railconnect NSW

EPD® AUSTRALASIA

Environmental Product Declaration

In Accordance with ISO 14025

New Intercity Fleet

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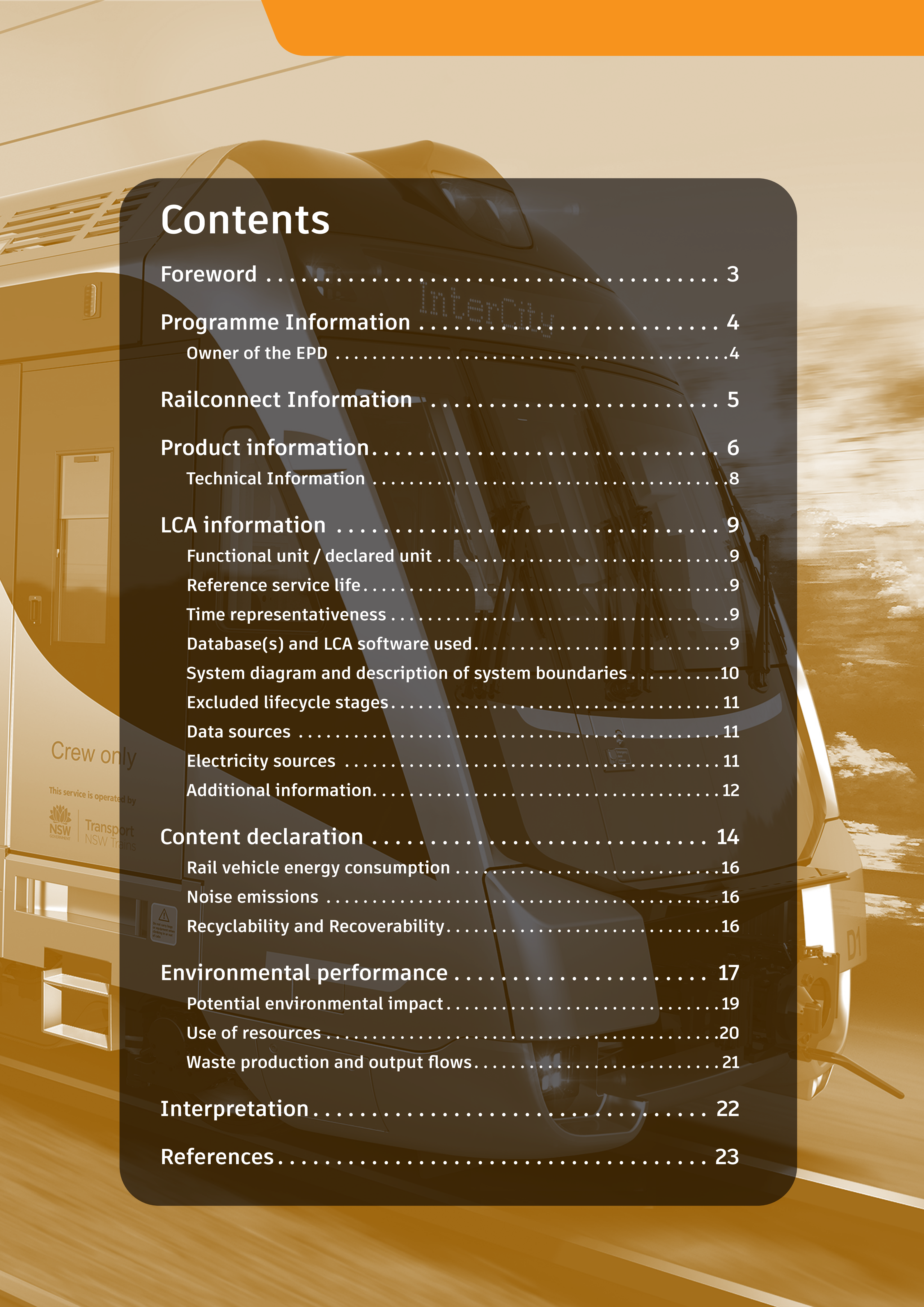

Contents

Foreword

At Railconnect, environment and sustainability are one of our key cornerstones, reflecting our dedication to developing products and services for sustainable mobility.

Here, we communicate the environmental performance of our product through this Environmental Product Declaration (EPD) following the international EPD® system. This EPD was developed in line with the UNIFE Product Category Rules for Rail Vehicles (PCR 2009:05) as well as the principles and procedures of ISO 14025:2006.

Based on Life Cycle Assessment methodology, this EPD serves as an externally validated communication tool, providing complete transparency of the benefit to our customers and other stakeholders. External validation has been carried out by independent verifiers approved by the technical committee of the international EPD® system.

This EPD gives a detailed insight into the environmental impact of the New Intercity Fleet trains throughout all phases of the vehicle life cycle.

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☒ Yes	☐ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD. EPDs within the same product category but from different programs may not be comparable.

Owner of the EPD

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Railconnect Information

RailConnect is a joint venture between Hyundai-Rotem, UGL and Mitsubishi, providing a new fleet of trains carrying customers from Sydney to the Central Coast, Newcastle, the Blue Mountains and the South Coast. The fleet of high capacity double deck trains will offer long distance customers a more enjoyable travelling experience, providing comfortable seating, advanced communications technology and enhanced commuter amenities.

RailConnect will design and build more than 500 carriages, with the first trains delivered by 2019 and the rest of the fleet being delivered progressively through to 2022. The joint venture will provide maintenance and asset management services to the new fleet commencing on delivery of the first train in 2019 for a period of 15 years, with options to extend the contract for an additional five years.

