Environmental Product Declaration

According to ISO 14025 for:

Solaris Urbino 12 hybrid bus

Programme	The International EPD® System EPD International AB | Box 210 60 | SE-100 31 Stockholm | Sweden www.environdec.com | info@environdec.com
Program Operator	EPD International AB
Registration Number	S-P-05600
EPD Version	1.0
Publication Date	31 March 2022
Validity	30 March 2027
Scope	Cradle-to-grave
Geographical Validity	Europe
Product Category Rules	PCR 2016:04 – UN CPC 49112 & 49113 Public and private buses and coaches. Version 2.0

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.

Product category rules (PCR): *PCR 2016:04 – UN CPC 49112 & 49113, Public and private buses and coaches. Version 2.0*
PCR review was conducted by: *Leo Breedveld, 2B Srl* *Contact via: breedveld@to-be.it*
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification
Third party verifier: *Leo Breedveld, 2B Srl* Approved by: The International EPD® System
Procedure for follow-up of data during EPD validity involves third party verifier: ☒ Yes ☐ No

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

1. SOLARIS INTRODUCTION

Solaris Bus & Coach sp. z o.o., being part of Group CAF, is one of the leading European bus and trolleybus manufacturers. Benefiting from 25 years of experience and having manufactured over 21 000 vehicles, Solaris affects the quality of city transport in hundreds of cities across Europe every day.

FIGURE 1 SOLARIS BUS & COACH HEADQUARTERS

Thinking of the future, the firm is setting new standards by dynamically developing its products, in particular in the electromobility sector. In 2001, the company introduced its first trolleybuses to the market, whereas in 2006 it premiered hybrid buses, in 2011 – its first battery-powered bus, and in 2014 – hydrogen-fuelled buses.

Solaris actively participates in the global transition to emission-free public transport and wants to be a strong partner for public transport operators by providing towns and cities with complex support in the transition to green solutions. In 2020, vehicles with alternative drives (electric buses, hybrid buses and trolleybuses) made up as much as 44% of the company's production. The manufacturer gradually strengthens its position as an electromobility leader, never ceasing in efforts to develop its e-mobility product range.

All Solaris vehicles, from the idea through design to execution, are created in the sites located near Poznań, Poland, which makes the company one of the largest employers in the region:

- Head Office and Bus Production in Bolechowo,
- Production of Steel Body Frames in Środa Wielkopolska/ Kijewo,
- Central Workshop, Customer Service Centre in Murowana Goślina,
- Production Support in Poznań,
- Solaris Logistics Center in Jasin.

Working toward the safety of the users of Solaris products and the highest quality of the vehicles produced, all buses and trolleybuses of the Solaris brand are manufactured in accordance with the Integrated Management System implemented in the company and certified according to the following international standards:

- ISO 9001:2015 Quality Management System,
- ISO 14001:2015 Environmental Management System,
- EN ISO 3834-2 Quality requirements for fusion welding of metallic materials.

While Solaris contributes to many of the UN Sustainable Development Goals (SDGs) and to building a better future, the company highlights taking a proactive role in achieving the following 4 Goals, associated directly with its business activity:

- Goal 7: Affordable and clean energy,
- Goal 9: Industry, innovation and infrastructure,
- Goal 11: Sustainable cities and communities,
- Goal 13: Climate action.

Solaris sustainability efforts are detailed in the Solaris Sustainability Report, available on Solaris website.

FIGURE 2 SOLARIS SUSTAINABILITY REPORT IS AVAILABLE ON SOLARISBUS.COM

2. SOLARIS URBINO 12 HYBRID BUS

The Solaris Urbino hybrid buses are equipped with a driveline consisting of an electric engine or engines and a conventional drive. Using this solution the buses manage to reduce fuel consumption by 20 to 30% on average, compared to a diesel-fuelled vehicle. What is more, Solaris' hybrid buses can also be adapted to cover a certain distance without generating CO2 emissions. Solaris has hybrid systems in a serial versions on offer. Urbino hybrid buses are available in 12 and 18 meter versions.

The Urbino 12 hybrid boasts exceptional drive parameters, but what makes it stand out particularly is the forceful and yet smooth acceleration. One of the main features of the drive is that it can recuperate kinetic energy during braking and this energy is subsequently transformed and stored as electric power in a storage facility – supercapacitor or batteries.

The drive unit used in the Urbino hybrid allows to significantly reduce fuel consumption and pollutant emission into the atmosphere. It is made possible by an electric engine fueled with power from a power storage facility.

