Carbon Footprint Report

Carbon footprint of the Volvo EX60

VERSION 1.0 (2026-01-21)

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The authors would like to thank all colleagues and suppliers who contributed in the data collection for the study.

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Executive summary

At Volvo Cars, sustainability is at the core of what we do. We have a long-standing history of pursuing our sustainability ambitions and aim to lead the way in the industry by working towards net zero greenhouse gas (GHG) emissions and a nature positive future, embracing the circular economy and conducting business responsibly. Our strategy is to become a fully electric car company.

We are committed to accompanying the release of each battery electric vehicle (BEV) with a comprehensive life cycle assessment (LCA) of its carbon footprint. In doing so, we intend to show our consistent improvements over time, as well as being transparent towards our customers, employees, investors, and other stakeholders interested in our carbon footprint performance.

This report presents the carbon footprint of the fully electric Volvo EX60, which goes into production in 2026. A rear wheel drive (RWD) variant with a 83 kWh battery was assessed, which is expected to be a commonly sold configuration. The manufacturing of the EX60 involves three manufacturing plants in Sweden operated by Volvo Cars, located in Torslanda, Olofström, and Floby.

A combination of technological innovations and value chain emission reduction initiatives result in a carbon footprint of 117 grams CO_2e/kilometre, corresponding to 23 tonnes CO_2e over the complete life cycle, when charging with European electricity mix, approximately 26 per cent lower than what is estimated to have been the outcome otherwise. These mitigation measures include mega casting of the aluminium rear floor, cell-to-pack battery design, renewable energy in industrial operations and utilisation of recycled materials. To enable accounting for these, an extensive amount of supplier-specific data was collected in order to derive the carbon footprint. Figure i illustrates how the different measures contributed to the reduced carbon footprint and the shares of material related emissions derived from specific and generic data respectively.

The assessment examines global warming potential (GWP), according to ISO 14067 guidelines with characterisation factors determined by the Intergovernmental Panel on Climate Change (IPCC) and has been reviewed by IVL Swedish Environmental Research Institute. The scope includes the cradle-to-grave vehicle life cycle, from extracting and refining raw materials to end-of-life treatment. The findings are not directly comparable with those of other studies, except where the same methodology and assumptions have been applied.

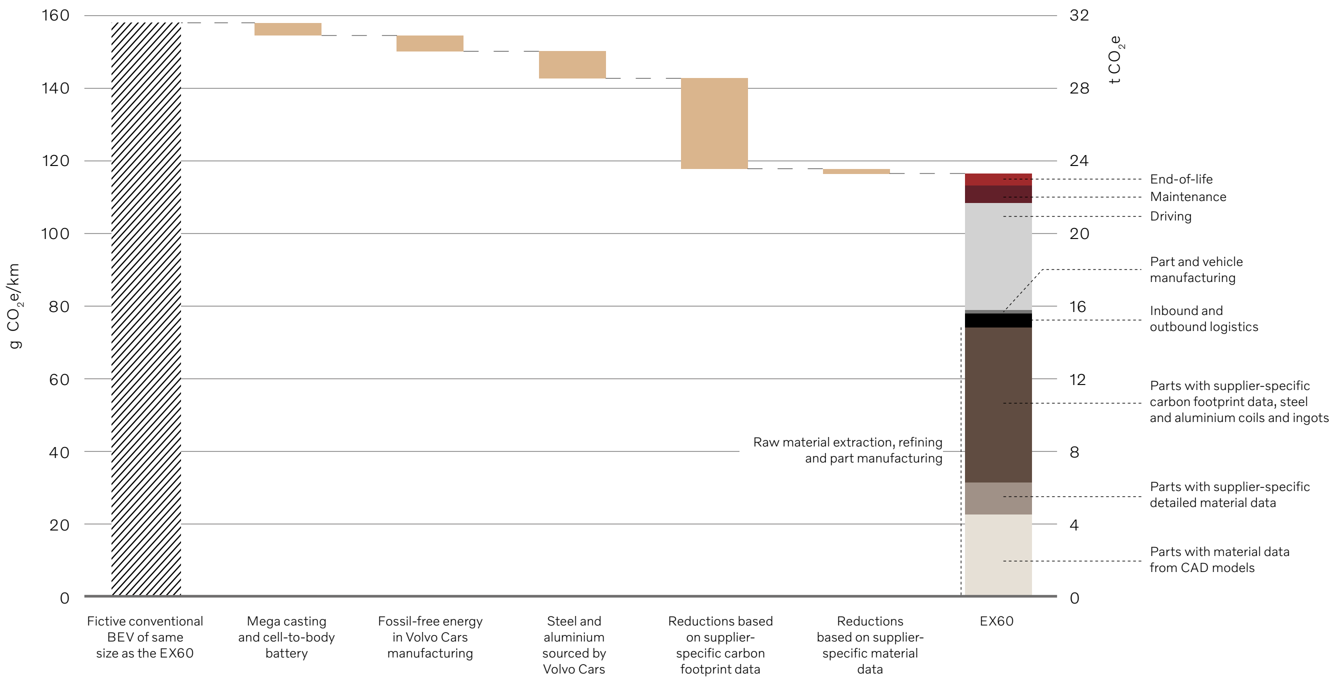


Figure i. *The influence of value chain emissions reduction initiatives, specific data collection, and technological innovations on the EX60 carbon footprint when charging with European electricity mix.*

The study assumes a lifetime driving distance of 200,000 kilometres and energy use according to Worldwide Harmonised Light Vehicle Test Procedure (WLTP) results. Carbon footprint is assessed for charging with European and global electricity mixes, as well as wind-generated electricity. Potential changes in electricity supply over the vehicle's lifetime are evaluated according to the International Energy Agency's Stated Policies Scenario (STEPS).

While raw materials extraction, refining, and part manufacturing contribute the most to the carbon footprint of the EX60, the energy sources of the electricity used for charging highly influence the outcome, as demonstrated in figure ii. Charging with global electricity mix results in a 31 per cent higher impact compared to the case with European electricity mix. If charged with wind-generated electricity however, the carbon footprint is reduced by 21 per cent in comparison with use of the European electricity mix.

In the sensitivity analysis, several future energy scenarios, lifetime driving distances and vehicle energy use variations are evaluated. Energy scenarios that reflect faster decarbonisation are beneficial for the EX60's carbon footprint, as well as longer lifetime driving distance since it implies an increased vehicle utilisation.

The conclusions in this carbon footprint study, as well as those of our other battery electric vehicles, support our strategy to become a fully electric car company. We will continue to mitigate greenhouse gas emissions throughout our value chain and advocate for emission reductions in electricity generation.

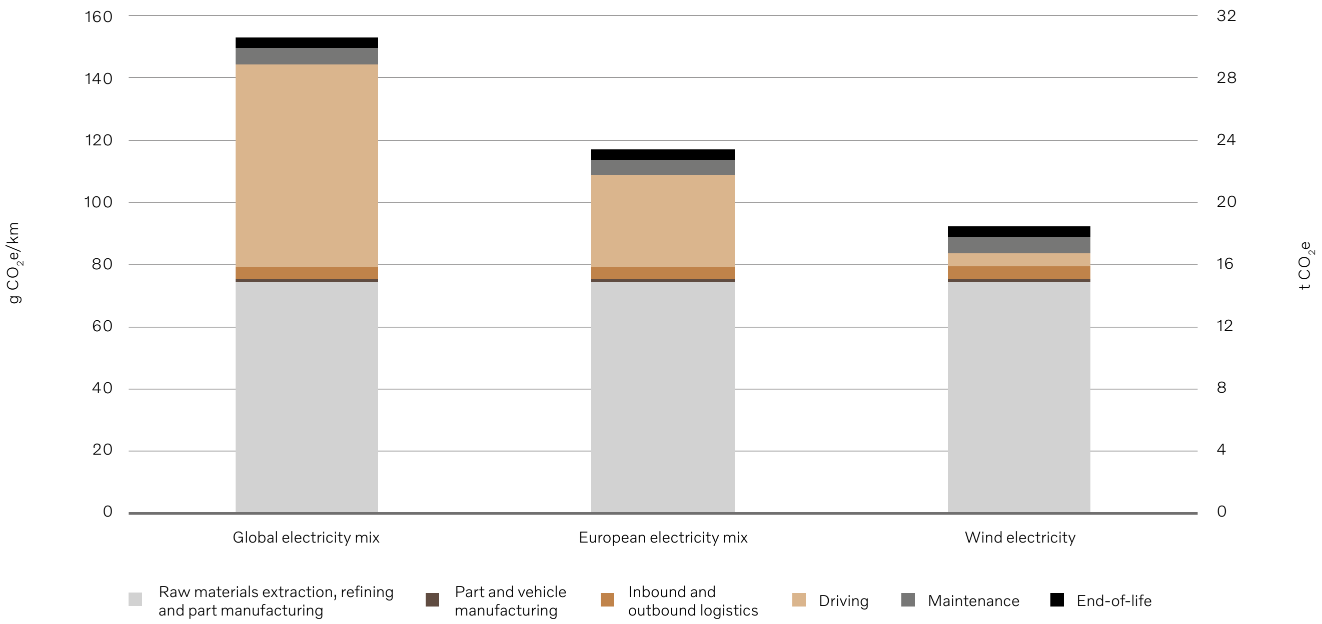


Figure ii. *The EX60's carbon footprint, when charging with different electricity mixes.*

Key findings

- The carbon footprint of the EX60 is 117 grams CO_2e/kilometre when charging with the European electricity mix, corresponding to 23 tonnes CO_2e over the complete life cycle.
- Technological innovations and value chain emissions reduction initiatives reduced the outcome with approximately 26 per cent compared to what is estimated to have been the outcome otherwise. These mitigation measures include mega casting of aluminium rear floor, cell-to-pack battery design, renewable energy in industrial operations and utilisation of recycled materials.
- If charging with wind electricity, the carbon footprint is reduced by 21 per cent to 92 grams CO_2e/kilometre, in comparison with the European electricity mix case.
- Raw materials extraction, refining, and part manufacturing contribute the most to the carbon footprint. Among ingoing materials, most greenhouse gas emissions are associated with steel and iron, aluminium, and polymer production.