Maintenance will be undertaken at a new facility in Kangy Angy, located between Sydney and Newcastle on the Central Coast of NSW. RailConnect will procure, supply, install, integrate and commission the maintenance facility installation works and provide input into the design of the maintenance facility construction.

The passenger cars will be designed, manufactured, tested and commissioned by Hyundai Rotem Company, with Mitsubishi Electric Australia as technology systems provider and UGL supporting design, testing and maintenance of the fleet. Hyundai Rotem Company is a world class provider of passenger trains to major cities across the globe, with proven capability in the delivery of intercity electric cars.

About Hyundai Rotem Company

Hyundai Rotem Company is part of the Hyundai Motor Group and Korea's only total railway systems specialist. The company has secured international competitiveness in the field of design, manufacture and after-sales service of railway vehicles. Hyundai Rotem Company has a proven record of supplying railway vehicles, including EMUs, high speed trains and passenger coaches, to customers across the world across 35 countries.

About UGL

UGL Limited is a leading provider of engineering, construction and maintenance services with a diversified end-market exposure across the core sectors of rail, transport and communication technology systems, oil and gas, water, power, resources and defence. Headquartered in Sydney, Australia, UGL operates across Australia, New Zealand and South East Asia employing over 10,000 people, including subcontractors.

About Mitsubishi Electric Australia

Mitsubishi Electric is a world leader in the supply of sub-systems for propulsion, train management and passenger information systems for use in public transport applications, supplying equipment for transportation applications in Australia since 1970. Mitsubishi Electric Australia is wholly owned by Mitsubishi Electric Corporation of Japan.

Product information

The New Intercity Fleet will provide a new level of comfort and convenience for the thousands of customers who travel between Sydney and the Central Coast and Newcastle, the Blue Mountains, and the South Coast.
It offers improved accessibility, enhanced safety, improved comfort and modern features including:

Accessibility
Improved accessibility on all cars with specific dedicated areas providing a best performance outcome from a DSAPT perspective for the range of users. Provision of 20 wheelchair spaces per trainset all with access to emergency help points including braille signage.

Lighting Systems
A lighter and more Improved internal train environment with energy saving LED lights and display screens. The NIF fleet will incorporate latest generation LED lighting for improved energy efficiency compared to current fleets to help reduce the environmental footprint and greenhouse gas emissions.

Quiet Cars
For the comfort of passengers, quiet cars are provided in each train, having a more subdued internal decor than other cars, with signage promoting a quieter environment.

Allocated Areas
A Specifically designed environment in each car providing comfortable seating as well as dedicated areas for wheelchairs and Guide Dogs, directly accessible upon entering the car.

Improved Seating
Wider, more spacious two-by-two seating for extra room and comfort with arm rests, tray tables, and high seat backs throughout, including bulkhead seating with increased backrest angle and headrests. Transverse seats have the addition of drop-down tables fixed on the back of seat.

Luggage and Carry-ons
Dedicated cars have additional luggage racks for those travelling long distances with large luggage. Additionally, dedicated cars include specific bicycle racking with adjacent seating areas.

Passenger Information
State of the art customer information system providing automatic announcements, hearing aid loops and electronic display screens both inside and out providing routing and station details. Interior and exterior CCTV is also included for passenger security.

Wide vestibules
Wide vestibules and minimised platform gaps promote both a safer and faster boarding and alighting experience. Draught screens protect passengers from inclement weather as well as provide stabilisation for passengers as they transition into and out of the priority seat.

Air Conditioning
The heating, ventilation and air-conditioning system for the NIF automatically maintains specified interior temperatures according to the ambient temperatures and passenger loadings. Fresh air rate per passenger has been increased from previous fleets.

Designed for Passengers
The NIF has been specifically designed for the people who shall use it, with a dedicated human factors team and in-depth passenger participation from all walks of life to ensure this train meets and improves upon expectations.

Connectivity
General power outlets are available throughout the train, with both an AC power supply socket and USB charging ports, conveniently located in seating areas allowing ease of powering equipment during use.

Toilets
Accessible and ambulant toilets are provided within dedicated cars. Accessible toilets are conveniently located adjacent to Allocated Areas.

Battery Management
The NIF battery system uses advanced light weight Li-polymer batteries, chosen for reduced maintenance, long life and being environmentally friendly.

Regenerative Braking
The NIF propulsion system extends the regenerative braking operating range by use of a new-generation micro-processor controller and advanced wheel slip/slide control system to maximise track adhesion levels.

Traction System
With an improved traction system and weight optimised train, overall power consumption is dramatically reduced compared with current fleets.

Emergency Door Control
In the event of an emergency, with the train in a stationary state, all exterior doors can be opened from either side of the door. Inter-car doors can also be opened in an emergency.

Emergency Detrainment
Each lead car is fitted with an emergency detrainment device, allowing controlled evacuation to an adjacent train or to track level in the event of an emergency.

Inter-car Doors
electric-driven, double-leaf sliding inter-car access doors are installed to reduce inter-car gangway noise levels, act as a fire barrier and to help improve passenger through-flow and movement.