The Solaris Urbino 12 hybrid is also available with a zero-emission function, which makes the vehicle like an electric bus. Thanks to the installation of the Stop-and-Go system, the diesel engine turns off completely during stopovers at bus stops and the opening of doors, but it turns on again immediately after the energy storage run out of power. A GPS can be installed in the vehicle, too, including corresponding software that allows for the activation of the Arrive-and-Go function. This option allows to switch off the diesel engine even as the bus is approaching a bus stop. Various tests have shown that thanks to this solution the bus can use up to 20 percent less fuel than similar vehicles with a conventional drive would use. Moreover, the engine operates so quietly that the noise level can be reduced significantly, which comes in handy in particular in crowded city centres.

The product system analysed is the Urbino 12 hybrid bus

FIGURE 3 URBINO 12 HYBRID BUS

12 000 mm
Length

3 100 mm
Height

2 550 mm
Width

320 mm
Entrance height

2 to 3
No. of doors

Up to 102
Passengers

151 kW
Nominal power of diesel engine

Hybrid drive system:
Series

120 kW
Continuous power of electric motor

2.1. VEHICLE INFORMATION

In the next table, further technical details of the vehicle are presented (service life is assumed 800 000 km).

TABLE 1 TECHNICAL DESCRIPTION OF THE VEHICLE

GROUP	CONCEPT	VALUE
CHASIS	DENOMINATION	Solaris Urbino 12 hybrid
	LENGHT	12 000 mm
	WIDTH	2 550 mm
	PASSANGER CAPACITY	102
	DRIVER CABIN POSITION	Left
DIESEL ENGINE	DENOMINATION	B4,5E6D210H
	NOMINAL POWER	151 kW
	NOMINAL TORQUE	850 Nm
	CYLINDERS	4
	EMISSION COMPLIANCE	Euro 6 stage D
	ENGINE POSITION	REAR, inline
ELECTRIC ENGINE	DENOMINATION	19HDS200TMGNX180-1
	CONTINOUS POWER	120 kW
	NOMINAL TORQUE	1016 Nm
	ENGINE POSITION	inline
ENERGY STORAGE SYSTEM	GENERATOR POWER	145 kW
	SUPERCAPACITATOR ENERGY	1 kWh
AXLES	AXLES	2
	WHEELS	4 wheels (6 tyres)
	FIRST AXLE LOAD (MAX)	7 245 kg
	SECOND AXLE LOAD (MAX)	12 600 kg
	DISTANCE BETWEEN AXLES	1-2 = 5 900mm
	FRONT OVERHANG	2 700 mm
	REAR OVERHANG	3 400 mm
STEERING CONTROL	DENOMINATION	RB Servocom
	WHEEL LOCK	56°
	TURN DIAMETER	21 000 mm
BRAKE SYSTEM	DENOMINATION	FRONT: KNORR SN7; DRIVE: KNORR SB7000
SUSPENSION	DENOMINATION	ZF Sachs shock absorbers Firestone bellows
	TYPE	Oil-filled dampers air bellows
SECURITY	SYSTEMS	EBS, ABS, ASR + brake pad wear indication
AIR CONDITIONER	DENOMINATION	Konvekta UL700 G3
ECE REGULATION №51	MOVING SOUND LEVEL	77.0 dB(A)
	STATIONARY SOUND LEVEL	74.0 dB(A) at idle

2.2 CONTENT DECLARATION

The percentage of materials included in the LCA is 99.15 % of the total theoretical weight of the product (see TABLE 2). The remaining portion has not been considered in the study because the material was unknown.

FIGURE 4 and FIGURE 5 depict the material composition of the whole bus and material breakdown of the bus by vehicle group, respectively. The unknown fraction (0.85%) is reported in the category "others".

TABLE 2 ANALYSED WEIGHT (BASED ON THE BOM – BILL OF MATERIALS) OF THE BUS FOR LCA

Group	Analysed weight (kg)	Theoretical weight (kg)
Frame	3230.0	11446.9
Running gear system	2289.5	
Powertrain	1558.8	
Electric harnesses and systems	635.5	
Exterior components	1354.3	
Interior components	837.1	
Driver Cabin	279.7	
Seats and railings	469.3	
Heating system, air conditioning	335.5	
Fluids	360.0	
Total	11349.7	% analysed -> 99.15

