ENVIRONMENTAL PRODUCT DECLARATION DT5

August 2013

BOMBARDIER ALSTOM

FOREWORD OF THE HOCHBAHN AG, HAMBURG

Hamburger HOCHBAHN AG is the largest transport authority in the Metropolitan Region of Hamburg. It operates a modern and efficient bus and underground network of high performance and quality standards.

The efficiency and modernity of the vehicle fleet with regard to passenger comfort, reliability and profitability are of central importance to the authority. Above all, this also includes the fulfilment of high requirements of climate and environmental protection, such as the reduction in energy consumption, pollutant emission as well as in noise and vibration emission, for example.

HOCHBAHN gives high priority to all these requirements, with the ecological aspects playing a very special role. This also explains the joint initiative of HOCHBAHN, ALSTOM and Bombardier for preparing an Environmental Product Declaration for Hamburg's new DT5 underground vehicle.

All results of this cooperation have an additional positive effect on the running maintenance process over the whole lifetime of the vehicle.

In addition, its dismantling ease, the environmentally friendly material selection and material recyclability will pay off again at the end of the vehicle's lifetime.

Thus, economic aspects could be brought in line with the consistent implementation of ecological improvements in a target-oriented way.

The result of this Environmental Product Declaration represents a consistent continuation of the project "Disassembly-friendly and recyclable rail vehicles by the example of Hamburg's underground vehicle of type DT4.5" of the year 2002. This overall approach is based on the future-oriented cooperation of the partners Alstom, Bombardier and HOCHBAHN.

Ulrich Sieg
Managing Board Service and Infrastructure
Hamburger Hochbahn AG

This Environmental Product Declaration has been prepared in accordance with the International EPD System of the IEC (International EPD Consortium). The EPD is in compliance with ISO 14025. The Life Cycle Assessment defined meets ISO 14040 and 14044. In addition, the development of the EPD has been based on the Product Category Rules for Rail Vehicles given by UNIFE (PCR 2009:05). The data used refer to the year 2011.

This Environmental Product Declaration includes all relevant data on environmental impacts during the entire life cycle of the vehicle. The data are used to compare the environmental compatibility of products.

Product Category Rules (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:

☐ intern ☒ extern

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EPDs within the same product category but from different programmes may not be comparable.
The program instructions of the IEC (International EPD Cooperation) were used.

The EPD is valid until 2016-07-30
Registration number: S-P-00084
For more information: www.environdec.com

Following downstream processes have been omitted due to fact that they contribute less than 1% of the total environmental impact: Rail vehicle dismantling Building, maintenance, dismantling and disposal of rail vehicle disassembly and waste treatment facilities.

RESPONSIBILITY FOR THE ENVIRONMENT

ENVIRONMENTAL MANAGEMENT SYSTEM OF THE CONSORTIUM

As one of the leading railway manufacturers, Alstom has been committed to environmental protection for many years. Already in 1996 Alstom Transport in Salzgitter was validated as the first railway manufacturer worldwide according to the European Ecological Audit Regulation (EWG) 1836/93 and was certified in 1997 according to the International Environmental Standard DIN EN ISO 14001.

As one of the largest production sites for rail vehicles in Germany, Alstom aims to reduce the environmental impacts of its products to a minimum. Both in the production and in the development of its rail vehicles Alstom pays much attention to an environmentally friendly use of resources, to the application of innovative technology and to emission reduction. The same applies to Bombardier.

Thanks to its Ecodesign Policy, Alstom communicates its obligations to the development of environmentally friendly products at all sites. Consequently, Alstom supports the production at sites certified according to ISO 14001, internally as well as externally with suppliers and subcontractors. Alstom designs and manufactures according to this policy and in consideration of the environmental impacts arising during the entire life cycle of a product, with the reduction in CO_2 emission having increased priority. The product development also reflects Alstom's environmental goals.

OBJECTIVES OF THE EPD

The major objective of this Environmental Product Declaration is the publication of the environmental impacts of the rail vehicle. This EPD includes all relevant data on the environmental impacts of the DT5 vehicle during its entire life cycle. The EPD results directly flow into the development of new products.

DT5 – SUSTAINABLE MOBILITY ON HAMBURG'S UNDERGROUND LINES

The DT5 vehicle concept of the consortium of ALSTOM Transport Deutschland GmbH and Bombardier Transportation is based on the development of the DT4 vehicles.

The DT5 is of a consistent lightweight design and allows energy recovery from braking, with the energy consumption being reduced substantially. In addition, the metro vehicle is characterized by a large number of recyclable materials and waives an exterior paint.

