SYDNEY METRO

ENVIRONMENTAL PRODUCT DECLARATION

EPD registration number: S-P-05266
Publication date: 2022-04-22
Revision date: 2022-05-05
Valid until: 2027-04-21

ALSTOM
• mobility by nature •

ALSTOM, AT THE FOREFRONT OF SUSTAINABILITY

As a promoter of sustainable mobility, Alstom places environmental issues at the heart of its R&D strategy, constantly designing solutions and products which are less energy-consuming, quicker to install, cheaper to maintain, and with higher lifespan and reduced carbon footprint.

For more than 10 years, the company has systematically introduced eco-design in its engineering procedures. Various environmental dashboards have been implemented. They help us to quantify and improve the environmental impact of our solutions from development phase up to final use. Today, Alstom can rely on a team of more than 100 experts to ensure the environmental performance of its portfolio and is able to develop innovative infrastructure solutions to tackle key environmental challenges.

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"**Sydney Metro has been a game changer for the travelling public of Sydney** and Alstom is delighted to continue to be a part of this iconic project. It strengthens Alstom's position as the market leader for the supply of railway technologies in Australia."
Ling Fang, Senior Vice President of Alstom Asia-Pacific.

SUSTAINABLE MOBILITY

ALSTOM, AT THE FOREFRONT OF SUSTAINABLE MOBILITY

Alstom develops and offers a range of systems, equipment and services for the rail sector and values its mission to support the transition towards global sustainable transport systems that are inclusive, environmentally-friendly, safe and efficient. As well as taking life cycle into account, from concept to recycling including maintenance and energy consumption, Alstom offers innovative solutions that respect the environment and meet the mobility needs according to a socially responsible model. As a major player in ecological transport, sustainable development is at the heart of Alstom's strategy.
Alstom has an environmental management system fully in place and 100% of manufacturing sites and regional centers with over 200 employees are certified according to ISO14001:2015.

ECODESIGN APPROACH

More than 10 years ago, Alstom systematically introduced Ecodesign into its engineering procedures to meet the expectations of sustainable motility. It has given rise to environmental assessments that focus on fundamental topics at the start of the development phase, the quantification of the environmental impact (life cycle assessments) and more ecological solutions. Today, more than 100 experts (eco-designers, experts for acoustic and energy-saving materials) endeavor to ensure the environmental performance of each solution. Ecodesign approach addresses the design and development of products using a life cycle perspective. It aims at continually improving the environmental performance of products through the management of their significant environmental aspects. In this context, life cycle assessment (LCA) is a relevant tool to identify and thus to allow the reduction of products' environmental impacts.

METRO SOLUTION

Sydney Metro Rolling stocks are built on Metropolis platform which is an Alstom-made driverless system, proven over 15 years, that is built on the principle of 'customization with modularity'.
It comes with a range of energy conservation features like optimum weight management, high insulation properties, reduced solar heat transmission to Interiors, Variable climate control, LED lighting, ambitious recyclability target, Regenerative braking, Train Control and Monitoring System (TCMS) controlling the traction, braking and HVAC systems, etc.

See Alstom's annual registration document for more information on Alstom Sustainable Development Strategy, including eco-design on www.alstom.com

DESCRIPTION OF THE PRODUCT

TECHNICAL DATA

	Vehicle data
Train composition	6 cars
Number of seats	330
Passenger capacity, all seats occupied and standee density of:	2 passengers/m²: 720 4 passengers/m²: 1152 6 passengers/m²: 1536
Body shell	Stainless steel
Total train weight (without passengers)	230 t
Car length	TC : 2255 mm / MC & MP: 2185 mm
Max External Width	2900 mm
Total height	3 950 mm (4 050 mm with pantograph)
Floor height	1 200 mm
Driver' operation	Fully Automatic Train Operation
Maximum Design / commercial speed	110 km/h
Acceleration (0 – 40 km/h):	1.2 m/s2
Service / Emergency deceleration	1.1 m/s2 / 1.4 m/s2
Power supply type and voltage	Catenary, 1.5 kV DC
Wheel / Tyre type	Wheel
Track gauge	1435 mm
Curve rad. line / depot	395m / 160 m
Climate conditions	Maximal External temperature 55°C at the condenser inlet.