Material composition

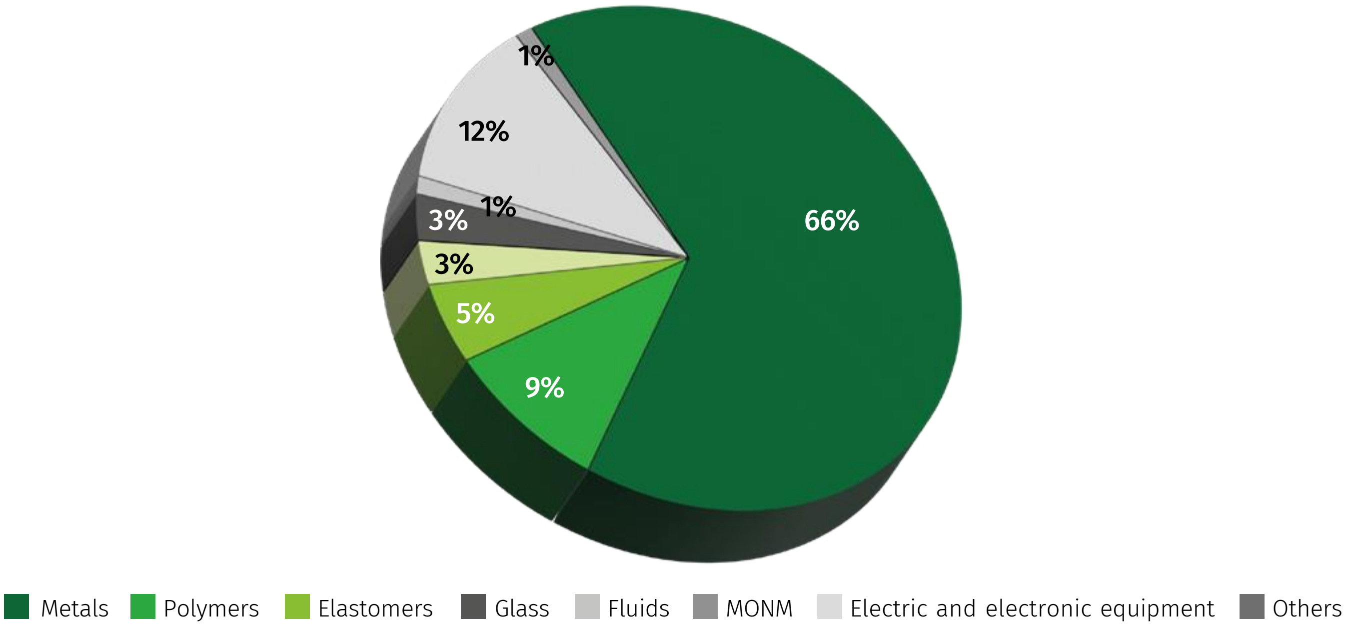


FIGURE 4 MATERIAL COMPOSITION OF THE WHOLE BUS (MONM; MODIFIED ORGANIC NATURAL MATERIAL)