Contents

Abbreviations

AAM:
Anode Active Material

APS:
Announced Pledges Scenario

BEV:
Battery Electric Vehicle

BF-BOF:
Blast Furnace-basic Oxygen Furnace

BOM:
Bill of Materials

CAM:
Cathode Active Material

dLUC:
Direct Land Use Change

EAF:
Electric Arc Furnace

EPD:
Environmental Product Declaration

GHG:
Greenhouse Gas

GWP-100:
Global Warming Potential
Over 100 Years

IC:
Integrated Circuit

IEA:
International Energy Agency

IMDS:
International Material Data System

IPCC:
Intergovernmental Panel on
Climate Change

LCA:
Life Cycle Assessment

LCI:
Life Cycle Inventory

Li-ion:
Lithium-ion

NDC:
Nationally Determined Contribution

NMC:
Nickel, Manganese and Cobalt

NZE:
Net Zero Emissions by 2050 Scenario

PCB:
Printed Circuit Boards

RWD:
Rear Wheel Drive

STEPS:
Stated Policies Scenario

VCU:
Vehicle Computational Unit

WLTP:
Worldwide Harmonised Light
Vehicle Test Procedure

1. Goal and scope definition

This chapter describes the goal of the study, the methodology used for data collection and calculations, as well as the scope of the assessment, including its system boundaries and key assumptions. It also specifies the intended audience of the report.

1.1 Goal of the study

Volvo Cars' aims to reach net zero greenhouse gas emissions by 2040, and the purpose of this report is to transparently share the progress towards that ambition. The goal of the study was to establish the carbon footprint of the Volvo EX60, and to identify the materials and activities that have the greatest impact. The report is intended for our customers, employees, investors, and other stakeholders interested in the environmental performance of our vehicles. The conclusions of the study will also provide guidance on effective actions to reduce the carbon footprint of our future vehicles.

1.2 Scope of the study

The study performed is a life cycle assessment (LCA) focusing solely on greenhouse gas (GHG) emissions, i.e. a so-called carbon footprint study. It was conducted in accordance with ISO 14067, which specifies requirements and guidelines for determining the carbon footprint of products. The impacts were assessed based on the global warming potential over 100 years (GWP-100) using characterisation factors from the most recent assessment report (Sixth Assessment Report, AR6) published by the Intergovernmental Panel on Climate Change (IPCC).

The following specific greenhouse gas emissions and removals were included in the carbon footprint:

- Fossil GHG emissions
- Biogenic GHG emissions and removals
- GHG emissions and removals resulting from direct land use change (dLUC)
- Aircraft GHG emissions

1.2.1 Product system

This study assesses the carbon footprint of the Volvo EX60, a battery electric vehicle (BEV). The equipment level of the studied vehicle corresponds to what is expected to be commonly selected by customers among the available configurations at the start of production and is considered representative of the car model as a whole. Details are provided in Table 1.

Table 1 *Sample vehicle used in the study.*

Model name	EX60
Fuel type	Electric
Driveline	Rear wheel drive (RWD)
Equipment level	Plus
Seats	5
Mass	2,130 kg
Dimensions (length x width x height)	4,803 x 1,908 x 1,639 mm
Energy use (preliminary)	147 Wh/km
Range (preliminary)	620 km
Traction battery capacity (nominal)	83 kWh
Traction battery cell type and cathode composition	Lithium-ion (Li-ion), NMC613

1.2.2 Functional unit and reference flow

The function of the vehicle is to transport people and their belongings. Accordingly, the functional unit of the study is defined as one passenger-kilometre. To avoid unnecessary complexity and uncertainty related to the occupancy rate, a default assumption of one passenger per vehicle was applied. This means that one passenger-kilometre is equivalent to one vehicle-kilometre. Therefore, vehicle-kilometre is the unit used to relate the results of the study over the full vehicle lifespan. Readers can easily recalculate the results by dividing them with the occupancy rate relevant to their context.

In practice, the carbon footprint was calculated for the vehicle's complete life cycle and then divided by the total distance driven over its lifespan. The reference flow in this study is defined as the vehicle mass divided by a lifetime driving distance of 200,000 kilometres. The vehicle mass used in this study is presented in Table 1.

1.2.3 System boundaries and allocation procedures

The study covers a full vehicle life cycle from cradle to grave, i.e. from resource extraction to the end-of-life treatment. Figure 1 provides an overview of the various life cycle stages and flows accounted for in the assessment.

An attributional approach was followed, i.e., the study did not aim to capture systemic changes.

The geographic boundary of the study related to the manufacturing of the vehicle at Volvo Cars' manufacturing plants in Sweden. The vehicle is sold globally, and the use phase was assessed using charging with a European and a global electricity mix, as well as wind-generated electricity. The end-of-life treatment was modelled according to what was assumed to be globally representative in 2041.

The time boundary of the study relates to vehicle manufacturing in 2026 and a vehicle lifespan of 15 years, after which end-of-life treatment was assumed. Driving and end-of-life were partly modelled using a prospective approach by taking possible future conditions into consideration. GHG emissions and removals were calculated as if they occurred at the beginning of the assessment period, without considering the effect of delayed emissions and removals of greenhouse gases.

No cut-off criteria were applied for material mass or energy use, with the intention of ensuring consideration of the complete inventory when quantifying the carbon footprint. Material content not clearly specified by suppliers was included and modelled to have the material composition of the rest of the vehicle. Finally, no carbon offsetting was accounted for.

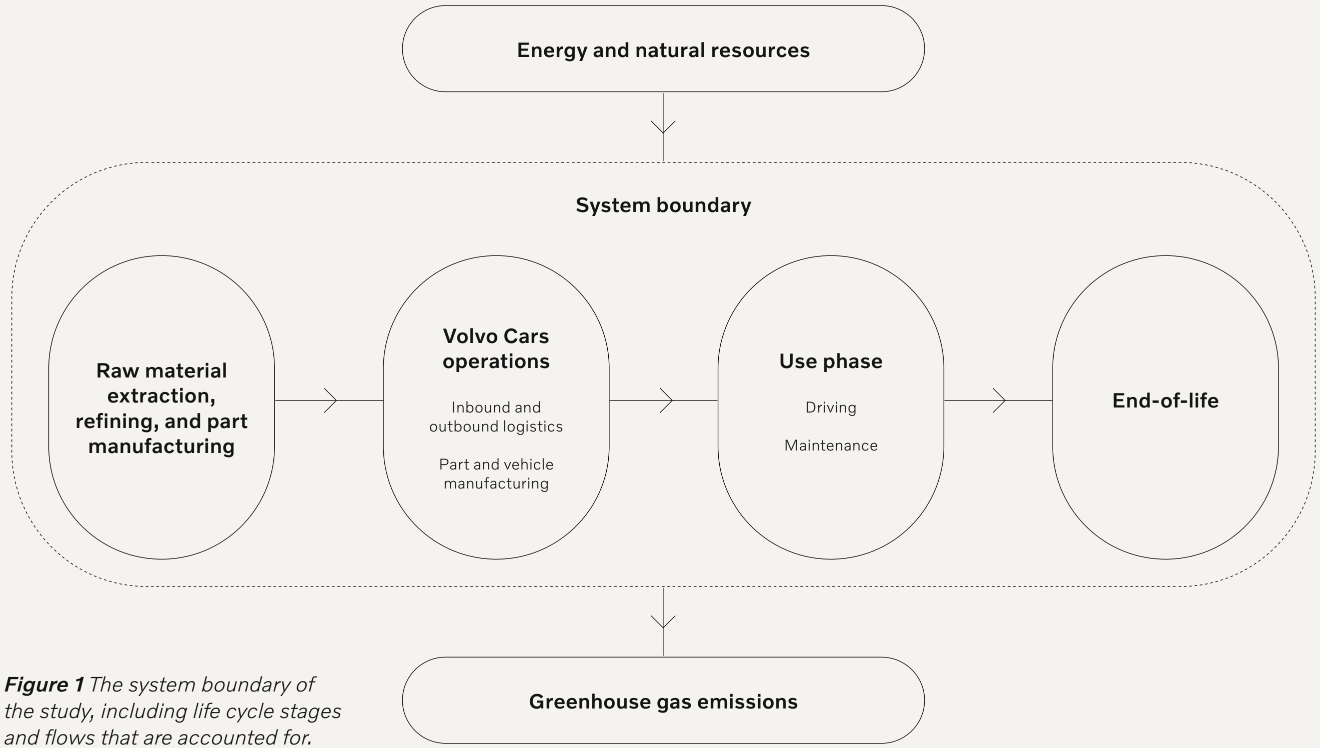


Figure 1 *The system boundary of the study, including life cycle stages and flows that are accounted for.*

To allocate impacts from recycling and waste handling, the so-called simple cut-off[1] approach was used, which means that the system boundary between product life cycles occurs at the point of lowest market value of the materials. This is common practice within the automotive industry, and follows the polluter pays principle, i.e., allocating waste treatment emissions to the product system generating the waste.