CONFIGURATIONS

- **2 driving Trailer Cars (TC)**
- **2 Motor cars with Pantograph (MP)**
- **2 Motor Cars (MC)**

TCs are provided with driver desk and driver controls as a provision for operating the train manually if required. They also contain front detrainment doors for emergency evacuation, multi purpose area for extra space for standing, luggage, prams, etc.

MCs and MPs are fitted with traction motors on bogies to move the train. MP cars are fitted with pantograph which connects to overhead catenaries to feed the train with high voltage current.

Car body:
Light weight, integrated welded structure of corrosion resistance austenitic stainless steel.

Interior, windows and doors:
Light weight interiors and insulation with good heat resistance, automatic door closing to limit heat transfer.

Bogies and running gears:
Efficient ride and comfort, controls speed and safety, low noise gear drive.

Comfort:
Efficient air-conditioning and ventilation systems: adjustment of the air flow depending on the number of passengers present, two HVAC units per car.

Propulsion and electric equipment:
Traction allows energy recovery during braking.

MAIN FACTS

Sydney Metro trainsets are based on Alstom's Metropolis range of metro trains, relying on proven technologies from decades of experience. More than 17,000 Alstom metro cars are operated currently in the world by more than 50 customers.

The Sydney Metro City & Southwest (SMCSW) project delivers a new 30-kilometre metro line extending metro rail from the end of Sydney Metro Northwest at Chatswood under Sydney Harbour, through new CBD stations and southwest to Bankstown. This is an extension of existing Sydney Metro Northwest (SMNW) which has delivered a 28-km metro line and currently completed the warranty phase. The key benefits of Sydney Metro are :

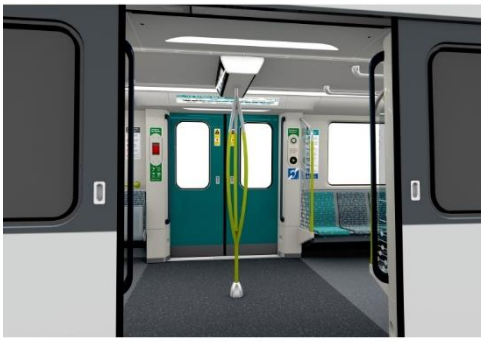
Sydney Metro is Australia's first fully-automated rail network and largest public transport project.

Fast journey

The Metropolis train was designed to be an aerodynamically efficient carbody. The Urbalis signaling system minimizes the time trains are stopped at stations and the time between each train.

Enhanced travel experience

Stations are equipped with platform screen doors for passenger safety. Each train is equipped with 38 surveillance cameras, emergency intercoms and provides real-time travel information as well as continuous mobile phone coverage.



Accessibility

All cars are designed respecting Disability Standards for Accessible Public Transport (DSAPT) requirements of Australia ensuring people with reduced mobility can move inside trains without difficulties. Accessibility is improved through three large double doors per carriage.

Noise emissions

The following noise performance levels are reached.

	Type	dB(A)
Internal noise	Stat	62.2
	100 km/h Open Track	69.5
	100 km/h Tunnel	76.1
External noise	Stat at 1m	76.7
	100 km/h at 7.5m	84

LIFE CYCLE DESCRIPTION

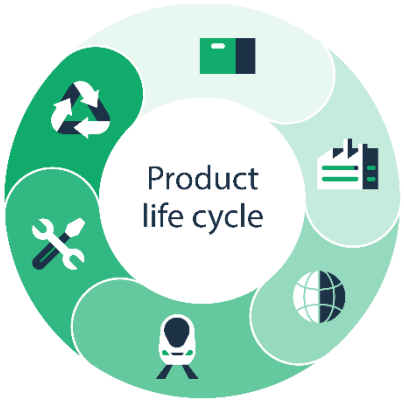
Environmental impacts of Sydney metro have been characterized through the realization of an LCA in accordance with ISO 14040:2006 and ISO 14044:2006 methodologies, and the requirements of the PCR for Rolling stock, UN CPC 495, 2009:05, version 3.04. The EIME Software-System and Databases for Life Cycle Engineering (EIME© v5.9.3 database version January 2022) were used to perform this life cycle impact assessment.