Material breakdown by vehicle group

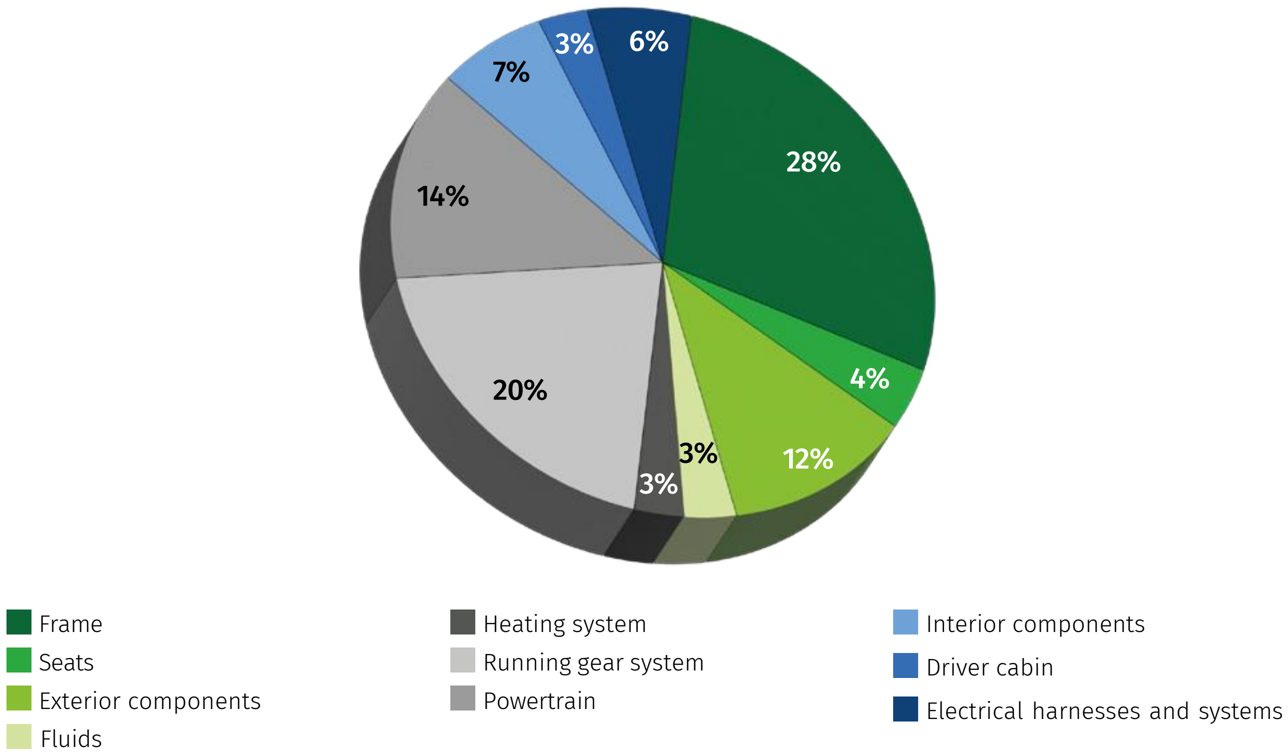


FIGURE 5 MATERIAL BREAKDOWN OF THE BUS BY VEHICLE GROUP*

*Vehicle group is a compartment of a bus

Detailed information about SVHC (substances of very high concern) in Solaris buses is listed in REACH declaration which is available on request.

3. ANALYSED SYSTEM SCOPE

3.1. FUNCTIONAL UNIT

The functional unit used in this study is “transport of one passenger along 1 km in the Solaris Urbino 12 hybrid bus”. According to the PCR guidelines, a travelled distance of 800 000 km may be assumed as stated in Directive 2009/33/EC. Therefore, the functional unit calculation presented in TABLE 3 includes the following parameters.

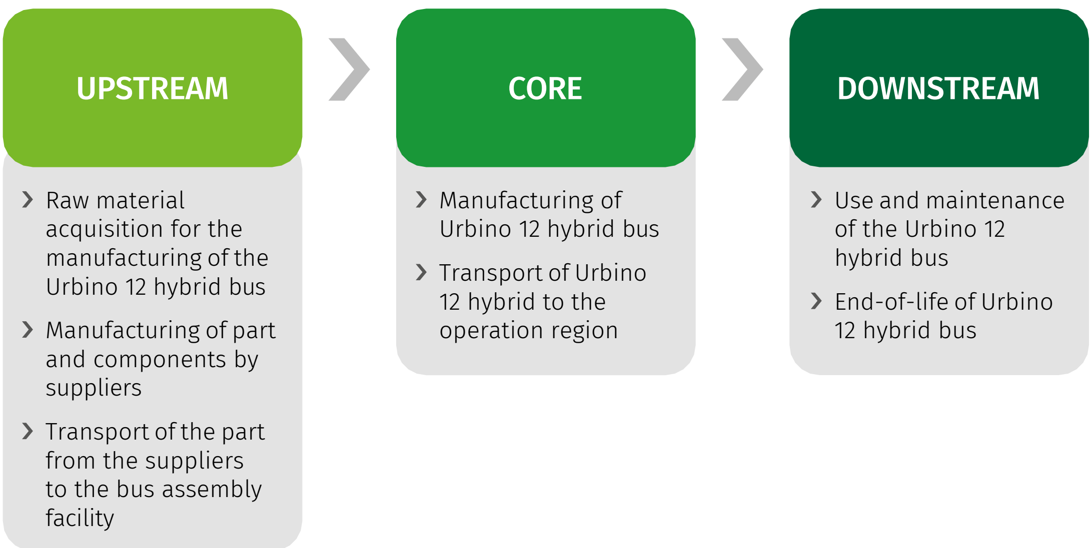
TABLE 3 FUNCTIONAL UNIT OF HYBRID BUS

Passenger capacity	Km/year	Service life (year)	Passenger*km
102	80 000	10	81 600 000

3.2. SYSTEM BOUNDARIES

This EPD is declared a cradle to grave study, divided into three sections (upstream, core, downstream), as presented in FIGURE 6. The presented flowchart strictly follows the PCR 2016:04 – UN CPC 49112 and 49113 – Public and private buses and coaches. Version 2.0 requirements. The manufacturing of production equipment, buildings and other capital goods, business travel of personnel, travel to and from work by personnel are all excluded.