To allocate the impact from the annual energy use and waste generation at Volvo Cars manufacturing facilities, the total impact was divided by the total production volume, regardless of the models or variants manufactured. The difference between models was estimated to be small, and to account for it would entail conducting and compiling extensive measurements and to then combine them with production volume forecasts for all models, which motivated this simplification.

Data for inbound logistics were based on the planned volumes for the Torslanda, Olofström, and Floby manufacturing plants in Sweden. Outbound logistics data for the Torslanda plant (where the vehicle manufacturing takes place) were derived in the same way.

Further details about allocations are provided in the Life cycle inventory analysis.

[1]*Also known as the recycled content method, or 100/0 method.*

1.2.4 Data requirements and quality assessment

Data quality was assessed based on requirements across several aspects in order to manage uncertainty, see Table 2.

Table 2 *Overview of data quality requirements for managing uncertainty.*

Aspect	Description	Requirements in this study
Time-related coverage	The age of data and the minimum length of time over which it is collected.	Generic data should be as recent as possible and no older than ten years.
Geographical coverage	The region in which data for unit processes should be collected.	Material production and refining data should be representative of the region where the materials or parts are produced, when known. Vehicle manufacturing data should be representative of the production location. Data for charging during the use phase should be representative of European and global averages. End-of-life data should be representative of global averages.
Technology coverage	The type of technology used (specific or average).	Data should be representative of the technologies used in production processes.
Representativeness	The degree to which dataset modelling reflects actual conditions.	Specific data should be used that is representative of processes under our operational control. Generic data may be used for upstream and downstream processes but should meet the above requirements for time-related, geographical and technological coverage.
Precision	The degree of variability in data values.	Data should be as representative as possible and obtained from reliable sources, with references provided.
Completeness	Ensuring all relevant input and output data are included for each dataset.	Generic data should be obtained from credible sources, such as recognised LCI databases. Specific data should cover all relevant inputs and outputs.
Reproducibility	Assessment of methodology and data. Ensuring independent parties can reproduce equivalent results.	Information about methodology and data (reference sources) should be provided.
Data sources	Assessment of the data sources used.	Data should be obtained from trustworthy sources, with references provided.
Information uncertainty	Inclusion of all data, models and assumptions.	Data should be obtained from credible sources, with references provided.

For the specific vehicle configuration subject to this study, a list of ingoing parts was established, a so-called bill of materials (BOM). The modelling of part production was based on material compositions of the parts in the BOM.

For many parts composed of materials associated with high levels of GHG emissions during production, specific carbon footprint data were collected from the suppliers. To ensure methodological compatibility, they were provided with standardised calculation guidelines, and their results were scrutinised to ensure sufficient accuracy and substantiation.

For other parts, generic data from recognised life cycle inventory (LCI) databases were used to assess the impact of ingoing materials, in many cases with improved accuracy thanks to additional data from suppliers related to the origin of ingoing materials, shares of recycled content and biobased materials. Assembly processes along the value chains were not accounted for because of lacking data, although their contributions to the total carbon footprint are likely to be minimal.

In addition to quality rating, data has been verified by comparing the total mass of the materials in the BOM with the certified vehicle mass, to ensure that the total mass of the vehicle has been accurately represented in the model.

1.2.5 Assumptions and limitations

Material and part related data, both specific and generic, come with limitations that are addressed within the data quality assessment as described in the previous section.

The use phase considered a vehicle lifetime of 15 years and a total driving distance of 200,000 kilometres, in line with other automotive LCA studies[2]. The relative impact of different lifetime driving distances compared to the default 200,000 kilometres was evaluated in a sensitivity analysis. Part replacements related to maintenance were adjusted accordingly.

Potential changes in European and global electricity mixes during this period were based on the International Energy Agency's (IEA) Stated Policies Scenario (STEPS). STEPS is a conservative scenario that only considers the projected effect of policies that are in place, as well as those that have been announced. The effect of changes to electricity mixes in other IEA scenarios was evaluated in a sensitivity analysis.

Vehicle energy use was calculated according to the Worldwide Harmonised Light Vehicle Test Procedure (WLTP). Calculations include losses during charging and driving but exclude use of non-essential auxiliary such as infotainment, air conditioning and other factors related to individual driver behaviour and preferences. Outside factors are also kept constant, such as a fixed temperature of 23°C, no wind, no slopes and no traffic. These test conditions are necessary to enable reproducibility and fair comparison between vehicles but also limits the representativeness of the use phase since driver behaviours and outside conditions can vary significantly. As this may lead to underestimation of the impact in some markets, the effect of 20 and 30 per cent increases in energy use was evaluated in a sensitivity analysis.

This study did not include GHG emissions derived from:

- Non-manufacturing operations, such as from business travels, research and development or other indirect activities.
- Manufacturing infrastructure, including construction and maintenance of buildings and production equipment.
- Construction and maintenance of roads and charging infrastructure.

1.2.6 Critical review

Compliance with the ISO 14067 standard has been critically reviewed by a third party, IVL Swedish Environmental Research Institute. See Appendix 7 – Critical review for the critical review statement.

1.2.7 Study report type and format

The study was conducted by Volvo Cars and this report was published on the company website in January 2026.

[2] *https://op.europa.eu/en/publication-detail/-/publication/1f494180-bc0e-11ea-811c-01aa75ed71a1*

2. Life cycle inventory analysis

This chapter outlines the various inputs and outputs considered in the study.

A combination of specific and generic data was used in the life cycle modelling, as Figure 2 shows. For generic data, recognised LCI databases were consulted, primarily from ecoinvent and Sphera. Appendix 3 provides details of the datasets used.

Some parts for which supplier-specific carbon footprint data were retrieved are described in Section 2.1.6, while common materials in remaining parts are addressed in Sections 2.1.1 to 2.1.5.

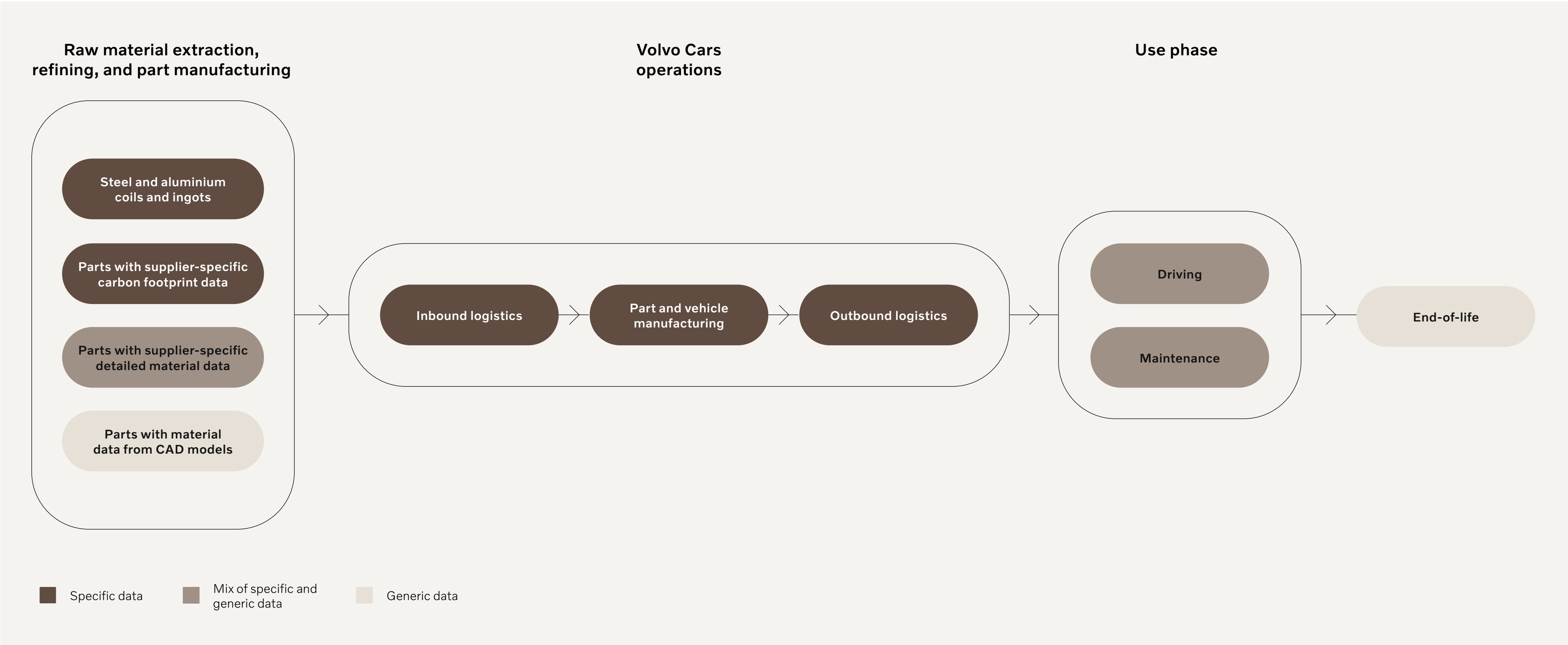


Figure 2 *Types of data sources used for modelling of different parts of the life cycle.*

2.1 Raw material extraction, refining, and part manufacturing

The material composition for each part in the BOM was extracted from CAD models, which are based on engineering design requirements and specifications from suppliers. While the CAD models are used in various simulations and iteratively updated along the vehicle development process, part designs and specifications were finalised when the material data was extracted for this study and thus considered reliable and accurate.

In previous carbon footprint studies, the International Material Data System (IMDS) was used as source for material information. Due to the release date being earlier for this report in relation to vehicle production start than for previous reports, relevant IMDS datasheets were generally not available at the time needed to be used as input for the study. While using IMDS datasheets would have reduced the manual effort of collecting data and offered more granular material information, the level of detail from CAD models was still fully sufficient for conducting the study with appropriate accuracy.