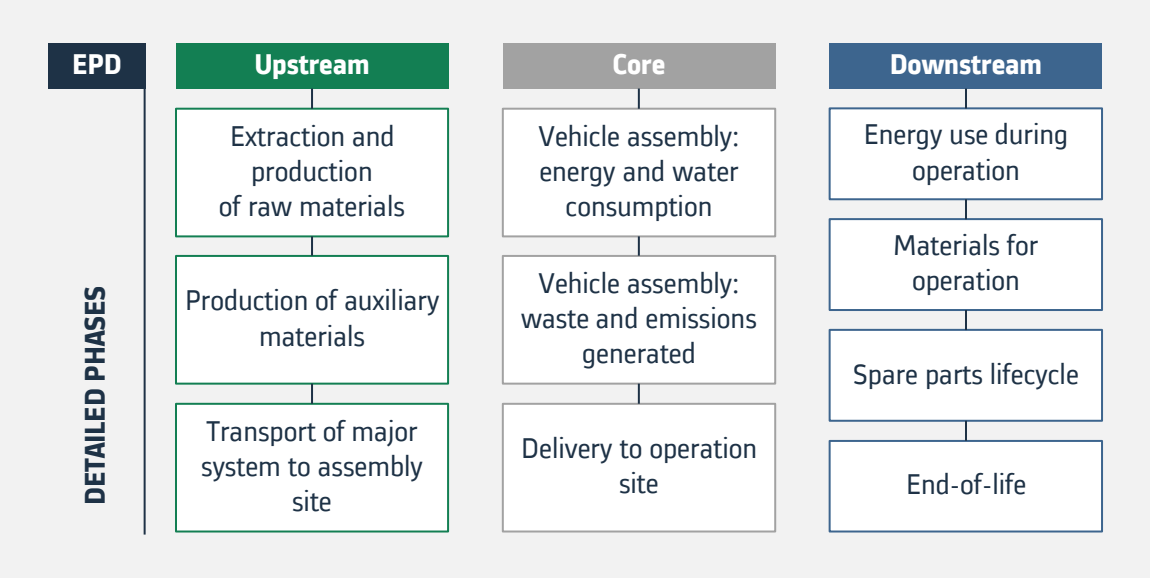
FUNCTIONAL UNIT

The functional unit for the performed LCA is transport of 1 passenger over 1 km using a 6 car Sydney metro with a capacity of 4 passengers/m2 in service for 35 years operating on the Metro Northwest – City & Southwest between Chatswood and Tallawong with an average running distance of 120 000 km per year.

LIFE CYCLE BOUNDARIES

The whole life cycle of the rolling stock is considered, in other words, the LCA is a "cradle to grave" LCA that takes into account all life cycle phases from the extraction of raw materials which compose the different equipment to the end-of-life waste management. Transport along the supply chain and to the operator site are included as well as all assembly activities (electricity, utilities and consumable) in Sri City (India). The operation of the rolling stock requires a certain amount of energy, both for commercial and pre-conditioning service. Maintenance include the materials used to operate the rolling stock and the spare parts in accordance with the project preventive maintenance plan. Finally, collection and treatment of end-of-life materials have been considered.
The Australian electricity grid mix has been used for the electricity consumption during operation, which is very close to the grid mix of the State of New South Wales.