FIGURE 6 SYSTEM DIAGRAM ILLUSTRATING THE LIFE CYCLE OF BUSES AND COACHES COVERED BY THE PCR REFERRED IN THE TEXT



3.3. DETAILS ABOUT THE LIFE CYCLE ASSESSMENT

The specific data on the material composition of the Solaris Urbino 12 hybrid bus was collected by Solaris Technical and ESG departments in 2021. Technical datasheets on certain components were also acquired from their suppliers during this project. Where it was not possible to get actual data, proxies and literature sources were used to fill in the data gaps.

The bus manufacturing stage accounts for all processes performed at Solaris assembly facilities; welding, bonding, painting, and main assembly. All these process stages take place in facilities over three production locations in Poland. Data collection includes all energy use and extra materials and chemicals for welding, bonding, painting, and the main assembly of the bus. Disposal of waste generated in this stage is also accounted for.

In the Solaris Sustainability Report (Solaris Sustainability Report 2020.pdf (solarisbus.com)) it was reported that the company's 71% suppliers are based in Poland. Higher participation of partners from Poland means the optimization of costs and delivery times, and thus enables Solaris to mitigate environmental impact. Solaris continuously works together with suppliers and partners to advance eco-awareness and build a circular green economy.

Due to lack of data on transported masses, a conservative scenario was chosen for modelling transport from the suppliers to the assembly site and from there to the clients in Europe. The maximum distance has been chosen in both cases.

Diesel consumption of a bus was collected based on the actual diesel consumption of a fleet of Solaris Urbino 12 hybrid buses. Therefore, diesel consumption was estimated to be 33 l/100 km as maximum in worst conditions. The combustion emissions of the engine was collected by WHTC test and the CO2 emissions were corrected according to UITP guidelines.

The maintenance stage accounts for all the spare parts that need periodic replacement in the whole buses lifetime. This can include, fluids, air and oil filters, batteries, etc.

To illustrate the end-of-life stage of the bus, the vehicle's recyclability and recoverability capacity has been calculated, based on the ISO 22628: 2002 standard – "Road vehicles – Recyclability and recoverability – Calculation method". Recyclability rates of the bus is shown in FIGURE 7 and recoverability rates of the bus is shown in FIGURE 8.

