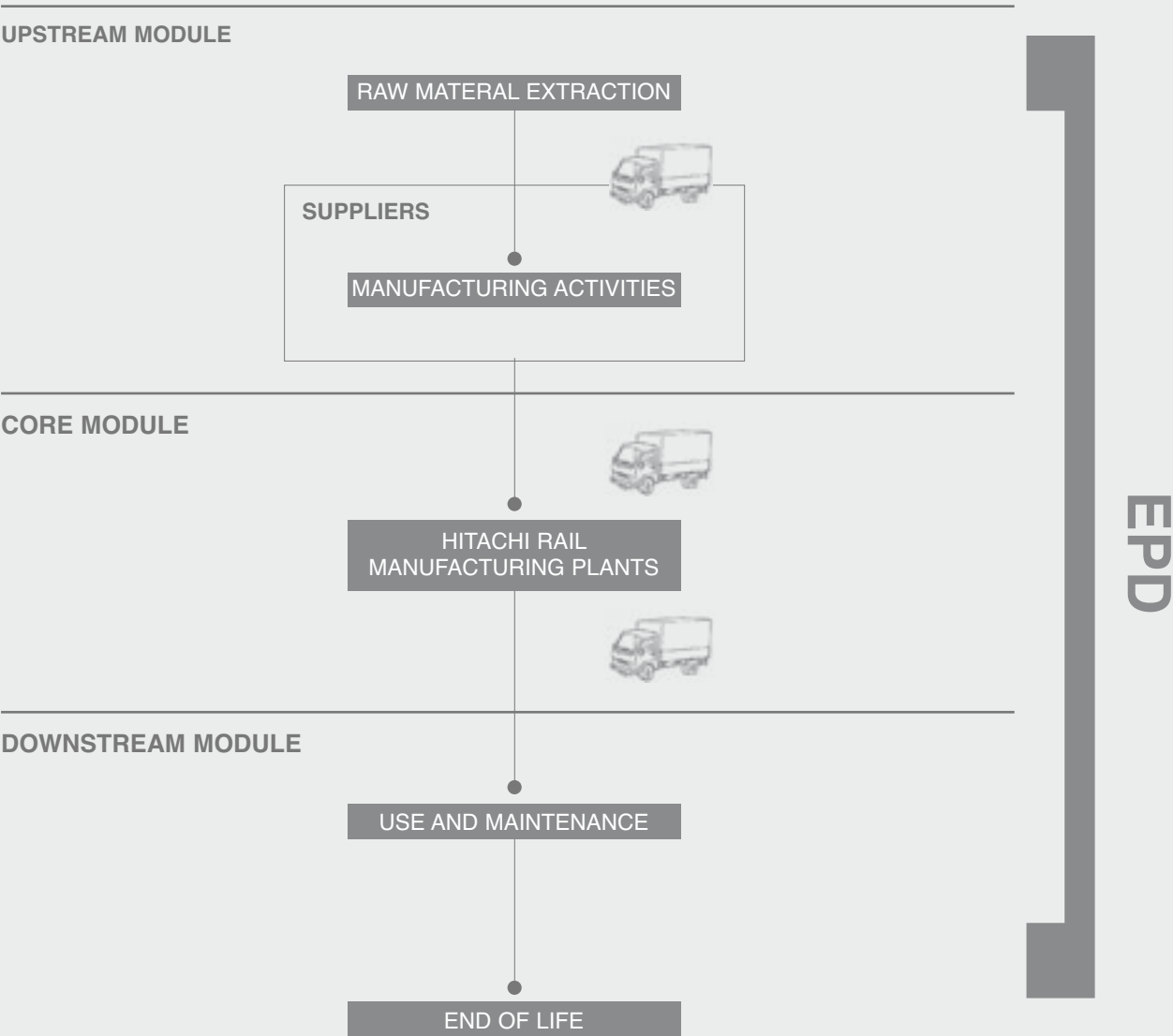
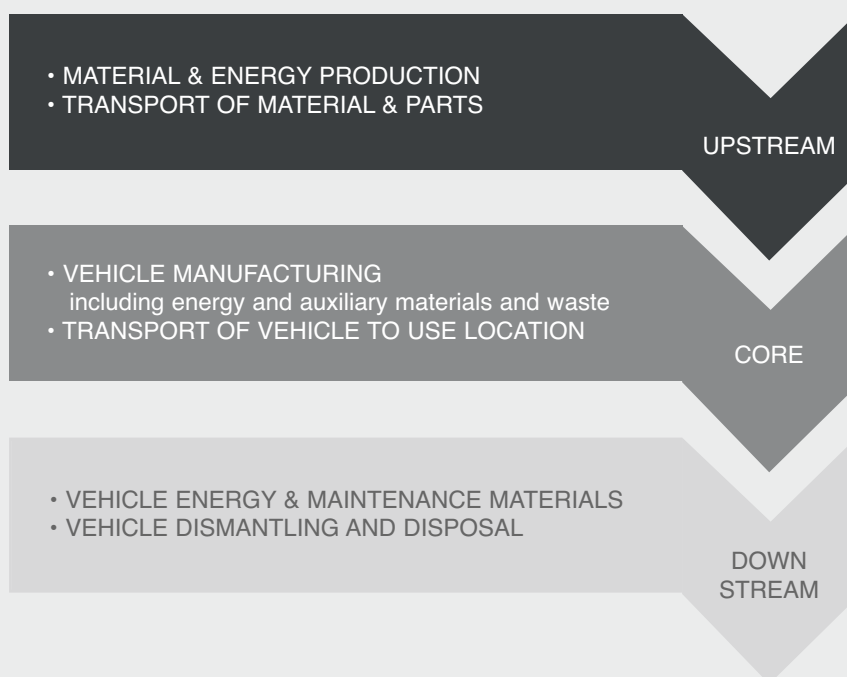