The high number of different material specifications from the CAD models were matched with 116 predetermined material categories relevant for LCA modelling. Material categories are further aggregated into material types when presenting findings, see Figure 3 and Table 3. The complete list of material categories can be found in Appendix 3.

Table 3 *Material types and categories.*

Material type	Number of material categories
Steel and iron	19
Aluminium	7
Polymers	60
Cathode/anode active materials	2
Fluids	5
Copper	3
Glass	2
Natural materials	2
Electronics	9
Other metals	5
Other materials	1
Unspecified materials	1

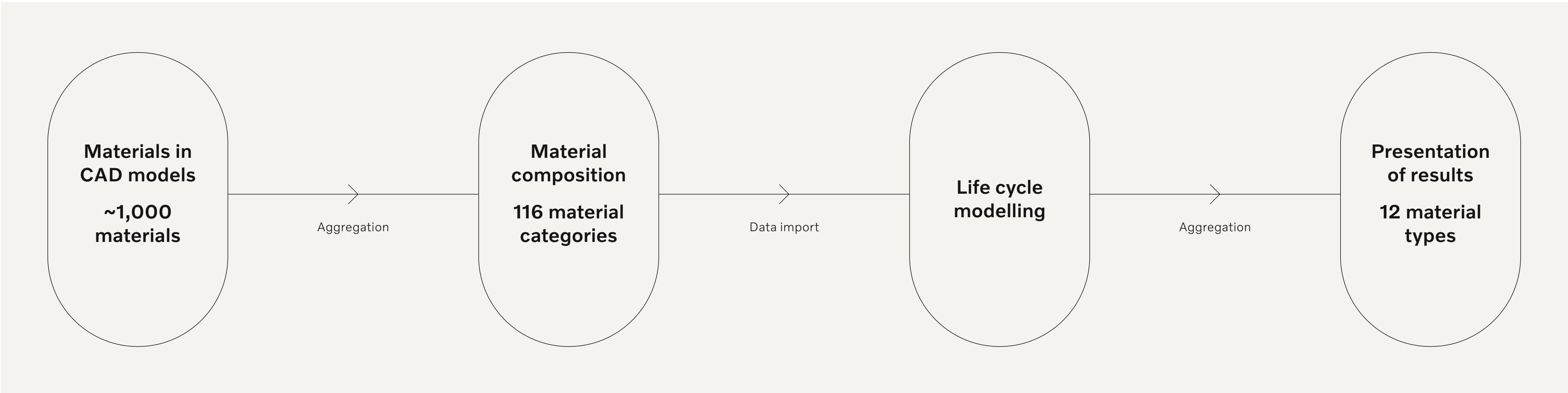


Figure 3 *Material aggregation steps.*

Figure 4 and Table 4 show the material composition of the vehicle according to material types.

Table 4 *Material composition shares.*

Material type	Share of vehicle mass
Aluminium	22%
Steel and iron	38%
Polymers	18%
Cathode/anode active materials	8.2%
Electronics	1.2%
Fluids	3.5%
Copper	1.7%
Other metals	0.21%
Glass	3.0%
Natural materials	0.071%
Other materials	0.15%
Unspecified materials	3.6%

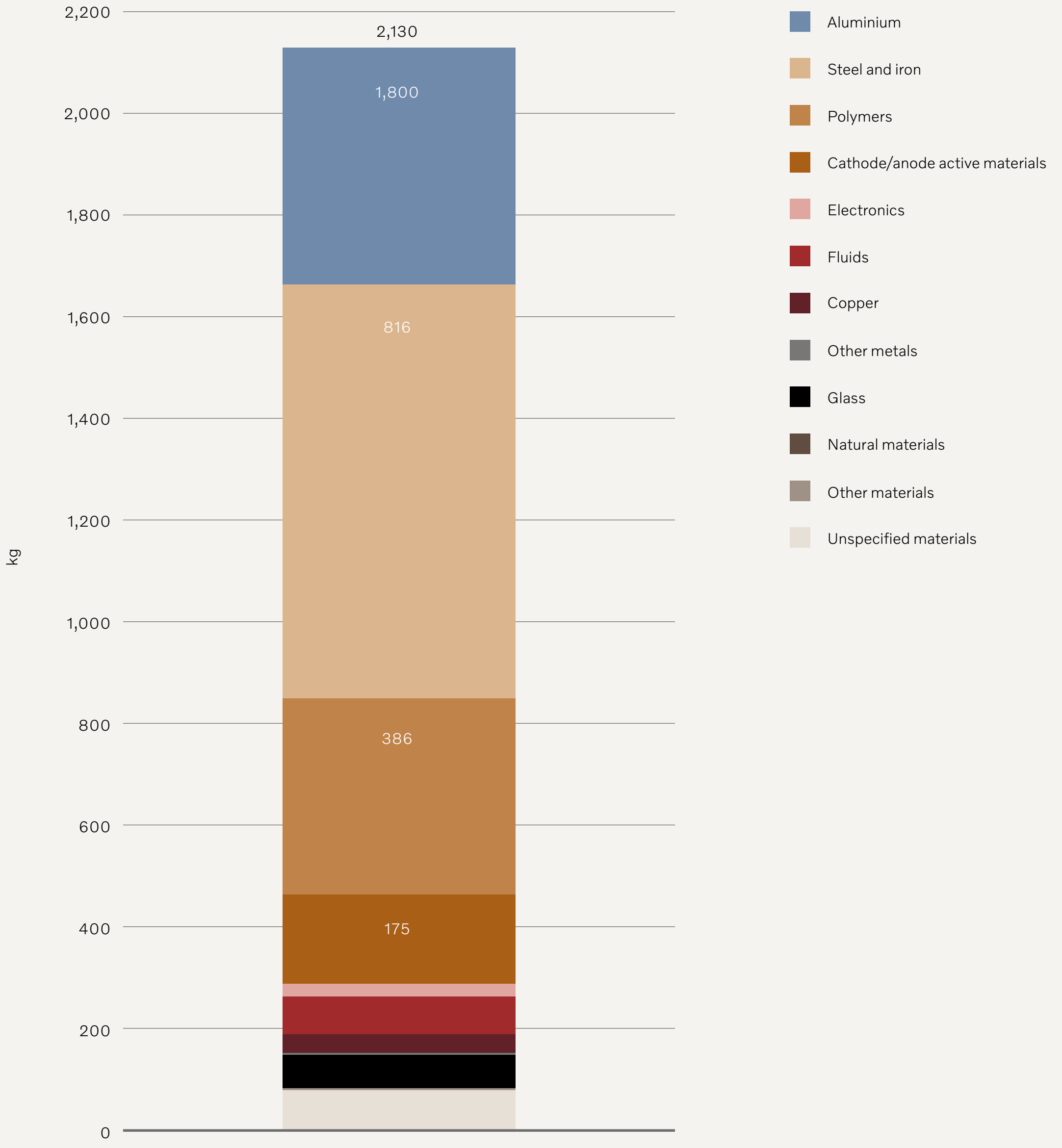


Figure 4 *Material composition.*

Findings and results from previous studies have given insights regarding emission hotspots, areas where data quality could be improved, and materials for which the retrieval of specific data should be prioritised. Based on this, for selected parts, the following two approaches were mainly used to obtain supplier-specific data:

- By utilising a standardised calculation guideline, suppliers declared their parts' material composition, shares of recycled content and biobased materials, and cradle-to-gate carbon footprints. The data were scrutinised to ensure sufficient accuracy and substantiation, and the result amended to related purchase agreements. In Figure 2, the container labelled *Parts with supplier-specific carbon footprint data* includes this type of data.
- When this approach was not viable, more detailed data related to the origin of ingoing materials, shares of recycled content and biobased materials were collected from the suppliers. This enabled improved accuracy for the selection of generic LCI datasets in the life cycle modelling. In Figure 2, the container labelled *Parts with supplier-specific detailed material data* includes this type of data.

For the parts without supplier-specific carbon footprint data (40 per cent of the vehicle mass), a combination of datasets, primarily from the ecoinvent LCI database, was applied to the material categories in each part to derive the carbon footprint. These datasets represent different routes of raw material extraction and refining, material processing, and relevant shares of recycled and/or biobased content. Datasets representing a commodity available on the market were commonly utilised. In many cases, the only available dataset representing the global market was used. Some datasets were however broken down to regional markets, in which case the following priority was adapted, depending on availability:

1. European market
2. Market of European country
3. Rest-of-world market

This approach was applied since the EX60 is manufactured in Sweden.

Figure 5 provides an overview of the share of recycled and biobased contents for different material types, and the share of primary aluminium produced with electricity from renewable energy sources in the electrolysis step. More details for the different material types are provided in the sections below.

Material waste from production processes is also accounted for by including the GHG emissions associated with the production of that material and waste handling. This is especially relevant for steel and iron, and for aluminium, since their production processes result in a significant amount of scrap material, which is sent for recycling. The total amounts of steel and iron, and aluminium considered are therefore larger than the amount ending up in the vehicle.