Technical Information

General characteristics

Total train length (10-car)	203.78 m
Cab car length	204,35 m
Intermediate car length	203.40 m
Bogie wheelbase	138.50 m
Car width	3.034 m
Car height above rail	4.402 m
Vestibule floor height	1.270 m
Upperdeck floor height	2.386 m
Lower deck floor height	0.376 m
New wheel diameter	0.940 m
Door per side	2
No. of seats	823
No. of wheelchair spaces	20
No. of tip-up seats	40
Maximum passengers (10-car)	1301
Toilets	3
Weight (10-car)	659.53

Performance

Power supply voltage	1500 Vdc
Maximum speed	160 kph
Total installed traction power	4200 kW
Start-up acceleration	0.8 m/s2
Service decelaration	1.01 m/s2
Emergency deceleration	1.1 m/s2

Product group classification for the New Intercity fleet is as follows:

UNSPSC 25121603: Passenger rail cars.
ANZSIC C2393: Railway Rolling Stock Manufacturing and Repair Services

The geographical scope of this EPD is Australia

LCA information

Functional unit / declared unit

The functional unit chosen to quantify the main function is transport of 1 passenger for 1 km. The total number of passengers was calculated according to the EN 15663 standard. This EPD is based on a 10-car configuration of the New Intercity Fleet (NIF) which is designed to carry 2494 passengers per day, with an expected service life of 35 years. The impacts presented are distributed over the service life of the rolling stock.

Reference service life

Not applicable for this EPD.

Time representativeness

Overall, the temporal scope for all upstream and core materials, utilities and transport is from July 2018 to July 2019. The temporal scope for transport data for the rolling stock from South Korea to NSW, Australia is November 2019 to February 2022 based on the train delivery schedule.

The data for downstream materials for maintenance is correct as of July 2019. The temporal scope for the data for all maintenance utilities including water, fuel and electricity is July 2016 to July 2017. Data for all operational utilities, except electricity has the same temporal scope of July 2016 to July 2017. The operational electricity consumption data for the NIF train is based is on the results of train testing in 2020 and is correct as of October 2020. It was not possible to source 12-month average data for operational electricity consumption as the train has not been operational for that long.

Database(s) and LCA software used

The inventory data for the processes are entered in the SimaPro® LCA software (v9.1.1.1) and linked to the pre-existing background data for upstream feedstocks and services. Inventory data was selected per the standards, in the following order of preference:

Upstream and Core processes

1. Ecoinvent 3.6 database (Ecoinvent Centre, 2019) for all international processes using global average processes.

2. European Platform on Life Cycle Assessment (ELCD)- developed by the Joint Research Centre (JRC) of the European Commission.

Downstream Processes

1. The Australian Life Cycle Inventory (AusLCI v1.31) being compiled by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (AusLCI), 2019).

2. The Australasian Unit Process LCI - Australian LCA database developed by Centre for Design from data originally developed with the CRC for Waste Management and Pollution Control as part of an Australian Inventory data project, 2014

3. Ecoinvent 3.6 database (Ecoinvent Centre, 2019) for all international processes using global average processes.

4. European Platform on Life Cycle Assessment (ELCD)- developed by the Joint Research Centre (JRC) of the European Commission.

System diagram and description of system boundaries

The system boundary of the LCA is cradle-to-grave and considers all life cycle phases from raw material extraction to end-of-life (EoL) waste management. The system diagram is depicted in Figure 1 and a detailed description of the life cycle stages is provided below.

Upstream Module: This module comprises of the extraction and production of raw materials required for the train's manufacturing and assembly. It also includes transportation of the raw materials from Tier 1 suppliers to the manufacturer.

Core Module: This module encompasses the assembly of the train at Hyundai's Changwon plant and its delivery to the location of use in Sydney, Australia. Briefly, the train cars are taken to the Pusan port in Korea by trucks (~45 km), then transported via sea freight to Port Kembla in New South Wales, Australia (~8,800 km) and then to the Eveleigh (96 km) or Kangy Angy (183 km) depot. The core module also includes the impacts from the treatment of waste generated from assembly processes at the manufacturer's site.

Downstream module: The downstream module includes the use and end-of-life (EoL) phase. The use phase comprises of the service life of the train. This includes the production and consumption of electricity and materials used to run and maintain the train during its service life. The end-of-life phase includes the impacts from transportation to landfilling/ recycling sites and those from landfilling of all non-reused and non-recycled components.