Due to its wide entrance, a minimized entry step as well as stepless passages between the car units and the resulting redundant entry and exit possibilities, the DT5 allows barrier-free travelling. Gangways between the cars improve the distribution of passengers throughout the whole vehicle. The air-conditioned passenger room, ergonomically designed seats as well as an extended information system using passenger screens provide a comfortable feeling of riding.

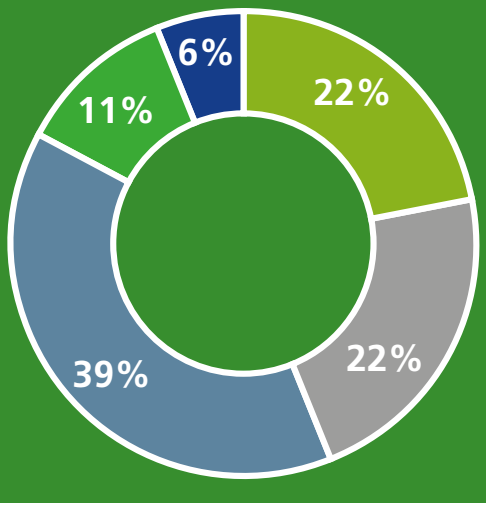
TECHNICAL DATA:

Number of cars	3
Vehicle length	38,800 mm
Car width	2,600 mm
Maximum vehicle height (above top of rail)	3,400 mm
Weight	54.7 t
Considered weight in the LCA	53.65 t
Seats (thereof folding seats)	96 (8)
Standees (4 pass./m²)	16
Maximum speed	80 kph
Installed engine power	810 kW

Technical Data of the DT5

MODULAR STRUCTURE

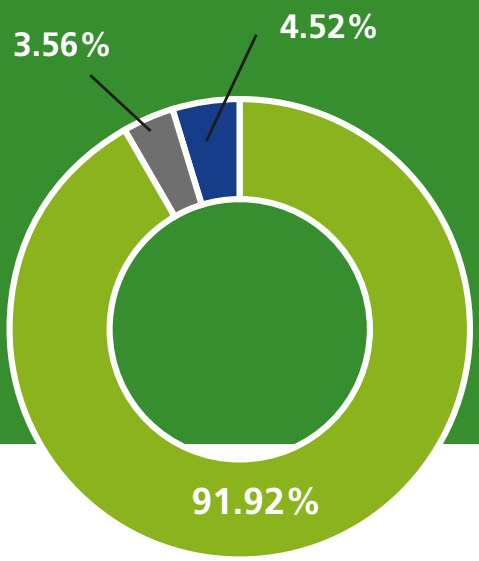
The DT5 is classified as an "Urban Passenger Service Vehicle" according to PCR 2009:05. Its modular structure has been determined in compliance with EN 15380-2.



- Carbody
- Interior, windows and doors
- Bogies and running gears
- Electric equipment
- Comfort systems

POTENTIAL RECYCLABILITY AND RECOVERABILITY

With the development of the three-car DT5 underground vehicle, Alstom sets standards for a sustainable product development.
A **recycling rate of 92%** has been calculated according to ISO 22628. The **recovery rate** amounts to **95.5 %**.

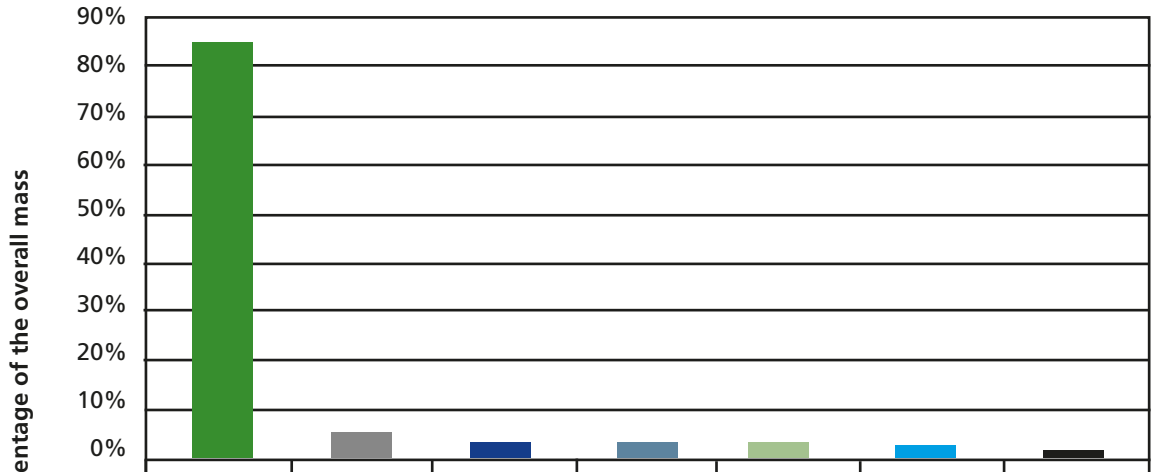


- Material recycling
- Energy recovery
- Disposal

modular structure of the DT5 / recyclability and recoverability

MATERIAL CONTENT

The materials used in the DT5 have been selected in consideration of high energy and resource savings.