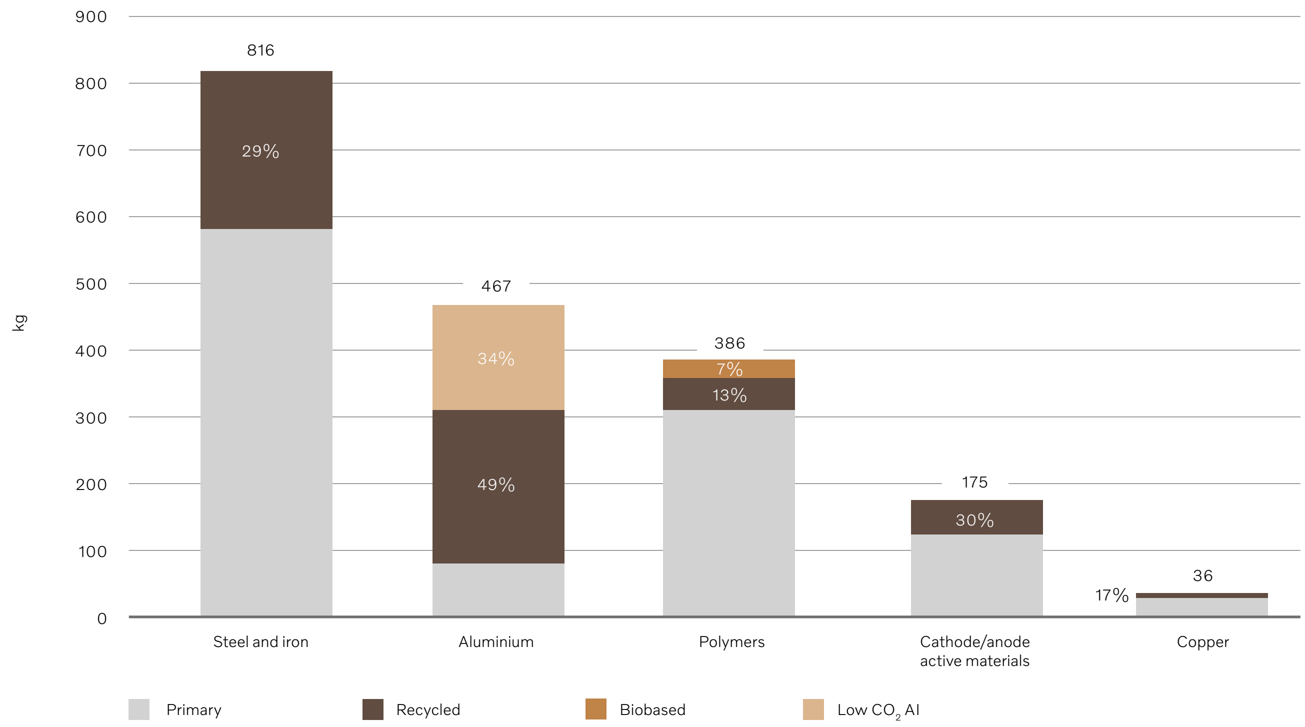


Figure 5 *Shares of primary, recycled and biobased materials, and low CO_2 aluminium.*

In accordance with the simple cut-off approach described in Section 1.2.3, the handling of the scrap material (such as transportation) is accounted for within the system boundary, but not the recycling process. The utilisation of recycled materials in manufacturing of new vehicle parts implies accounting for emissions related to the recycling process (and any further refining or processing). This contrasts with primary materials, which entail emissions from extraction (such as mining) and refining. Utilisation of recycled materials typically results in emissions reductions, though the extent of these reductions varies between materials. Figure 6 illustrates the system boundary and how impacts are allocated between product systems.

2.1.1 Aluminium

For aluminium parts manufactured within Volvo Cars, suppliers of aluminium coils and ingots have provided data on recycled content and the carbon footprint for the specific alloys used. These parts include, among others, the hood, fenders, battery cooling plate, battery undershield, and rear floor, and together they make up 21 per cent of the vehicle's total aluminium mass.

This aluminium, sourced by Volvo Cars, is:

- 45 per cent primary, produced with electricity from renewable energy sources in the electrolysis step
- 55 per cent recycled

Internal data on the material utilisation rate was used to determine amounts of input based on the mass of the finalised part, and the amount of scrap material generated, which was also accounted for. Scrap material is either remelted and reused on site or sent to an aluminium supplier for recycling. Energy used for processing (cutting, stamping, casting, machining and joining) is accounted for in the part and vehicle manufacturing life cycle stage.

For the remaining parts containing aluminium for which there were no supplier-specific carbon footprint data, they were modelled with applicable datasets for aluminium production, and different aluminium processing technologies, such as casting, rolling or extrusion.

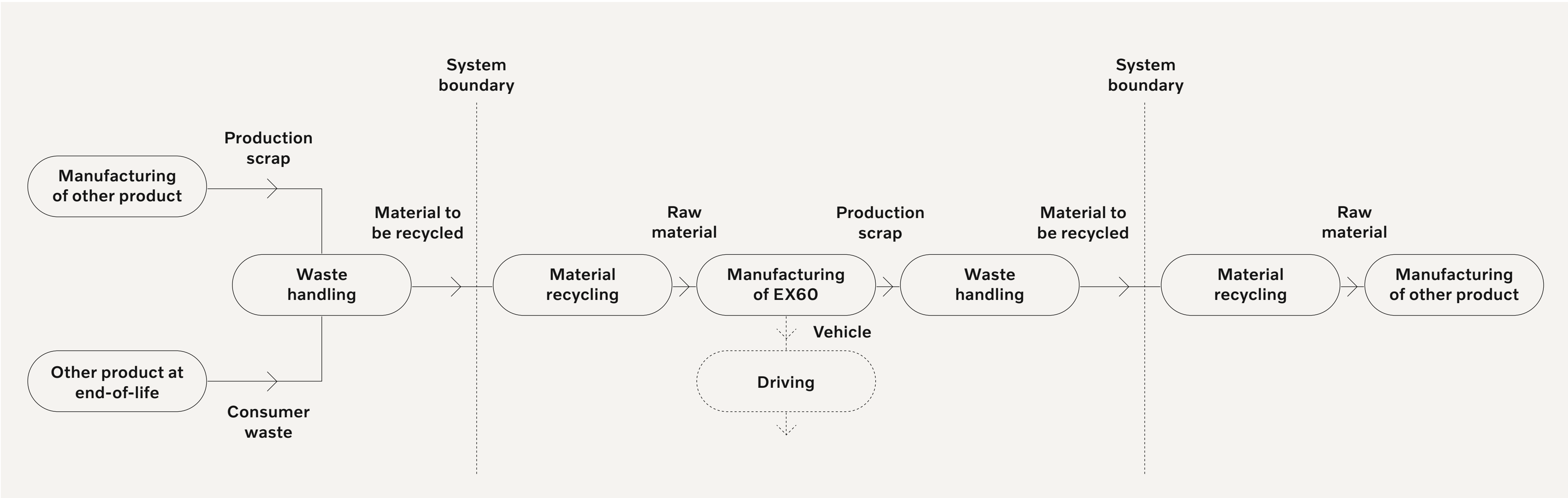


Figure 6 *Allocation of impacts from waste handling and recycling with the simple cut-off approach.*

This aluminium, not sourced by Volvo Cars and without supplier-specific carbon footprint data, is:

- 70 per cent primary
- 27 per cent recycled in wrought and 46 per cent recycled in cast, resulting in 30 per cent overall recycled content

Cast aluminium was modelled with a die-casting process, incorporating 36 per cent of recycled material and a generic material utilisation rate of 95 per cent. The wrought aluminium, which consist mainly of processed aluminium sheets, totals in a utilisation rate of 62 per cent when accounting for manufacturing steps. The production-related aluminium waste generated during part manufacturing was included in the impact calculations.

Parts for which supplier-specific carbon footprint data was collected contain aluminium as well, and the overall recycled content of all aluminium in the EX60 is 49 per cent.

2.1.2 Steel

For steel parts manufactured within Volvo Cars, suppliers of steel coils have provided data on recycled content and carbon footprint through Environmental Product Declarations (EPDs) for the specific alloys used. These parts include, among others, parts of the body sides, the tailgate, pillars and panels, and make up 33 per cent of the total mass of steel in the vehicle.

[3]*https://worldsteel.org/wp-content/uploads/Fact-sheet-on-scrap_ 2021.pdf*

This steel, sourced by Volvo Cars, is from European suppliers utilising either the blast furnace-basic oxygen furnace (BF-BOF) production route (conventional steel production) or the electric arc furnace (EAF) production route (incorporating high shares of scrap metal as feedstock), resulting in an overall 30 per cent share of recycled content.

Internal data on material utilisation rates were used to determine amounts of input based on the mass of the finalised part, as well as the amount of scrap material generated, which was also accounted for. Scrap material is either returned to steel suppliers for recycling or sent for high-value recycling into metal powder. Energy used for processing (cutting, stamping and joining) are accounted for in the part and vehicle manufacturing life cycle stage.

For the remaining parts containing steel, not sourced by Volvo Cars and for which no supplier-specific carbon footprint data were available, they were modelled with applicable datasets for steel production, and different steel processing technologies, such as cold rolling or hot dip/electro galvanising. This steel has an average recycled content of 21 per cent and material utilisation rate between 55 and 77 per cent depending on steel type and manufacturing process. The production-related steel waste generated during part manufacturing was included in the impact calculations.

According to the World Steel Association[3], approximately 15 to 25 per cent steel scrap is used in conventional steel production. The overall recycled content of all steel in the EX60 is 24 per cent, including the steel in parts with supplier-specific carbon footprint data.

2.1.3 Electronics

Electronics include printed circuit boards (PCBs), components mounted on them, and flat-panel displays. It does not include chassis, cables, or other components in electronic devices, which are sorted into other material categories.