Figure 1 – System boundaries. All main module from the extraction of natural resources to the end of life are included



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



Exclusions (Cut off)

Cut off rules applied are consistent with the PCR requirements.

Environmental Results

Environmental impacts

Parameter	Unit	Upstream	Core	Downstream	Total
Global Warming Potential (GWP)	kg CO ₂ eq.	0.0002099	0.0001571	0.0057392	0.0061060
Ozone Depletion Potential (ODP)	kg CFC-11 eq.	-	-	-	-
Acidification potential (AP)	kg SO ₂ eq.	0.0000018	0.0000004	0.0000262	0.0000284
Eutrophication potential (EP)	kg PO ₄ ³⁻ eq.	0.0000004	0.0000000	0.0000024	0.0000028
Formation potential of tropospheric ozone (POCP o POFP)	kg C ₂ H ₄ eq.	0.0000001	0.0000000	0.0000013	0.0000014
Abiotic depletion potential - Elements	kg Sb eq.	0.0000000	0.0000000	0.0000001	0.0000001
Abiotic depletion potential - Fossil fuels	MJ, net calorific value	0.0029932	0.0020074	0.0941957	0.0991963

Use of resources

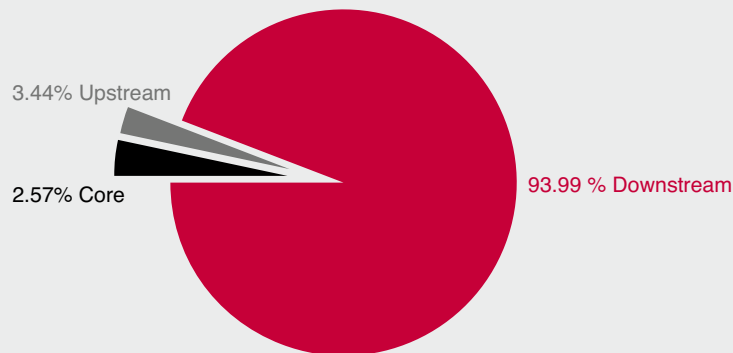
Parameter	Unit	Upstream	Core	Downstream	Total
Primary energy resources - Renewable					
Use as energy carrier	MJ, net calorific value	0.0002573	0.0000354	0.0031336	0.0034263
Used as raw materials	MJ, net calorific value	0.0000192	0.0000008	0.0000473	0.0000673
Total	MJ, net calorific value	0.0002765	0.0031810	0.0031810	0.0034937
Primary energy resources - Non Renewable					
Use as energy carrier	MJ, net calorific value	0.0032692	0.0021927	0.1102974	0.1157593
Used as raw materials	MJ, net calorific value	-	-	-	-
Total	MJ, net calorific value	0.0032692	0.0021927	0.1102974	0.1157593
Secondary material	kg	-	-	-	-
Renewable secondary fuels	MJ, net calorific value	-	-	-	-
Non-renewable secondary fuels	MJ, net calorific value	-	-	-	-
Net use of fresh water	m ³	0.0013581	0.0000985	0.0089990	0.0104556