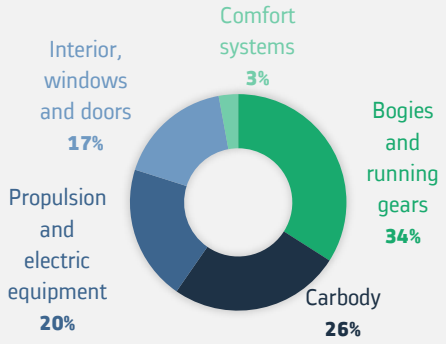


LIFE CYCLE DESCRIPTION

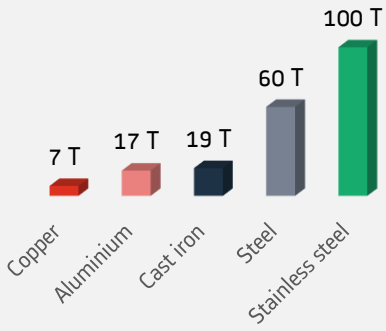
BILL OF MATERIALS

	Upstream (vehicle)	Downstream (spare parts)	Total
Electric and Electronic Equipment (EEE)	8 711	10 381	**19 092**
Elastomers	4 957	5 329	**10 286**
Fluids	424	256	**680**
Glass	4 073	10	**4 083**
Metals	197 147	114 155	**311 302**
MONM	4 560	255	**4 815**
Polymers - filled and unfilled	7 218	1 783	**9 001**
Others	3 473	16 536	**20 009**
Total	230 563	148 705	**379 268**

Rolling stock manufacturing: Share of mass by PCR categories

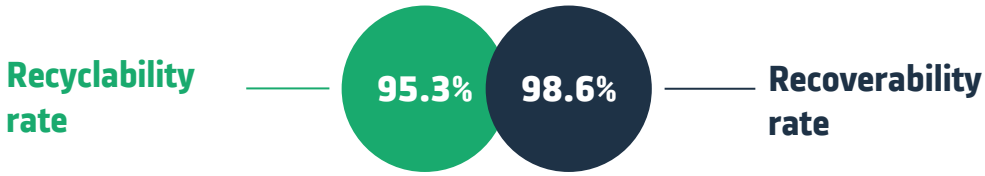


Rolling stock :Top five materials for manufacturing (upstream)



A RECYCLABLE SOLUTION

Using materials featuring high recyclability and considering disassembly early in the design maximises the overall recoverability. Material recycling and energy recovery aggregates to a 98.6% recoverability rate by applying the ISO 22628:2002 methodology



HAZARDOUS SUBSTANCES

For many years, Alstom has been proactively engaged in the reduction of hazardous substances resulting in benefits for:

- **Health**: Avoid production and corresponding risks, avoid use inside Alstom and Alstom's suppliers' premises
- **Environment**: Avoid any release into the environment and emissions at end-of-life, allow recycling
- **Cost**: Avoid extra cost for end-of-life treatment

Alstom's standard for hazardous substances management considers applicable Australian regulation and railway sector principles. No hazardous substances are used in any prohibited application to produce the Sydney metro.