Electronic devices in a vehicle vary in composition based on their function, and the following types were defined to account for this:

- Power electronics PCB assembly
- DC-link type capacitor (only used for reference vehicle, see section 4.2)
- Silicon carbide power module (only used for reference vehicle, see section 4.2)
- Heavy computational and signal processing electronics
- Optoelectronics and displays
- Mixed power and signal electronics

For each type, one representative device was chosen for deeper analysis. The representative device could be for a different car model or even a different type, but with the same function. This involved identifying electronic components, such as integrated circuits (ICs), capacitors, resistors, and thermistors, from circuit diagrams. The production and mounting of these components were then modelled by matching them with LCI datasets from ecoinvent and Sphera. Extra care was taken with the ICs, since these are an environmental hotspot among electronic components.

Most of the electronic devices in the BOM were then identified and characterised according to the electronic device types. Their carbon footprint was derived by scaling the carbon footprint of the representative device of each type by their mass. 74 per cent of the total mass of electronics was characterised as power electronics.

In the remaining cases (7 per cent of the total mass of electronics), modelling was done with an LCI dataset from ecoinvent that an earlier internal investigation found to be the most representative for electronics in a vehicle.

2.1.4 Polymers

This material type includes polymer materials such as plastics and elastomers. Polymers in parts, for which supplier-specific carbon footprint data were not available, were modelled using datasets for polymer production and injection moulding which has a material utilisation rate of almost 100 per cent. Recycled plastics was modelled with a dataset for mechanically recycled plastics.

Some parts are made of filled polymers containing certain amounts of talc or glass fibres, which were also accounted for. The most common filled polymers and ranges of filler contents are detailed in Table 5.

Table 5 *The most common filled polymers and their most common filler shares.*

Filled polymer	Talc content	Glass fibre content
PP	15–30%	20–30%
PBT	22%	
PA		30%

The share of recycled and biobased polymers (including elastomers in the tyres) in the EX60 is 13 and 7 per cent respectively.

2.1.5 Unspecified materials

Materials categorised as unspecified are those that were included in CAD models but could not be matched with the material categories relevant to LCA modelling, accounting for less than 4 per cent of the total vehicle mass. For LCA modelling purposes, the material composition of the rest of the vehicle was applied to the unspecified materials along with corresponding generic LCI datasets.

2.1.6 Parts with supplier-specific carbon footprint data

Parts with large shares of potentially high impact materials, complex constructions, and/or material compositions were identified in the BOM. For 38 of those parts, more detailed data related to material sources, shares of recycled content, and the carbon footprint of the complete part were requested and retrieved from the related suppliers. To ensure methodological compatibility, the suppliers were provided with adequate guidelines, and to ensure sufficient data quality, the data was reviewed by Volvo Cars upon delivery.

This type of data collection is being integrated into the regular sourcing process at Volvo Cars, according to which the share of recycled content and carbon footprint of a sourcing package are qualifiers for the sourcing decision and are amended to the purchase agreement, signed and committed to by the nominated supplier. Some of the data collection efforts for this study were part of an implementation pilot, including the amendment to the purchase agreement. For other parts, data were collected through dialogue between design engineers and sustainability specialists, at Volvo Cars and the supplier.

For those parts, the recycled content was 51 per cent in aluminium, 23 per cent in steel and 6 per cent biobased or recycled in polymers.

A brief description of a selection of parts for which supplier-specific carbon footprint data were retrieved follows below, and a list of all those parts can be found in Appendix 3.

Battery cells

The traction battery comprises 168 prismatic Li-ion battery cells, with a total mass of 333 kilograms. The cathode active material (CAM) is an oxide containing nickel, manganese and cobalt (NMC), while the anode active material (AAM) consists of graphite. The CAM material composition corresponds to NMC613.

For cell manufacturing, the supplier uses steam from industrial waste incineration for heating and electricity from non-fossil energy sources. Supplier-specific data were used for CAM, AAM, electrolyte, separator, current collectors, and aluminium enclosure, while remaining materials were modelled with generic datasets from Sphera and ecoinvent. The recycled content of CAM, copper, and aluminium for the enclosure was 30 per cent for all of them.

Vehicle computational unit (VCU)

The VCU is the central computer of the vehicle and enables the centralisation of vehicle-wide functionalities, such as safety, connectivity, advanced driver-assistance systems, propulsion control, and thermal and climate control. It is the largest electronic device within the vehicle, containing a high number of ICs.

Since modelling of electronics is complex and involves managing uncertainties, the retrieval of specific data from the supplier for the VCU provides high-quality data for a potential hotspot part. The supplier has secured electricity from renewable energy sources for the VCU production to reduce related GHG emissions.

Power box

The power box is an electronic device enabling the high voltage traction battery to supply power for other purposes than vehicle propulsion, as well as handling conversions and controls necessary for charging, possibly bi-directional. It can convert between direct current and alternating current as well as between high and medium or low voltage levels, all in one integrated unit. One decarbonisation effort undertaken by the supplier has been to utilise aluminium with 36 per cent recycled content in the power box.

Inverter

A silicon carbide type inverter controls the electric motor. It converts the high voltage direct current voltage to 3-phase alternating current voltage and vice versa between the traction battery and the electric motor. This enables propulsion of the rear wheels as well as charging of the traction battery by means of brake regeneration. The supplier has secured electricity from renewable energy sources for the inverter production to reduce related GHG emissions.

Seat structures

The seat structure serves two primary functions: ensuring passenger safety and providing ergonomic comfort. It is designed with a steel framework that offers high rigidity while enabling individual adjustments to accommodate diverse user needs. This structural integrity is essential for maintaining a secure seating position during vehicle operation.

2.2 Volvo Cars operations

Activities that Volvo Cars has operational control over and how their impacts are accounted for are described in this section.

2.2.1 Inbound and outbound logistics

Inbound logistics concerns the transportation and storage of parts and materials to Volvo Cars manufacturing plants relevant to the EX60, while outbound logistics involves transporting the finished vehicles to dealers. Depending on supplier and dealer locations, different modes of transportation are used, which are combined with the applicable transportation distances, additional mass for packaging and corresponding emission data from the Network of Transport Measures to calculate the carbon footprint, see Appendix 3. Since the manufacturing of the EX60 had not yet started when the study was conducted, internal statistics and data from 2024 for vehicles manufactured in Torslanda, combined with sales forecasts for the EX60 (including volumes and target markets), were used as input.

2.2.2 Part and vehicle manufacturing

The manufacturing of the EX60 involves three manufacturing plants in Sweden operated by Volvo Cars, located in Torslanda, Olofström, and Floby. The Torslanda plant is supplied with electric drives (electric motor, reduction gear and inverter assembled into one unit) from Floby and various body components from Olofström. Some body components are also produced on-site in Torslanda, including the cast aluminium rear floor (see Section 4.2.2 for more details). Remaining processes in Torslanda include battery assembly (see Section 4.2.3 for more details), body assembly, surface treatment and painting, and final assembly.

Historical data from 2024 and 2025 on energy usage and waste generation were collected from all plants, with allocation based on total output of vehicles, body components, and electric motors, respectively. Forecasts were used for new production processes. The methods for heating differ between the plants based on local infrastructure and requirements. They involve combustion of biomethane, heat pumps and district heating sourced from industrial waste heat and renewable energy. The electricity supplied to all plants is sourced from hydropower. The datasets used to model the manufacturing impact are listed in Appendix 3.

2.3 Use phase

The use phase was defined to cover a vehicle lifetime of 15 years and a total driving distance of 200,000 kilometres. Impacts are associated with the energy required for driving and greenhouse gas emissions resulting from the production and end-of-life treatment of replacement parts needed for routine maintenance.

2.3.1 Driving

The climate impact of driving was calculated by combining the vehicle energy use per kilometre with the impact of electricity generation and transmission associated with charging.

Vehicle energy use was based on the preliminary WLTP result of 147 Wh/km, which was the best available estimation at the time the study was conducted, derived from simulations. The effect of a 20 and a 30 per cent increase in energy use was evaluated in a sensitivity analysis to reflect the possible influence of individual driver behaviour and external conditions not accounted for within WLTP, as described in Section 4.1.3.

A total driving distance of 200,000 kilometres was assumed over the lifetime of 15 years, with annual driving distances distribution according to the TranSensus LCA Consolidated Guidelines[4], as illustrated in Figure 7.

The impact of electricity generation and transmission used for charging was modelled for European and global electricity mixes, as well as for wind-generated electricity. Electricity generation mixes and their potential changes over time were based on the IEA's future energy scenario STEPS, as shown in Figure 8 and Figure 9. STEPS reflects current and announced policies in a range of sectors and countries, while two other scenarios, the Announced Pledges Scenario (APS) and the Net Zero Emissions by 2050 Scenario (NZE), which reflect different assumptions, were evaluated in a sensitivity analysis, see Section 4.1.1. LCI datasets from ecoinvent were used to model the impact of the energy sources making up the electricity generation mixes. For more details on the underlying data, see Appendix 3.

2.3.2 Maintenance

The quantities of parts replaced in routine vehicle maintenance are detailed in Appendix 5, and are based on sales data, service book recommendations, and input from Volvo Cars aftermarket sales specialists. Modelling of raw material extraction and refining, part manufacturing, and end-of-life handling applies the same methodology as that used for all other parts.