Recyclability Rate

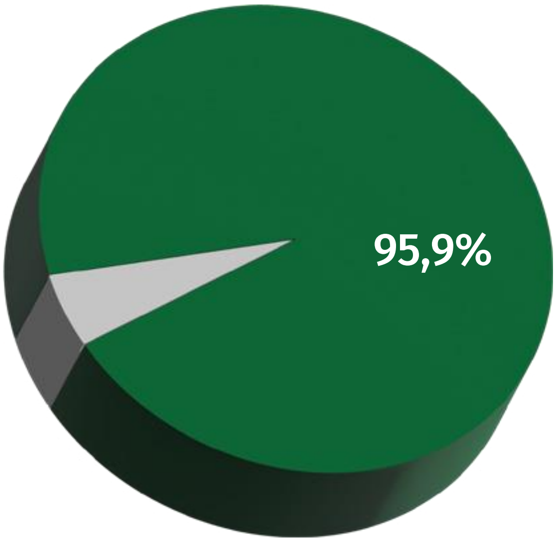


FIGURE 7 RECYCLABILITY RATES OF THE BUS

Recoverability Rate

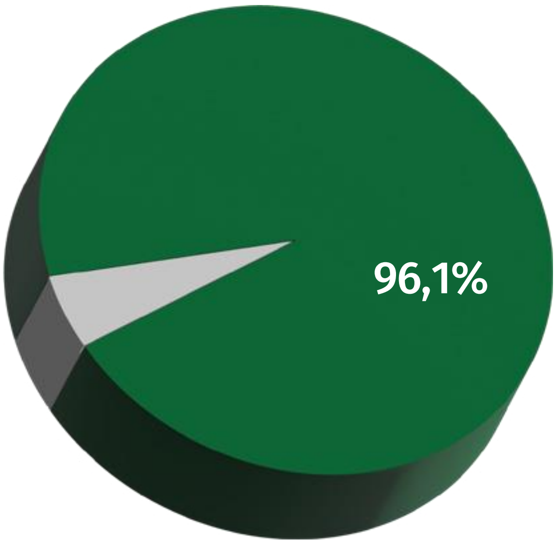


FIGURE 8 RECOVERABILITY RATES OF THE BUS

An LCA model has been made using the Simapro 9.2.0.1 software tool and the Ecoinvent 3.7 life cycle inventories database. The results of the environmental impacts throughout the life cycle of the vehicle have been calculated, as well as the consumption of natural resources and waste management, according to the requirements set out in the PCR 2016: 04 – UN CPC 49112 and 49113 – Public and private buses and coaches. Version 2.0.

The characterization factors used for environmental impact categories calculations have been derived from the CML-IA environmental impact calculation methodology (version 4.8 – August 2016), from the Intergovernmental Panel on Climate Change (IPCC 2013 – AR5), from the LOTOS-EUROS methodology as applied in the ReCiPe LCIA 2008 method and from the AWARE method on water scarcity (WULCA recommendations on characterization model for water scarcity 2015, 2017). These factors are in line with the recommended databases used in the PCR ("Env. Perf. Indicators | EPD International," n.d.).

4. ENVIRONMENTAL PERFORMANCE

Environmental impacts

TABLE 4 POTENTIAL ENVIRONMENTAL IMPACTS

PARAMETER		UNIT	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Global warming potential (GWP)	Fossil	kg CO2 eq.	7.0E-04	1.8E-04	1.0E-02	1.1E-02
	Biogenic	kg CO2 eq.	8.1E-05	1.0E-06	2.3E-05	1.0E-04
	Land use and land transformation	kg CO2 eq.	1.2E-06	9.9E-07	5.8E-07	2.8E-06
	TOTAL	kg CO2 eq.	7.8E-04	1.8E-04	1.0E-02	1.1E-02
Depletion potential of the stratospheric ozone layer (ODP)		kg CFC 11 eq.	1.3E-10	1.3E-11	1.8E-09	2.0E-09
Acidification potential (AP)		kg SO2 eq.	4.2E-05	1.2E-06	1.7E-05	6.0E-05
Eutrophication potential (EP)		kg PO_4^{3-} eq.	9.6E-07	1.1E-07	2.1E-06	3.2E-06
Photochemical oxidant formation potential (POFP)		kg NMVOC eq.	9.1E-06	6.9E-07	1.5E-05	2.5E-05
Abiotic depletion potential – Elements		kg Sb eq.	1.1E-07	3.5E-10	1.1E-08	1.2E-07
Abiotic depletion potential – Fossil resources		MJ. net calorific value	8.9E-03	2.2E-03	1.4E-01	1.5E-01
Water scarcity potential		m3 eq.	2.7E-04	2.3E-05	7.1E-05	3.7E-04

Use of resources

TABLE 5 INDICATORS DESCRIBING USE OF PRIMARY AND SECONDARY RESOURCES

PARAMETER		UNIT	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	9.4E-03	2.3E-03	1.4E-01	1.5E-01
	Used as raw materials	MJ, net calorific value	3.4E-04	0	5.1E-05	3.9E-04
	TOTAL	MJ, net calorific value	9.8E-03	2.3E-03	1.4E-01	1.6E-01
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	6.5E-03	5.3E-04	7.6E-06	7.0E-03
	Used as raw materials	MJ, net calorific value	1.8E-05	0	7.6E-06	2.6E-05
	TOTAL	MJ, net calorific value	6.5E-03	5.3E-04	1.5E-05	7.0E-03
Secondary material		kg	3.9E-05	0	2.4E-06	4.1E-05
Renewable secondary fuels		MJ, net calorific value	0	0	0	0
Non-renewable secondary fuels		MJ, net calorific value	0	0	0	0
Net use of freshwater		m3	8.1E-06	2.9E-06	5.7E-07	1.2E-05

Waste production and output flows

TABLE 6 INDICATORS DESCRIBING WASTE PRODUCTION

PARAMETER	UNIT	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Hazardous waste disposed	kg	1.4E-07	2.1E-09	3.9E-07	5.3E-07
Non-hazardous waste disposed	kg	2.1E-04	1.3E-05	1.8E-04	4.1E-04
Radioactive waste disposed	kg	2.9E-08	4.2E-09	1.0E-06	1.1E-06