Waste production and output flows

Parameter	Unit	Upstream	Core	Downstream	Total
Hazardous waste disposed	kg	0.0000001	0.0000007	0.0000001	0.0000008
Non-hazardous waste disposed	kg	0.0000000	0.0000046	0.0000052	0.0000098
Radioactive waste disposed	kg	0.0000000	0.0000000	0.0000002	0.0000002
Components for reuse	kg	N/A	-	-	0.0000000
Material for recycling	kg	N/A	0.0000263	0.0001327	0.0001589
Materials for energy recovery	kg	N/A	0.0000035	0.0001343	0.0001378
Exported energy, electricity	MJ	N/A	-	-	-
Exported energy, thermal	MJ	N/A	-	-	-

As energy mix for the Use Phase has been adopted the National Italian Residual Mixer 2018 in average tension (Version 1.2, 2019-07-11 of Association of Issuing Bodies). Ecoinvent database has been adopted for all processes related to basic material and electronic parts production, as well as for waste treatment. This shows the difference of performance, particularly among the Use Phase, when compared to the previously published EPD.

GWP



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



Additional Information

Energy Consumption

Caravaggio Train electricity consumption for Using Phase has been evaluated by the HR Engineering simulating a 70 km route of mission profile in compliance with the CEI CLC/TS_50591: 2014-05 standards (as required by the reference PCR) and TECREC 100_001 2010-03-11. The outcomes of the simulation supplied a specific consumption of 8.15 kWh / km. The number of passengers used for the functional unit calculation is 920.

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 and trumpets. Following table represents the internal and external noise levels in different operating conditions of the train.

	Zone	U.M.	Stationing	Speed at 80 km/h	Speed at 160 km/h
Internal Noise	Cabin	LpAeq,T [dB(A)]	60	n.a.	66
	Salons	LpAeq,T [dB(A)]	60	n.a.	67
External Noise		LpAeq,T [dB(A)]	68	80	80

The noise analysis has been carried out according to ISO 3095 and ISO 3381.



Potential recyclability and recoverability

	Recovery		Undefined residue
Reuse (Component Parts) 0	Recycling (Materials) 196,089 kg	Energy recovery (Materials) 2,536 kg	Waste (Materials) 5,994 kg
Recyclability rate 95.8%			
Recoverability rate 97.1%			
Vehicle mass 204.620 kg			

	Recyclability	Recoverability
End of life	95.8%	97.1%
Maintenance	94.8%	95.9%
Total life cycle	95.1%	96.3%

Other environmental information

Hitachi Rail has developed and certified environmental (ISO 14001) and worker's health and safety (OHSAS

18001) management systems. Hitachi Rail 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 trigger an allergic reactions has been completely avoided.

Glossary

Acidification Potential (AP):

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 ($\text{kg CO}_{2\text{eq}}$).

HVAC. Heating, Ventilating, and Air Conditioning.

MONM, Modified Organic Natural Materials.