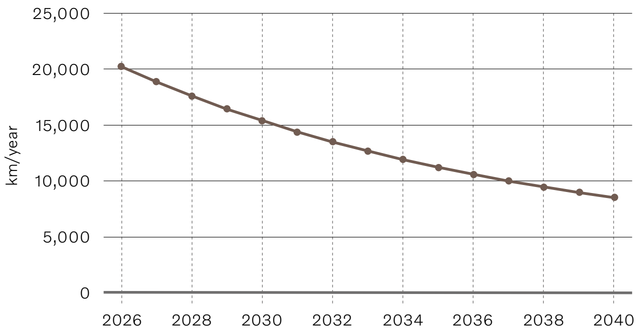


Figure 7 *Annual driving distance in the use phase, adopted from TranSensus LCA Consolidated Guidelines.*

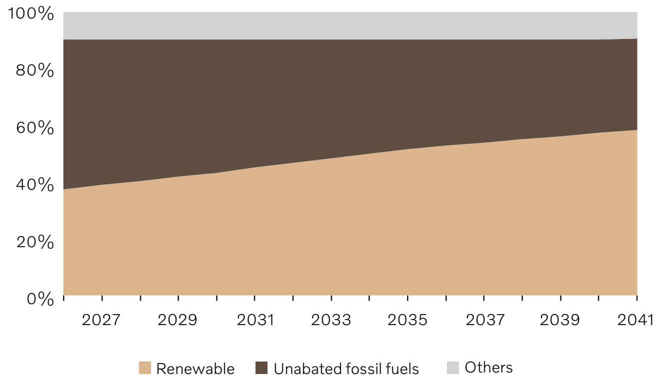


Figure 8 *Changes in the global electricity mix for STEPS.*

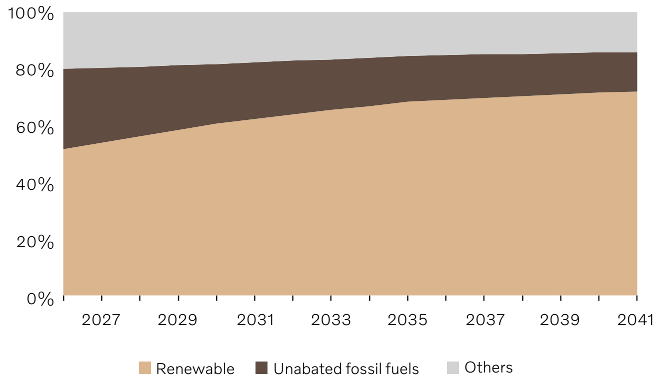


Figure 9 *Changes in the European electricity mix for STEPS.*

[4] *https://lca4transport.eu/wp-content/uploads/2025/08/TranSensus-LCA_D-5-2_Guidelines_final_revision.pdf*

2.4 End-of-life

As explained in Section 1.2.3, the so-called simple cut-off approach was applied for the allocation of impacts from recycling and waste handling. This approach determines where the system boundary is drawn and thereby which activities are accounted for in relation to the end-of-life treatment of the vehicle, as illustrated in Figure 10. Accordingly, for material being recycled, the impact of dismantling and pre-treatment (such as shredding) was included, but not the recycling process itself (such as material separation and refining). Instead, this impact was allocated to the product system utilising the recycled material. No system expansion was applied in this study; thus, no credits were given for materials being recycled and potentially avoiding other material production, or for energy recovered during waste incineration and potentially avoiding other energy production.

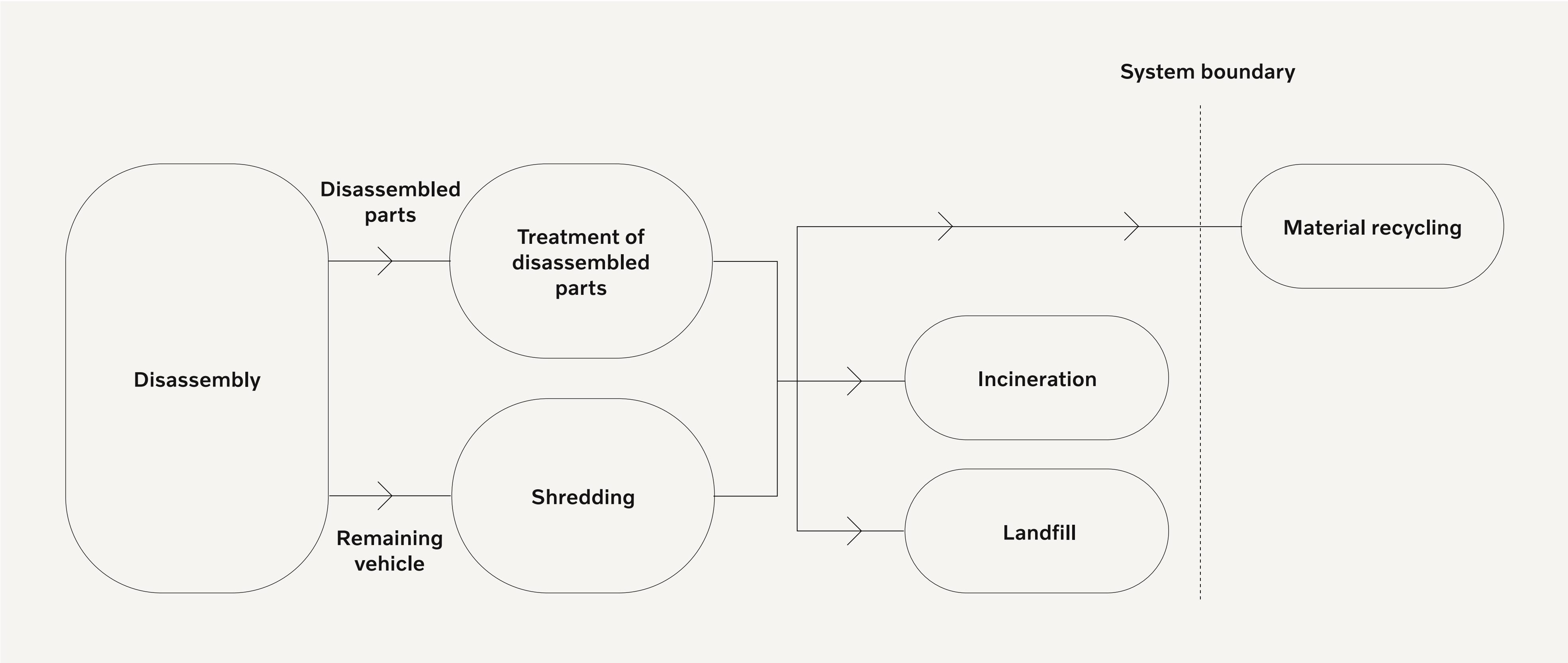


Figure 10 *System boundary at end-of-life with simple cut-off approach.*

The end-of-life treatment was modelled according to what was assumed to be globally representative in 2041. It begins with a disassembly step to remove fluids, hazardous components, and parts that are candidates for specific recycling efforts. The disassembled parts are treated, and the remaining vehicle is shredded, with the resulting fractions used for material recycling, incineration, or landfill deposition.

The disassembly step was modelled by separating fluids, tyres, the 12 V battery, and the traction battery from the rest of the vehicle. After 500 kilometres of road freight transportation, the fluids were assumed to be incinerated and the 12 V battery recycled. The traction battery cells were assumed to be recycled via the hydrometallurgical method, which involves shredding as a pretreatment. An assumption was made that 50 per cent of the tyres are recycled and 50 per cent are incinerated.

What remains of the vehicle is shredded and separated into the following fractions:

- Ferrous metals
  (steel and iron)
- Non-ferrous metals
  (aluminium, copper, other metals)
- Shredder light fraction
  (polymers, glass, natural materials, electronics)

It was assumed that the metal fractions are sent for further refining and material recycling. The shredder light fraction can be incinerated or sent to landfill sites. For the purposes of this study, half of the polymers were assumed to be incinerated and the rest sent for landfill while remaining combustible materials are incinerated, and non-combustible materials are sent for landfill.

Shredding of the remains of the vehicle after disassembly and the traction battery cells requires electricity, which was modelled with the global average electricity mix in 2041 according to STEPS.

3. Life cycle impact assessment

The interpretation of life cycle inventory data in terms of their contribution to the carbon footprint is presented in this chapter.

The values of summands in this report have been rounded to two significant figures to improve clarity and consistency, as well as to acknowledge the inherent uncertainties.

3.1 Result per life cycle stage for different electricity sources

The life cycle carbon footprint of the EX60, when charged with three different electricity mixes, is shown in Figure 11, with corresponding values disclosed in Table 6. The results show that the main contributing life cycle stages are raw material extraction, refining, and part manufacturing, and driving. The driving contribution varies significantly with the electricity mix used for charging, ranging from dominant for the global electricity mix to minor for wind electricity.