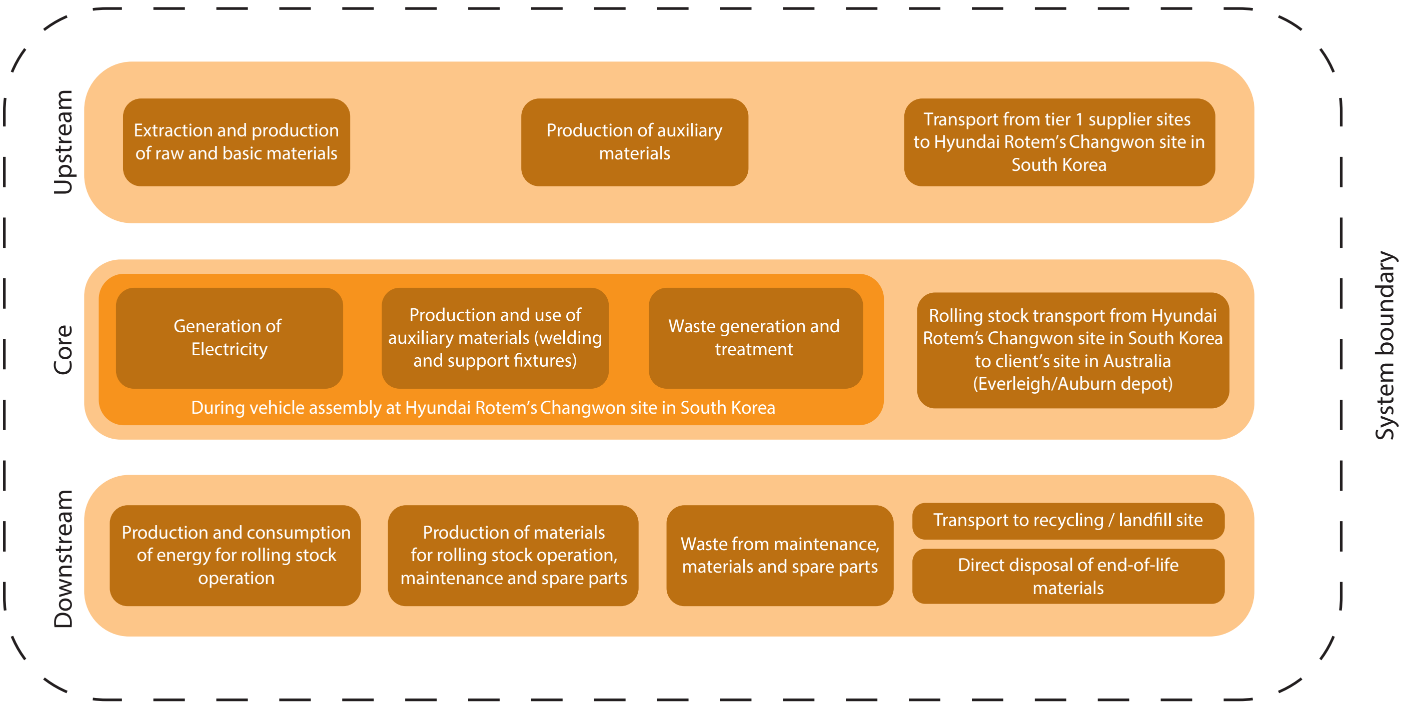


Figure 1 | System boundary for the EPD

Excluded lifecycle stages

Based on the PCR guidelines, the impacts associated with recycling and re-use of materials are excluded, as they are allotted to the user of these resources in the subsequent processes.

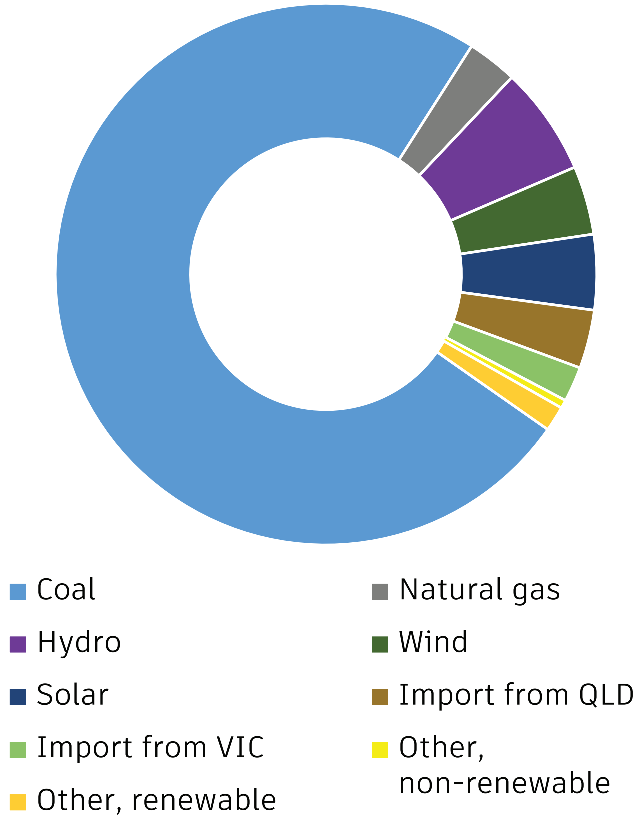
Data sources

The data sources for background data have been outlined earlier in the database section. The foreground data, i.e. the data for construction, maintenance and the end-of-life of the train was sourced from Hyundai Rotem and its relevant suppliers.

Electricity sources

The grid mix used to model the use phase is based on the 2018 New South Wales grid mix sourced from the Department of Industry, Science, Energy and Resources (see Table 1).[1,2] The split of electricity imported from Vic and Qld is based on the NSW grid data from AusLCI library (v1.31) in SimaPro.

Figure 1 | Graphical representation of electricity source



Electricity source	Contribution (%)
Coal	74.4%
Natural gas	3.0%
Hydro	6.5%
Wind	4.1%
Solar	4.5%
Import from QLD	3.5%
Import from VIC	2.1%
Other, non - renewable	0.5%
Other, renewable	1.5%
Total	**100%**

Table 1 | NSW electricity grid mix

Additional information

Information pertaining to cut-off rules, allocation and compliance with standards is provided in Table 2.