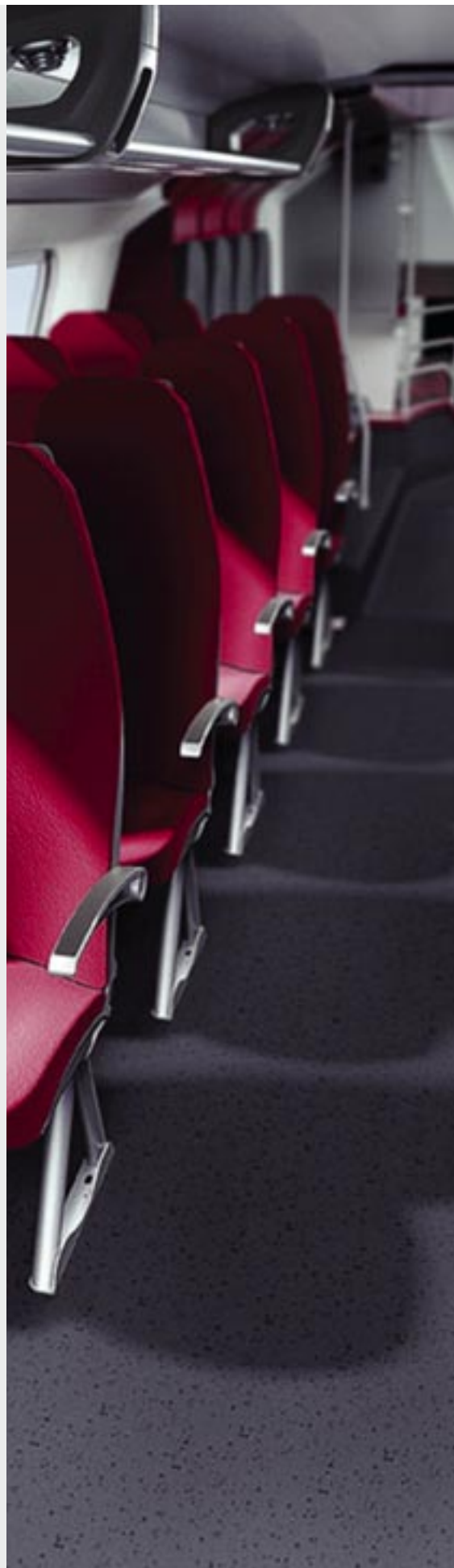
Ozone Depletion Potential

(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 ($\text{kg C}_2\text{H}_4$).

SVHC. Substances of Very High Concern.



References

- Life cycle assessment of Caravaggio Train Rev 03 - Final report, Altran Italia and Hitachi Rail, 11 October 2019
- Use Phase - Piattaforma Treno Caravaggio - Analisi Treni Energia
- Technical Recommendation UIC and UNIFE - Specification and verification of energy consumption for railway rolling stock - TECREC 100_001 2010-03-11 e CEI
- 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 3.0, 2017-12-11
- 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
- ISO 14040:2006 - Environmental management - Life cycle assessment - Principles and framework
- ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines
- ISO 3095:2013 - Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles
- EN ISO 3381:2011 - Railway applications - Acoustics - Measurement of noise inside railbound vehicles
- OHSAS 18001:2007 - Occupational Health and Safety Assessment Series
- UNI EN ISO 14001:2015 Environmental management systems - Requirements with guidance for use
- Database Ecoinvent 3.0.2.1, 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 informations

EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden,
E-mail: info@environdec.com.

EPD in the same product category but coming from different cannot be compared. The owner of the EPD has the exclusive property and responsibility of the EPD itself.

Product Category Rules (PCR) 2009:05 version 3.01 - UN CPC: 495 n. of Registration: S-P-01175	
Product Category Rules (PCR) reviewed and conducted by: The Technical Committee of the International EPD® System. Chair: Adriana Del Borghi	
Independent verification of the declaration and data, according to ISO 14025:2006:	
<input type="checkbox"/> EPD process verification	<input checked="" type="checkbox"/> EPD verification
Third party verifier: Adriana Del Borghi (delborghi@tetisinstitute.it)	
Approved by International EPD® System	
Valida fino: 2024/10/11	
Procedure for follow-up of data during EPD validity involves third party verifier:	
<input checked="" type="checkbox"/> YES	<input type="checkbox"/> NO

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