TABLE 7 INDICATORS DESCRIBING OUTPUT FLOWS

PARAMETER	UNIT	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Components for reuse	kg	0	0	0	0
Material for recycling	kg	1.7E-05	6.0E-06	9.9E-05	1.2E-04
Material for energy recovery	kg	0	2.0E-06	1.5E-05	1.7E-05
Exported energy, thermal	MJ	0	0	0	0

4.1. RESULTS INTERPRETATION

TABLE 8 depicts the environmental profile of Solaris Urbino 12 hybrid bus over all stages of its lifecycle. The environmental impacts are the most significant in the use stage, originating from diesel combustion. These impacts comprise from 26.7% to 89.8% in all categories, except abiotic depletion (elements) and water scarcity potential. These two categories are mainly concerned with the consumption of materials and freshwater, which contribution is consequently lower in this stage. The environmental profile of Solaris Urbino 12 hybrid bus is shown in FIGURE 9.

TABLE 8 ENVIRONMENTAL IMPACTS BY LIFE CYCLE STAGE

LIFE CYCLE STAGE	GWP*	POCP	AP	EP	ADP-EL	ADP-FF	WSP
Raw Material acquisition	5.9%	33.3%	68.4%	27.7%	91.1%	5.3%	74.2%
Raw material transport	0.5%	2.9%	1.4%	2.8%	0.1%	0.5%	0.4%
Bus manufacturing	1.4%	2.6%	1.9%	3.2%	0.3%	1.2%	6.1%
Transport to client	0.2%	0.1%	0.1%	0.2%	0.0%	0.2%	0.0%
Bus use	89.5%	53.2%	26.7%	61.8%	1.4%	89.8%	6.2%
Bus maintenance	1.4%	7.7%	1.3%	4.0%	7.1%	2.9%	11.8%
End of life	1.0%	0.3%	0.1%	0.4%	0.0%	0.1%	1.2%

*Global warming potential (100y) | Photochemical oxidation | Acidification potential | Eutrophication potential | Abiotic depletion potential – Elements | Abiotic depletion potential – Fossil fuels | Water scarcity potential