	Metals	Polymers	Elastomers	Glass	Fluids	MONM	Others
TOTAL	84.87%	5.17%	1.93%	1.96%	3.25%	1.83%	0.99%

material content of the DT5

TECHNICAL PERFORMANCE

ELECTRICITY CONSUMPTION

Based on a load of 208 passengers (seats occupied and 3.3 pass./m²) and an energy recovery rate of 40 %*[1], the three-car DT5 has an energy consumption of 2.6 kWh/km. This calculation is based on the line profile simulation of Hamburg's U1 underground line (one way) using a contingency time of 5 %. The load factor for this calculation and for a maximum of 256 passengers amounts to 81.25 %.

*[1] ***only the traction equipment (no heating or auxiliary system) was considered in the simulation***

NOISE EMISSIONS

The noise emissions of the DT5 have been measured according to DIN EN ISO 3095 and DIN EN ISO 3381, with the external noise level having been measured at a distance of 7.5 m from the track centre and 1.2 m above the top of the rail.

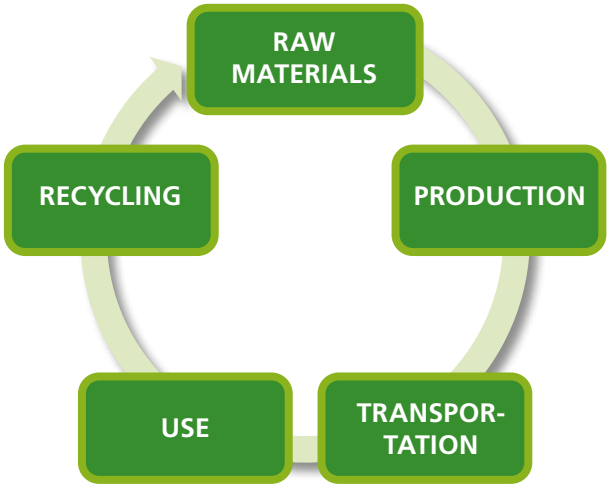
With 75 dB(A) at a speed of 60 km/h, the DT5 is extremely low in noise. The table below shows further results according to PCR 2009:05.

Noise	dB(A)
Stationary sound pressure level**[2]	52
Acceleration sound pressure level	74
Constant speed sound pressure level (at 60 kph)	75

[2] ***deactivated, auxiliaries including air conditioning unit, maximum level*

ENVIRONMENTAL IMPACTS

To be able to make a statement on the environmental compatibility of a rail vehicle, so-called Life Cycle Assessments (LCA) have to be drawn up, which analyse the environmental impacts of a rail vehicle during its entire life cycle, i.e. from its production via its use up to its disposal.