Item	Description
Cut-off rules	As per the PCR, data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts is to be included. Furthermore, a minimum of 95% of the total weight of the declared product shall be included if compliant with the cut off criteria on elementary flows in Section 4.4. Based on these requirements, we have not excluded any elementary flows, except the packaging for components transported by plane, and have included 99.9% of the total weight of declared product in our calculations.
Allocation	According to PCR 2009: 05 (v3.02), the methodological choices pertaining to allocation for reuse, recycling and recovery have been set as per the polluter pays principle (PPP). Thus, in this EPD, the impacts associated with recycling and re-use of materials are excluded, as they are allotted to the user of these resources in the subsequent processes. The only impact of recycling allotted to Hyundai Rotem is due to the travel to the recycling plant. Conversely, the impacts associated with landfilling of the non-recyclable / non-reusable components as well as the transportation of materials to landfill and recycling sites are allocated to the primary user i.e. (Hyundai Rotem). ISO 14021 guidelines were used to determine if a material can be considered as recycled.[3] Materials from scrap reutilisation, which can be re-claimed in the same process that generated it, are not considered as recycled content for the purpose of this EPD. However, post-consumer scrap utilised in steel manufacturing is considered as recycled content and is accounted for in the secondary material indicator. Furthermore, the allocation approach for the generic databases utilised in this LCA is also compliant with the PCR 2009:05 (v3.02). More specifically, the burden of primary production of materials is always allocated to the primary user of a material. If a material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials. The consequence is that recyclable materials are available burden-free to recycling processes and secondary (recycled) materials bear only the impacts of the recycling processes. Also, producers of wastes do not receive any credit for the recycling or re-use of products resulting out of any waste treatment.

Item	Description
Compliance with standards	This EPD has been developed to comply with: ISO 14040:2006 and ISO14044:2006+A1:2018 which describe the principles, framework, requirements and provides guidelines for life cycle assessment (LCA).[4,5] ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations -- Principles and procedures, which establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations.[6] General Programme Instructions (GPI) for the International EPD System V3.0 – containing instructions regarding methodology and the content that must be included in EPDs registered under the International EPD System.[7] Instructions of the Australasian EPD Programme V3.0 – a regional annex to the general programme instructions of the International EPD System.[8] AEPDP Guidance on the use of background LCI data (29 June 2018).[9] AEPDP Guidance on the use of INA in EPDs (23 Oct 2017).[10] Product category rules (PCR): Rolling stock product category classification: UN CPC 495 2009:05 VERSION 3.02 valid until: 2022-12-27.[11] Recyclability and Recoverability Calculation Method Railway Rolling Stock (2013, version 00)- UNI LCA 001:00. [12] Railway applications - Definition of vehicle reference masses- EN 15663: 2019.[13]

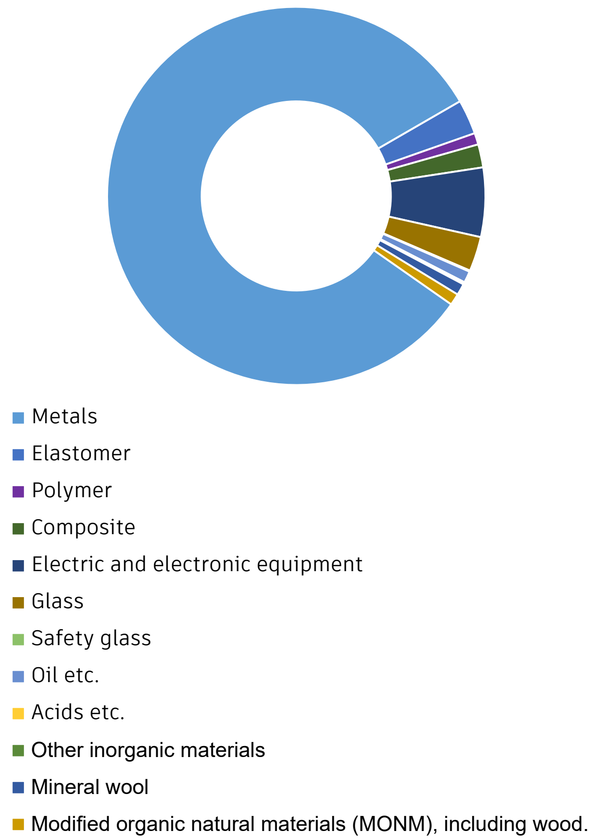
Table 2 | Additional information for cut-off rules, allocation and compliance with standards

Content declaration

Table 3 contains a comprehensive list of materials used for construction of the rolling stock, while Figure 4 depicts a graphical representation of the same. This rolling stock does not incorporate any of the prohibited chemicals listed in the Railway Industry Substance List.

The gross weight of materials declared in this report (Table 3 and Figure 2) is >99.9% of the weight of one unit of the product. The materials in the subsequent section are classified into the categories as per the PCR 2009:05 (v3.02) and UNI-LCA-001.

Figure 2 | Graphical representation of the materials percentage composition



Materials category	Weight (kg)	Percentage (%)
Metals	420,397	83%
Elastomer	14,629	3%
Polymer	7,359	1%
Composite	7,958	2%
Electric and electronic equipment	27,954	6%
Glass	13,018	3%
Safety glass	18	<0.1%
Oil etc.	4,652	1%
Acids etc.	280	<0.1%
Other inorganic materials	0.2	<0.1%
Mineral wool	3,193	1%
Modified organic natural materials (MONM), including wood.	7,138	1%
Total	**506,598**	**100%**