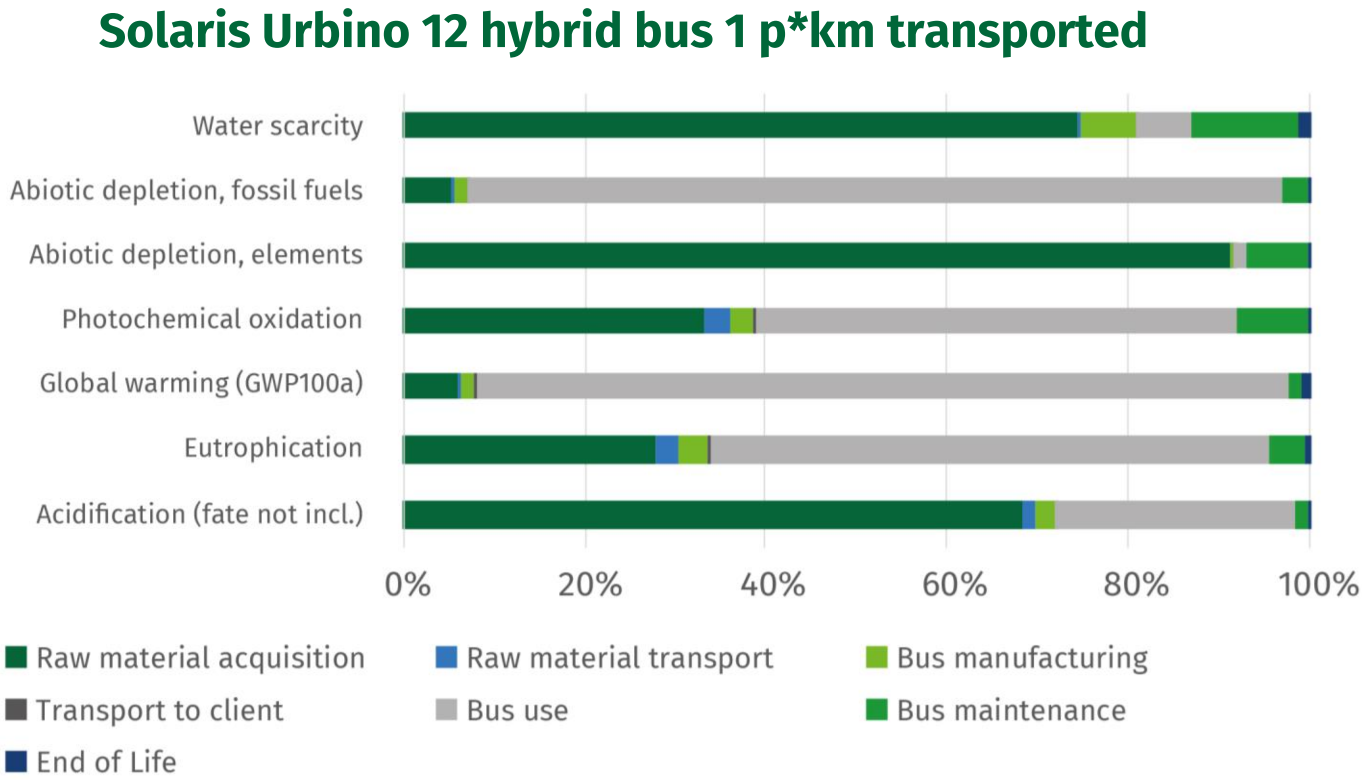


FIGURE 9 ECO PROFILE OF SOLARIS URBINO 12 HYBRID BUS

5. INFORMATION ON THE VERIFICATION SYSTEM

The EPD owner has the sole ownership, liability, and responsibility of the EPD. The verifier and the program operator do not make any claim nor have any responsibility for the legality of the product. Note that EPDs of the same product category but from different programs may not be comparable. Information on verification system is shown in FIGURE 10.

Programme	The International EPD® System EPD International AB | Box 210 60 | SE-100 31 Stockholm | Sweden www.environdec.com | info@environdec.com
Program Operator	EPD International AB
Registration Number	S-P-05600
EPD Version	1.0
Publication Date	31 March 2022
Validity	30 March 2027
Scope	Cradle-to-grave
Geographical Validity	Europe
Product Category Rules	PCR 2016:04 – UN CPC 49112 and 49113 Public and private buses and coaches. Ver 2.0
Review of the Product Category Rules (PCR) conducted by	The Technical Committee of the International EPD® System Chair: Maurizio Feschi Contact via: info@environdec.com
Product Category Rules (PCR) prepared by	The Technical Committee of the International EPD® System PCR Moderator: Gorka Benito Alonso, IK INGENIERIA Contact via: g.benito@ik-ingenieria.com
Product group code	UN CPC 49112 and 49113
Independent verification of the data and declaration, as per ISO 14025:2006	☐ EPD process certification ☒ EPD verification
The procedure for monitoring the EPD during its validity period requires external verification	☒ Yes ☐ No
Verifying entity	Leo Breedveld, 2B Srl Contact via: breedveld@to-be.it Approved by: The International EPD® System
LCA study conducted by	TNO innovation for life www.tno.nl
Name of the company and contact	SOLARIS Solaris Bus & Coach sp. z o.o. Obornicka 46, Bolechowo-Osiedle 62-005 Owińska, Poland www.solarisbus.com

FIGURE 10 INFORMATION ON THE VERIFICATION SYSTEM

6. EXTERNAL REFERENCES

SOLARIS

www.solarisbus.com

Solaris Sustainability Report

Solaris_Sustainability_Report_2020.pdf (solarisbus.com)

*EPD Chapter 1 – Solaris Introduction and EPD Chapter 2 – Solaris Urbino 12 hybrid bus were provided by the Solaris Team (reference to the email on 1 December 2021 from Weronika Krzywicka-Styzińska, Environmental Projects Coordinator Solaris)

Additional information on the International EPD® System

www.environdec.com

The International EPD® System is based on a hierarchical approach using the following international standards:

– ISO 9001, Quality management systems

– ISO 14001, Environmental management systems

– ISO 14040, LCA – Principles and procedures

– ISO 14044, LCA – Requirements and guidelines

– ISO 14025, Type III environmental declarations

www.iso.org

PCR:

PRODUCT CATEGORY RULES (PCR). Public and private buses and coaches. Product Category Classification: UN CPC 49112 & 49113. PCR 2016:04 VERSION 2.0 DATE 2020-12-04

Database used for the LCA:

An LCA model has been made using the Simapro 9 software tool and the Ecoinvent 3.7.1 life cycle inventories database.

www.simapro.com

www.ecoinvent.org

TNO

www.tno.nl

7. VERSION HISTORY OF EPD

VERSION 1.0, 2022: First registration