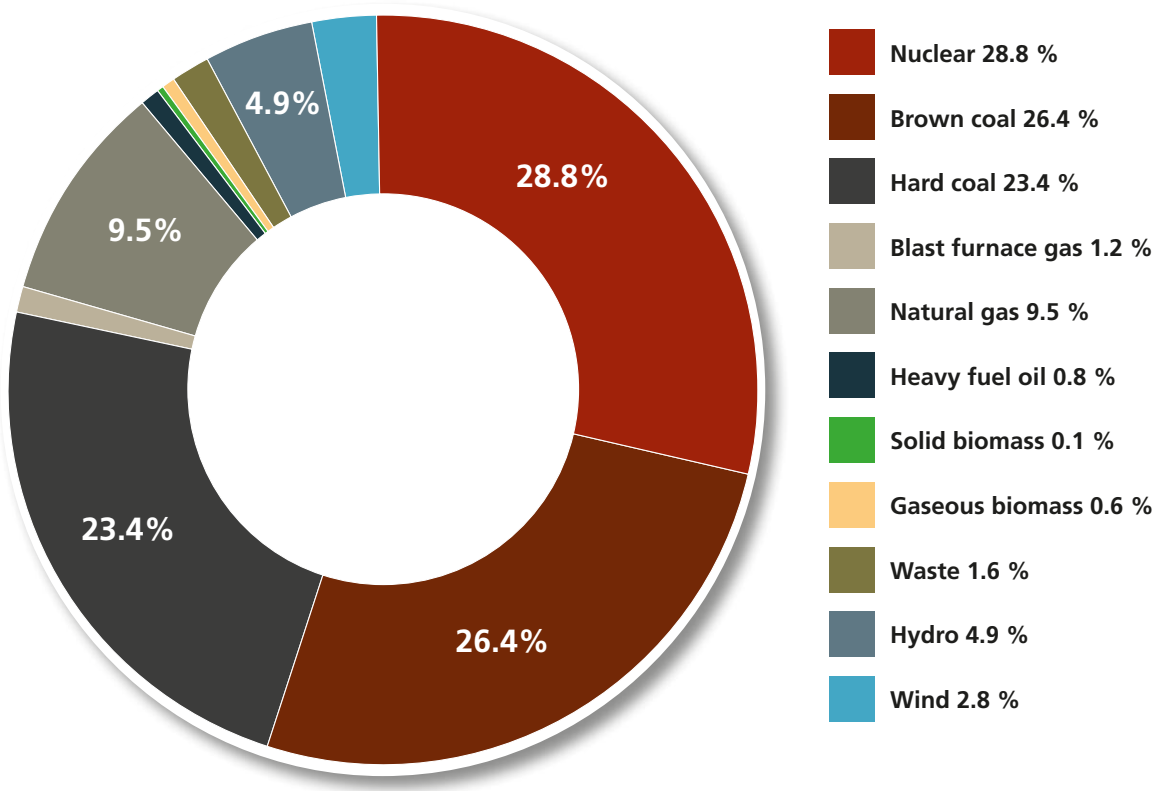


The Life Cycle Assessment of the DT5 has been drawn up according to ISO 14040 and 14044. The analysed life cycle of the DT5 amounts to 30 years, in which about 4 million km are covered. According to PCR 2009:05, the LCA results are thereby divided into 3 phases: Upstream Module, Core Module and Downstream Module.

The Upstream Module includes the extraction and production of raw materials, for example. The Core Module describes, inter alia, the production of the rail vehicle and the corresponding energy consumptions (power, water, gas). The Downstream Module demonstrates the energy consumption during the operation phase (use), the transport of the vehicle to the customer and the disposal of the product (End-of-Life).

The environmental impacts of the energy consumption during use are determined by means of the German energy mixture of the year 2002 (ELCD Database 3.0).

GERMAN ENERGY MIXTURE OF THE YEAR 2002



USE OF RESOURCES OF THE DT5 ACCORDING TO PCR 2009:05

NON-RENEWABLE RESOURCES

	Upstream	Core	Downstream		Total
			Use	End-of-Life	
Material [kg/Passenger· 100 km]					
Inert rock	3.33E-04	2.69E-02	4.57E+00	6.03E-06	4.60E+00
Calcium carbonate	3.22E-04	1.23E-04	1.86E-02	4.28E-06	1.90E-02
Natural aggregate	2.98E-08	2.48E-05	3.45E-03	4.45E-07	3.48E-03
Others	1.92E-03	7.49E-05	3.05E-03	4.04E-06	5.06E-03
Energy [kWh/Passenger · 100 km]					
Uranium	1.42E-02	8.68E-03	1.43E+00	1.56E-05	1.46E+00
Crude oil	1.58E-02	1.97E-03	5.96E-02	8.96E-06	7.74E-02
Hard coal	4.74E-02	5.21E-03	8.45E-01	6.37E-06	8.98E-01
Lignite (brown coal)	3.71E-03	5.61E-03	9.54E-01	1.59E-06	9.63E-01
Natural gas	1.98E-02	2.10E-02	3.52E-01	2.19E-05	3.93E-01
Others	2.31E-07	6.14E-07	2.97E-07	1.60E-08	1.15E-06
Total	**1.01E-01**	**4.24E-02**	**3.64E+00**	**5.43E-05**	**3.79E+00**