ENVIRONMENTAL IMPACTS

POTENTIAL ENVIRONMENTAL IMPACTS - Transport of 1 passenger for 1 km

Indicators	Short name	Unit	Upstream	Core	Downstream	Total
Global Warming Potential – total	GWPt	kg CO_2 eq.	2.85E-04	3.76E-05	1.14E-02	1.17E-02
Global Warming Potential – biogenic	*GWPb*	*kg CO_2 eq.*	*1.85E-06*	*3.04E-07*	*5.99E-06*	*8.14E-06*
Global Warming Potential - land use and land use change	*GWPlu*	*kg CO_2 eq.*	*8.04E-12*	*0.00E+00*	*1.15E-13*	*8.14E-12*
Global Warming Potential – fossil	*GWPf*	*kg CO_2 eq.*	*2.83E-04*	*3.72E-05*	*1.14E-02*	*1.17E-02*
Acidification potential	AP	kg SO_2 eq.	1.58E-06	4.20E-07	6.41E-05	6.61E-05
Eutrophication potential	EP	kg PO_4^{3-} eq.	1.59E-07	3.07E-08	3.00E-06	3.20E-06
Photochemical oxidant formation potential	POCP	kg NMVOC eq.	9.40E-07	2.93E-07	2.79E-05	2.91E-05
Abiotic depletion potential – elements	ADPe	kg Sb eq.	2.11E-08	2.84E-12	5.10E-08	7.21E-08
Abiotic depletion potential – fossil fuels	ADPf	MJ	2.79E-03	4.94E-04	1.71E-01	1.74E-01
Water Depletion Potential	WDP	m^3 world eq. deprived	2.06E-04	9.30E-06	4.75E-04	6.90E-04
Ozone Depletion Potential*	ODP	kg CFC-11 eq.	2.25E-10	7.86E-11	1.49E-10	4.53E-10
Ionizing radiation - Human Health*	IRHH	kg U-235 eq.	4.98E-05	1.37E-06	1.02E-04	1.53E-04
Particulate Matter formation potential*	PM	Disease occurrence	1.48E-11	2.64E-12	4.65E-10	4.82E-10

* Optional indicators

GLOBAL WARMING POTENTIAL

Contribution to planet global warming by the emission of greenhouse gases. GWP-total is expressed as the sum of GWP-fossil, GWP-biogenic and GWP-land use and land use change

PHOTOCHEMICAL OZONE CREATION POTENTIAL

Measure of the potential of gases (NOx, CO, VOCs, etc.) to form tropospheric ozone under the effect of solar radiation

EUTROPHICATION POTENTIAL

Measure of the emission of substances (e.g., phosphorus, nitrogen) increasing oxygen scarcity in waters

DEPLETION OF ABIOTIC RESOURCES-ELEMENTS

Depletion of mineral and metallic resources due to extraction

DEPLETION OF ABIOTIC RESOURCES-FOSSIL FUELS

Depletion of energetic fossil resources (natural gas, coal, etc.)

ACIDIFICATION POTENTIAL

Potential of atmospheric acidification caused by the emission of gas with acidifying effects

WATER DEPLETION POTENTIAL

Measure of the reduction of the total amount of usable water due to human activities

OZONE DEPLETION POTENTIAL*

Contribution made by the discharge of specific gases (e.g., CFCs) responsible for ozone layer depletion

IONIZING RADIATION*

Emissions of radionuclides with damage to human health and ecosystems (generally linked to use of nuclear power in an electricity mix)

PARTICULATE MATTER FORMATION*

Health impact of emissions of small particles and liquid droplets (e.g., organic chemicals, soil or dust particles)

POTENTIAL ENVIRONMENTAL IMPACTS – Breakdown - Transport of 1 passenger for 1 km

For most indicators, the downstream phase is responsible for the most significant part of the environmental impacts. This is especially due to the electricity consumption for traction and auxiliaries during the use of the metro for the 35 years of its expected lifetime.

FOCUS ON ENERGY CONSUMPTION

The energy consumption is based on an equipped vehicle, occupied with 1152 passengers and all auxiliary and passenger comfort systems operating.

The electric power considered for HVAC use was calculated based on the average climatic conditions reported in Sydney between 1958 and 2018. It is split between cooling (50%), heating (30%) and ventilating (20%) modes.

Traction consumption simulations have been conducted for peak hours and off-peak hours of commercial service and incorporate the recovery of train's kinematic energy (electromechanical braking). Optimization of tractive effort and speed depending on track and train parameters to decrease energy consumption with full respect of trip time requirement was taken into account as well.

Finally, energy consumed by the auxiliaries for pre-conditioning has also been considered, with a converter efficiency of 90%.