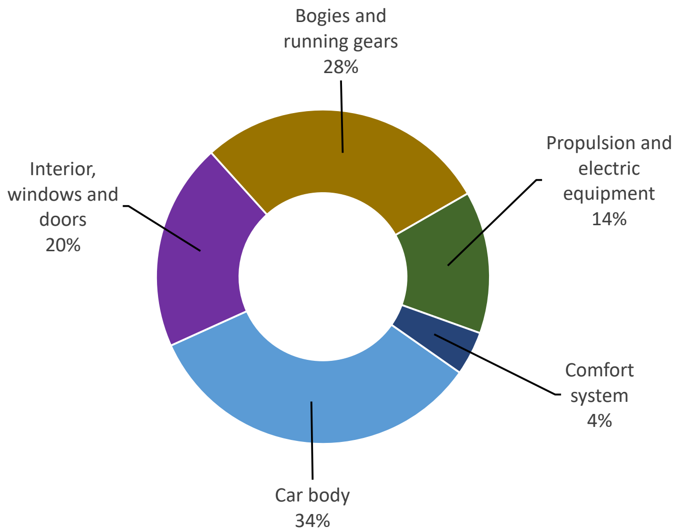
Table 3 | Materials composition of the rolling stock -10 car coach

Content declaration (cont.)

As per the PCR 2009:05 (v3.02), the rolling stock has been classified into five product groups i.e. Car Body, Interior Windows and Doors, Bogies and Running Gear, Propulsion and Electric equipment and Comfort System. The total mass of the rolling stock is 506,598 kg.

Table 4 and Figure 3 provide a detailed breakdown of the mass per category.

Figure 3 | Graphical representation of the product group classification by mass



Product Group (PG)	Main Product Group (MPG)	Mass -MPG (kg)	Mass - PG (kg)
Car body	B	159,646	169,823
	S	10,177	
Interior, windows and doors	C	20,636	101,697
	D	64,826	
	N	16,235	
Bogies and running gears	E	112,227	143,790
	R	25,241	
	Q	6,323	
	M	0	
Propulsion and electric equipment	F	31,861	69,797
	G	0	
	H	15,458	
	J	1,406	
	K	1,333	
	P	3,046	
	T	0	
	U	16,692	
Comfort system	L	21,492	21,492
Total			**506,598**

Table 4 | Product group classification of the rolling stock

Rail vehicle energy consumption

The electricity consumption for the rolling stock is based on the operational energy consumption data for a previous version of the similar rolling stock in New South Wales, Australia.

The train uses 22.46 kWh of electricity. It is assumed that the train travel 250,000 km per year. Based on this the total operation electricity use over the lifetime (35 years) of the rail vehicle is 1.97×10^8 kWh

Noise emissions

The New Intercity Fleet trains are certified according to ISO 3095:2013 and ISO 3381:2005.[14,15]

Whilst stationary, the external noise of the Train measured at 7500mm from the track centre and at a height of 1200mm from the top of the rail shall not exceed 59 dBA LpAeq. Similarly, the internal noise in the saloon measured at 1200mm and 1600mm above the floor shall not exceed 65 dBA LpAFmax under the stationary condition.

Whilst accelerating, the external noise of the Train measured at 7500mm from the track center and at a height of 1200mm from the top of the rail shall not exceed 80 dBA LpAeq.

During Braking, the external noise of the Train measured at 7500mm from the track center and at a height of 1200mm from the top of the rail shall not exceed 80 dBA LpAeq.

Recyclability and Recoverability

The recyclability and recoverability rates of the rail vehicle have been calculated as per the UNI-LCA-001 (see Table 5), which in turn refers to ISO 226289 for the calculation formula. The material and energy recovery factors have been sourced from UNI-LCA-001.

End of life recovery	
Recyclability rate	94.7%
Recoverability rate	94.7%

Table 5 | Recyclability and recovery rates of the rail service

All materials used in the rail vehicle, are recovered either in the pre-treatment or the dismantling step. Hence the amount of material processed through shredding is zero.
Energy recovery as a recycling process is relatively uncommon and less feasible in Australia. Therefore, the materials sent for energy recovery are zero. Instead, the materials which are not recovered or recycled in the pre-treatment and dismantling stages are assumed to be landfilled.

Environmental performance

The environmental impact indicators declared in the EPD are summarised in Table 6.

All indicators except Photochemical oxidant formation potential (POFP) and Water Scarcity Footprint (WSF) are calculated based on the Leiden University's Institute of Environmental Sciences (CML) characterisation factors.

POFP is calculated as per the ReCiPe 2008 method, while WSF as per the **A**vailable **W**ater **R**emaining (AWARE) method of Water Use in Life Cycle Assessment (WULCA).

The assessment results for potential environmental impact, use of resources, waste production and output flows are provided in Table 7,8,9 and 10 respectively.

Impact category	Unit	Description
Global Warming Potential (GWP)	kg CO_2 equivalent	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare. Global Warming Potential is calculated with a time horizon of 100 years.
Acidification Potential (AP)	kg SO_2 equivalent	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.
Eutrophication Potential (EP)	kg PO_4^{3-} equivalent	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.
Photochemical oxidant formation potential (POFP)	kg NMVOC equivalent	A measure of emissions of precursors that contribute to ground level smog formation produced by the reaction of Volatile Organic Compounds (VOC) and carbon monoxide in the presence of nitrogen oxides under the influence of Ultraviolet (UV) light.