RENEWABLE RESOURCES

	Upstream	Core	Downstream		Total
			Use	End-of-Life	
Material [kg/Passenger · 100 km]					
Water	5.43E-01	6.24E-02	1.56E+01	1.02E-03	1.62E+01
Oxygen	5.01E-04	4.78E-02	3.92E+00	9.09E-04	3.97E+00
Carbon dioxide	1.25E-04	1.30E-05	1.88E-03	2.05E-08	2.02E-03
Others	1.96E-14	0.00E+00	4.80E-18	3.99E-22	1.96E-14
Energy [kWh/Passenger · 100 km]					
Hydropower	2.97E-05	4.91E-04	8.14E-02	2.99E-07	8.19E-02
Biomass	2.07E-10	1.42E-14	2.95E-16	1.71E-11	2.24E-10
Wind power	5.78E-07	5.41E-04	9.26E-02	8.15E-08	9.31E-02
Solar energy	7.95E-08	5.11E-05	8.14E-03	5.61E-08	8.19E-03
Geothermics	2.69E-08	1.63E-06	1.19E-04	2.41E-08	1.21E-04
Others	1.17E-03	2.09E-04	6.51E-05	7.55E-09	1.44E-03
Total	**1.20E-03**	**1.29E-03**	**1.82E-01**	**4.68E-07**	**1.85E-01**

WASTE GENERATION

WASTE					
	Upstream	Core	Downstream		Total
			Use	End-of-Life	
Material [kg/Fahrgast · 100 km]					
Hazardous	3.71E-04	8.57E-06	4.34E-04	8.56E-06	8.23E-04
Non-hazardous	2.80E-02	2.69E-02	4.58E+00	7.31E-06	4.63E+00
Total	2.84E-02	2.69E-02	4.58E+00	1.59E-05	4.63E+00

POTENTIAL ENVIRONMENTAL IMPACTS

The potential environmental impacts are quantified by so-called impact categories (see glossary).
The individual categories are calculated by means of the substances arising during the entire life cycle.

ENVIRONMENTAL IMPACT CATEGORIES					
	Upstream	Core	Downstream		Total
			Use	End-of-Life	
Material [kg/Passenger · 100 km]					
EP [kg PO_4 eq.]	1.60E-06	1.18E-07	9.81E-06	7.57E-08	1.16E-05
AP [kg SO_2 eq.]	1.44E-04	1.51E-05	1.45E-03	9.54E-08	1.61E-03
GWP [kg CO_2 eq.]	2.47E-02	9.31E-03	8.42E-01	5.69E-04	8.76E-01
ODP [kg CFC-11 eq.]	2.61E-08	9.38E-10	1.39E-07	1.16E-12	1.66E-07
POCP [kg C_2H_4 eq.]	5.44E-06	2.20E-06	3.03E-05	4.77E-09	3.80E-05

GLOSSARY

TERM	DESCRIPTION
EPD	An Environmental Product Declaration contains verifiable and comparative statements on the environmental impacts of a product. It is based on a Life Cycle Assessment (LCA). So-called Product Category Rules determine the content of an EPD. The PCR 2009:05 is applied to rail vehicles.
LCA	A Life Cycle Assessment demonstrates the environmental impacts of a rail vehicle during its entire life cycle.
MONM	= Modified organic natural materials The material category MONM describes the used organic materials, such as leather, wood, cardboard and cotton fleece.
Impact categories	Impact categories are selected environmental topics, which reflect the consolidated values of emissions or resource consumption and represent the potential environmental impacts.
GWP	The Global Warming Potential describes the impacts of certain gases on the anthropogenic, i.e. man-made greenhouse effect. The relevant greenhouse gases are indicated in CO_2 equivalents, i.e. the emissions are set in relation to CO_2 concerning their potential greenhouse effect.
ODP	The Ozone Depletion Potential describes the depletion of the stratospheric ozone layer caused by mankind. If the ozone concentration in the stratosphere is too low, this may cause photosynthesis failures, for example, and humans may suffer from skin cancer and eye diseases, for example.
POCP	The Photochemical Ozone Creation Potential quantifies the photochemical ozone-forming potentials of individual emissions. Excessive photochemical ozone creation leads to a high, particularly toxic ozone concentration near ground level.
AP	The Acidification Potential describes the acid deposition in plants, soils and surface waters caused by the conversion of air pollutants in acid.
EP	Water Eutrophication comprises the natural or man-caused accumulation of nutrients in waters or soils. An excess of nutrients affects the biological balance, which leads to fish kill in waters, for example.
Recycling rate	The recycling rate describes the ratio of the quantity of material that can be reused, recycled or both to the whole mass of the vehicle.
Recovery rate	The recovery rate is composed of the material mass that can be recycled, reused or energetically recovered.

Photos: Hamburger HOCHBAHN AG Bernd Rosenthal, Fotolia.com: Iakov Kalinin, drubig-photo, incomible
Design: bruhndesign.de

BOMBARDIER
the evolution of mobility

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