	Value
Distance traveled per year	120 000 km
Operation time	365 days/year
	19 hours/day
Energy consumption	**0.012 kWh/pass.km**

USE OF RESOURCES - Transport of 1 passenger for 1 km

Indicators	Unit	Upstream	Core	Downstream	Total
Use of renewable primary energy excluding renewable primary energy used as raw material	MJ	6.24E-05	8.80E-05	1.31E-02	**1.33E-02**
Use of renewable primary energy resources used as raw material	MJ	1.77E-05	3.82E-08	1.30E-06	**1.90E-05**
Total use of renewable primary energy resources	MJ	8.00E-05	8.80E-05	1.31E-02	**1.33E-02**
Use of non-renewable primary energy excluding non-renewable primary energy used as raw material	MJ	5.27E-03	5.10E-04	1.79E-01	**1.85E-01**
Use of non-renewable primary energy resources used as raw material	MJ	9.36E-05	8.08E-06	9.30E-05	**1.95E-04**
Total use of non-renewable primary energy resources	MJ	5.35E-03	5.19E-04	1.79E-01	**1.85E-01**
Total Primary Energy	MJ	5.44E-03	6.06E-04	1.92E-01	**1.98E-01**
Use of secondary material	kg	2.03E-05	2.38E-07	1.57E-05	**3.63E-05**
Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of non-renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Net use of freshwater	m^3	4.28E-06	2.93E-07	1.12E-05	**1.58E-05**

WASTE AND OUTPUT FLOWS - TRANSPORT OF 1 PASSENGER FOR 1 KM

Indicators	Unit	Upstream	Core	Downstream	Total
Hazardous waste disposed	kg	3.51E-04	1.29E-06	4.42E-04	**7.96E-04**
Non-hazardous waste disposed	kg	1.21E-04	6.35E-06	1.86E-03	**1.99E-03**
Radioactive waste disposed	kg	5.06E-08	1.04E-09	1.98E-07	**2.50E-07**
Components for reuse	kg	N/A	0.00E+00	0.00E+00	**0.00E+00**
Materials for recycling	kg	N/A	0.00E+00	7.56E-05	**7.56E-05**
Materials for energy recovery	kg	N/A	0.00E+00	4.05E-06	**4.05E-06**
Exported Energy, electricity	MJ	N/A	0.00E+00	0.00E+00	**0.00E+00**
Exported Energy, thermal	MJ	N/A	0.00E+00	0.00E+00	**0.00E+00**

PROGRAMME RELATED INFORMATION AND VERIFICATION

General Programme Instructions for the International EPD® System version 3.01 2019-09-18

Product category rules (PCR): Rolling stock, PCR 2009:05, version 3.04, UN CPC 495

PCR review was conducted by:

The Technical Committee of the International EPD® System. A full list of members available on www.environdec.com/TC. The PCR review panel may be contacted via info@environdec.com.

Members of the Technical Committee were requested to state any potential conflict of interest with the PCR moderator or PCR committee and were excused from the review.

Independent verification of the declaration and data, according to ISO 14025:2006

☐ **EPD Process Certification (internal)** ☒ **EPD Verification (external)**

Third party verifier:

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Accredited by:

Recognized individual verifiers, approved by the International EPD System.

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

Programme:	The International EPD® System EPD International AB Box 210 60 SE-100 31 Stockholm Sweden www.environdec.com
EPD registration number:	S-P-05266
Published:	2022-04-22
Valid until:	2027-04-21
Revision date:	2022-05-05
Product Category Rules:	Rolling stock, PCR 2009:05, version 3.04
Product group classification:	UN CPC 495
Reference year for data:	2021
Geographical scope:	Global

An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

EPD owner:	Alstom 48, rue Albert Dhalenne 93482 Saint-Ouen, Cedex France
LCA producer:	Alstom 48, rue Albert Dhalenne 93482 Saint-Ouen, Cedex France
Programme operator:	EPD International AB info@environdec.com
Revision	2022-04-22 First issue 2022-05-05 Editorial update: correction of switch between recyclability and recoverability rates p. 7

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