Table 6 | Description of the environmental impact indicators declared in the EPD

Impact category	Unit	Description
Abiotic Depletion Potential - Elements	kg Sb equivalent	This indicator is derived for extraction of elements and is a relative measure with the depletion of the element 'antimony' as a reference.
Abiotic Depletion Potential - Fossil Fuels	MJ	This indicator is derived from the extraction of fossil fuels. The resources in this impact category are fuels such as oil, natural gas, and coal, which are all energy carriers and assumed to be mutually substitutable. This indicator is expressed in MJ.
Water Scarcity Footprint (WSF)	m^3 H_2O equivalent	It quantifies the potential of water deprivation, to either humans or ecosystems, and serves in calculating the impact score of water consumption at midpoint in LCA or to calculate a water scarcity footprint as per ISO 14046. It is based on the available water remaining (AWARE) per unit of surface in a given watershed relative to the world average, after human and aquatic ecosystem demands have been met.
Ozone Depletion Potential (ODP)	kg CFC-11 equivalent	A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Table 6 | Description of the environmental impact indicators declared in the EPD

Potential environmental impact

The LCA assessment results for all environmental impact categories and modules as outlined in the PCR 2009:05 (v3.02) are provided in Table 7.

Parameter	Unit	Upstream	Core	Downstream-Use phase	Downstream-EoL	Total
Global Warming Potential - Fossil (GWPF)	kg CO_2 eq.	8.26E-04	3.49E-05	7.31E-03	8.26E-08	8.18E-03
Global Warming Potential - Biogenic (GWPB)	kg CO_2 eq.	2.02E-06	6.01E-07	4.72E-06	4.76E-08	7.39E-06
Global Warming Potential - Land use and land use change (GWPL)	kg CO_2 eq.	1.64E-06	2.24E-08	4.06E-07	1.20E-11	2.07E-06
Global Warming potential - Total (GWPT)	kg CO_2 eq.	8.30E-04	3.55E-05	7.32E-03	1.30E-07	8.19E-03
Acidification Potential	kg SO_2 eq.	4.52E-06	1.63E-07	1.10E-05	1.63E-10	1.57E-05
Eutrophication Potential	kg PO_4 eq.	3.82E-06	7.28E-08	4.03E-06	3.79E-11	7.92E-06
Photochemical Oxidant Formation Potential (POFP)	kg NMVOC	3.32E-06	1.34E-07	2.14E-05	2.53E-10	2.48E-05
Abiotic Depletion Potential – Elements (ADP-E)	kg Sb eq.	3.63E-07	7.34E-10	1.20E-07	7.09E-13	4.83E-07
Abiotic Depletion Potential - Fossil Fuels (ADP-F)	MJ	1.18E-02	4.93E-04	8.00E-02	7.25E-07	9.23E-02
Water Scarcity Footprint (WSF)	m^3 H_2O eq.	1.74E-04	5.94E-06	3.89E-02	8.24E-08	3.91E-02
Ozone Depletion Potential (OPD)	kg CFC-11 eq.	7.83E-11	2.50E-12	3.93E-11	8.01E-15	1.20E-10

Table 7 | Assessment results for potential environmental impact

Use of resources

The amount of primary and secondary resources as well as the freshwater usage per module for this rolling stock is presented in Table 8.

Parameter		Unit	Upstream	Core	Downstream-Use phase	Downstream-EoL	Total
Primary energy resources - Renewable	Use as energy carrier	MJ	1.11E-03	3.85E-05	6.86E-03	8.30E-09	8.01E-03
	Use as raw mtls	MJ	4.67E-06	0.00E+00	4.51E-10	0.00E+00	4.67E-06
	Total	MJ	1.12E-03	3.85E-05	6.86E-03	8.30E-09	8.02E-03
Primary energy resources - Non Renewable	Use as energy carrier	MJ	1.12E-02	5.38E-04	7.50E-02	7.41E-07	8.67E-02
	Use as raw mtls	MJ	5.90E-05	0.00E+00	3.06E-05	0.00E+00	8.96E-05
	Total	MJ	1.13E-02	5.38E-04	7.50E-02	7.41E-07	8.68E-02
Secondary material		kg	5.84E-06	8.14E-08	8.19E-07	0.00E+00	6.74E-06
Renewable secondary fuels		MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels		MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Net use of fresh water		m^3	9.87E-06	3.03E-07	1.42E-05	1.52E-10	2.44E-05

Table 8 | Assessment results for the use of resources

Waste production and output flows

The amount of waste and end-of-life materials produced per module for this rolling stock is presented in Table 9 and 10 respectively.

Parameter	Unit	Upstream	Core	Downstream-Use phase	Downstream-EoL	Total
Hazardous waste disposed	kg	2.15E-08	6.56E-10	0.000	1.63E-12	5.30E-08
Non-hazardous waste disposed	kg	1.10E-04	1.48E-05	6.79E-04	3.57E-07	8.04E-04
Radioactive waste disposed	kg	3.22E-08	2.24E-09	9.46E-09	4.13E-12	4.40E-08

Table 9 | Assessment results for waste production

Parameter	Unit	Upstream	Core	Downstream-Use phase	Downstream-EoL	Total
Components for reuse	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	kg	0.00E+00	1.33E-06	0.00E+00	2.20E-05	2.33E-05
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 10 | Assessment results for output flows

Interpretation

The total carbon emissions over the lifetime of this train are **0.008 kg or 8.2 g CO_2 eq. per passenger kilometre.**

The Downstream (Use Phase) module dominates the Global Warming Potential (GWP-T) impact category (~90%), followed by the Upstream module (~10%). The Core and Downstream End-of-Life modules account for <1% of GWP impact (See Figure 4)

The Downstream (Use phase) also dominates the POFP, Acidification (AP), Eutrophication (EP) Abiotic depletion (fossil fuel) indicators and Water Scarcity Footprint (WSF) indicators.

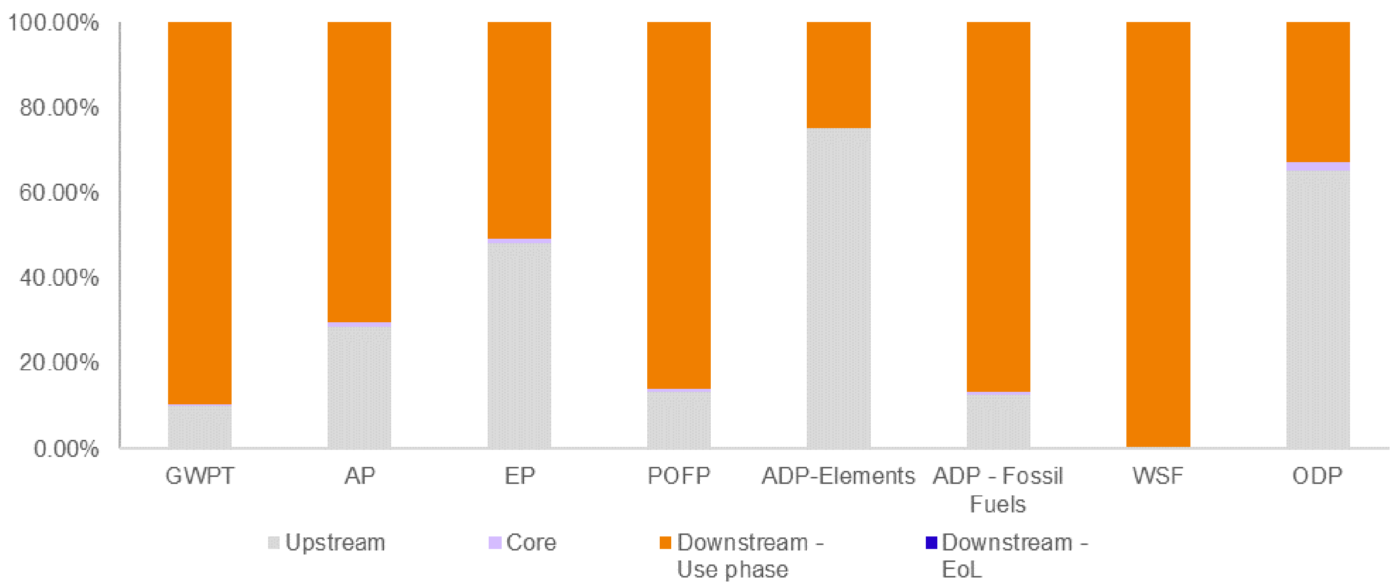


Figure 4 | Relative contribution of modules to environmental impact indicators

The Upstream module dominates the Ozone Depletion Potential (ODP) and Abiotic depletion (elements) categories.

Overall, the most significant contributor to CO_2 emissions i.e. Global Warming Potential (GWP-Total) is the operational electricity used for the rail vehicle, contributing to ~86 % of the total CO_2 emissions.

In terms of materials, the most significant contributor are the electronic components, accounting for ~9% of the total CO_2 emissions.

References

1. Department of the Industry, Science, Energy and Resources. Australian Energy Statistics, Table O, 2020. https://www.energy.gov.au/publications/australian-energy-update-2020 (2020).

2. Department of the Industry, Science, Energy and Resources. Australian Energy Statistics, Table D, 2020. https://www.energy.gov.au/publications/australian-energy-update-2020 (2020).

3. International Organization for Standardization. ISO 14021:2016 Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling).

4. International Organization for Standardization. ISO 14040:2006. Environmental management – Life cycle assessment – Principles and framework.

5. International Organization for Standardization. ISO 14044:2006. Environmental management – Life cycle assessment – Requirements and guidelines.

6. International Organization for Standardization. ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and procedures.

7. The International EPD System. General Programme Instructions for The International EPD® System v3.0. (2017).

8. EPD Australasia. Instructions of the Australasian EPD programme v3.0 - A regional annex to the General Programme Instructions of the International EPD® System. https://epd-australasia.com/wp-content/uploads/2018/09/Australasian-Annex-to-GPI_3.0-2018.pdf (2018).

9. AEPDP Technical Advisory Group. Australasian EPD Technical Advisory Group Guidance On The Use Of Background LCI Data. https://epd-australasia.com/wp-content/uploads/2018/07/AEPDP-TAG-Guidance-on-the-Use-Background-LCI-data-v2-22Jun18.pdf (2018).

10. AEPDP Technical Advisory Group. Australasian EPD Technical Advisory Group Guidance On the use of INA In EPDs. https://epd-australasia.com/wp-content/uploads/2018/06/AEPDP-TAG-Guidance-on-the-Use-of-INA-in-EPDs-23Oct17.pdf (2017).

11. The International EPD System. Product category rules (PCR): Rolling stock product category classification: UN CPC 495 2009:05 VERSION 3.02. (2020).

12. UNIFE Sustainable Transport Committee Topical Group: Life Cycle Assessment. Recyclability and Recoverability Calculation Method: Railway Rolling Stock. (2013).

13. Committee for Standardisation (CEN). EN 15663:2019 Railway applications – Vehicle reference masses.

14. International Organization for Standardization. ISO 3095:2013 Acoustics – Railway applications – Measurement of noise emitted by railbound vehicles.

15. International Organization for Standardization. ISO 3381:2005 Railway applications - acoustics - measurement of noise inside railbound vehicles.