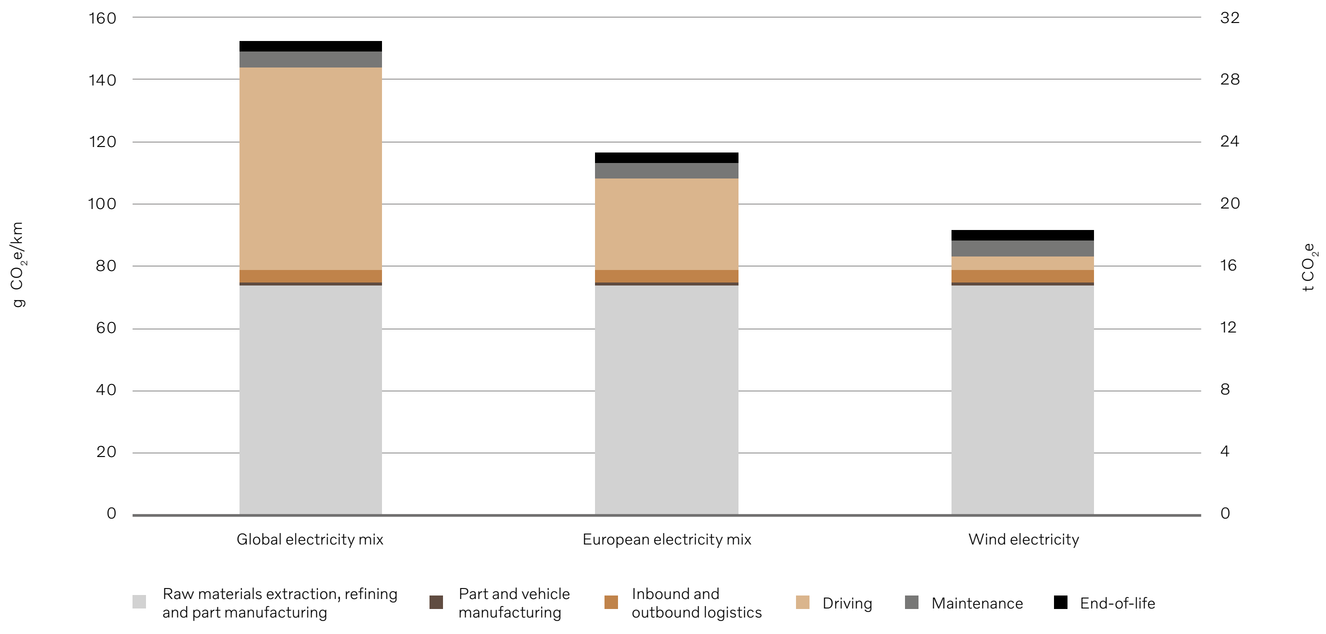


Figure 11 *The EX60's carbon footprint, when charging with different electricity mixes.*

Table 6 *Total carbon footprint, per vehicle kilometre and lifetime driving distance.*

	Per vehicle kilometre [g CO_2e/km]			Lifetime driving distance [t CO_2e]		
	Global electricity mix	**European electricity mix**	**Wind electricity**	**Global electricity mix**	**European electricity mix**	**Wind electricity**
Raw material extraction, refining, and part manufacturing	74	74	74	15	15	15
Part and vehicle manufacturing	0.77	0.77	0.77	0.15	0.15	0.15
Inbound and outbound logistics	3.9	3.9	3.9	0.79	0.79	0.79
Driving	65	29	4.5	13	5.9	0.90
Maintenance	5.1	5.1	5.1	1.0	1.0	1.0
End-of-life	3.4	3.4	3.4	0.67	0.67	0.67
Total	**152**	**117**	**92**	**30**	**23**	**18**

As illustrated in Figure 2, different types of data were used in the study to model various life cycle stages. Table 7 shows the proportion of the carbon footprint derived from each type of data, when charging with the European electricity mix. On aggregated level, 22 per cent was derived from generic data, 37 per cent from a mix of specific and generic data, and 41 per cent from specific data.

***Table 7** Types of data used in different life cycle stages and their respective shares of the carbon footprint when charging with the European electricity mix.*

		Carbon footprint		
Type of data	**Life cycle stage**	**[g CO_2e/km]**	**[t CO_2e]**	**Share**
Generic data	Raw material extraction, refining, and manufacturing of parts with material data from CAD models	22	4.5	19%
	End-of-life	3.4	0.7	2.9%
Mix of specific and generic data	Raw material extraction, refining, and manufacturing of parts with supplier-specific detailed material data	8.8	1.8	7.6%
	Driving	29	5.9	25%
	Maintenance	5.1	1.0	4.4%
Specific data	Raw material extraction, refining, and manufacturing of parts with supplier-specific carbon footprint data, and steel and aluminium coils and ingots	43	8.6	37%
	Inbound and outbound logistics	3.9	0.79	3.4%
	Part and vehicle manufacturing	0.77	0.15	0.66%
Total		**117**	**23**	**100%**

3.2 Contributions from raw material extraction, refining, and part manufacturing

Figure 12 and Table 8 illustrate the carbon footprint of raw material extraction, refining, and part manufacturing in this study, broken down by material type.

As described in Section 1.2.4 and in the Life cycle inventory analysis, supplier-specific carbon footprint data were collected for many parts, and also for the steel and aluminium sourced by Volvo Cars for parts manufactured inhouse. These parts are grouped together in the middle bar, with the most contributing parts presented separately.

From a material perspective, aluminium is the main contributor to the carbon footprint, primarily due to high electricity consumption during electrolysis and smelting in aluminium production. The second largest contributing material type is steel and iron. These emissions are primarily caused by the inherent GHG emissions associated with the BF-BOF production route of steel from iron ore. Polymers is the third largest contributor, with emissions occurring in all processing steps from petroleum extraction to shaping of the final part.

From a part perspective, the largest contribution comes from the battery cells. The major share of these emissions is associated with the CAM and AAM, whose contributions are presented separately in the left bar. Emissions from parts of steel and aluminium sourced by Volvo Cars are also notable, derived from 31 and 21 per cent of the total mass of steel and aluminium respectively, but account for 28 and 14 per cent of the carbon footprint contribution from steel and aluminium. Finally, the power box, inverter and VCU are the three electronic devices associated with the highest level of GHG emissions.

Table 8 *Contributions of various material types to the carbon footprint.*

Material type	Share of carbon footprint contribution
Aluminium	29%
Steel and iron	23%
Polymers	14%
Cathode/anode active materials	12%
Electronics	11%
Fluids	3.9%
Copper	2.2%
Other metals	0.77%
Glass	0.48%
Natural materials	0.071%
Other materials	0.17%
Unspecified materials	4.6%
Part manufacturing[a]	2.0%

[a] Part manufacturing refers to the impact of operations at suppliers of parts for which specific data were available, including logistics, manufacturing, and waste treatment.

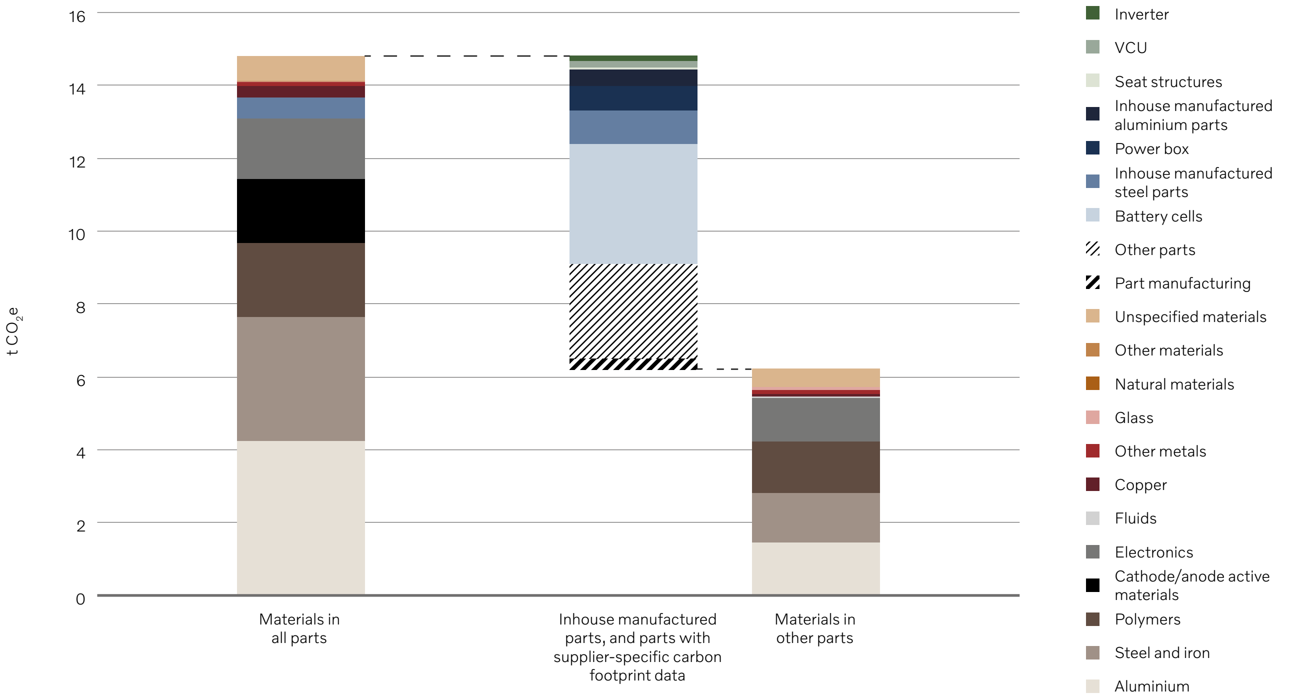


Figure 12 *The carbon footprint resulting from the raw materials extraction, refining, and part manufacturing life cycle stage.*

3.3 Contributions from specific GHG emissions and removals

The carbon footprints presented in previous sections are the combined contribution of the global warming potential from specific GHG emissions and removals. Figure 13 and Table 9 highlight to what extent each of these contributes to the total carbon footprint.

If the specific inventory data covered only the total carbon footprint, generic datasets were used to estimate the non-fossil GHG emissions and removals, and the difference between their sum and the total carbon footprint was then allocated to fossil GHG emissions.

Almost all GHG emissions have a fossil origin, with biogenic GHG emissions being the second largest contributor but remaining at significantly lower levels and basically mirrored by an equivalent removal. Other sources contribute less than 1 per cent of the total emissions.

Raw material extraction, refining, and part manufacturing, and driving are the primary contributors to fossil GHG emissions. Driving contributes the most to biogenic GHG emissions and removals, related to electricity from bioenergy. For dLUC, the largest share of emissions is related to part and vehicle manufacturing, while removals primarily occur in raw material extraction, refining and part manufacturing. Most aircraft emissions are related to raw material extraction, refining and part manufacturing.

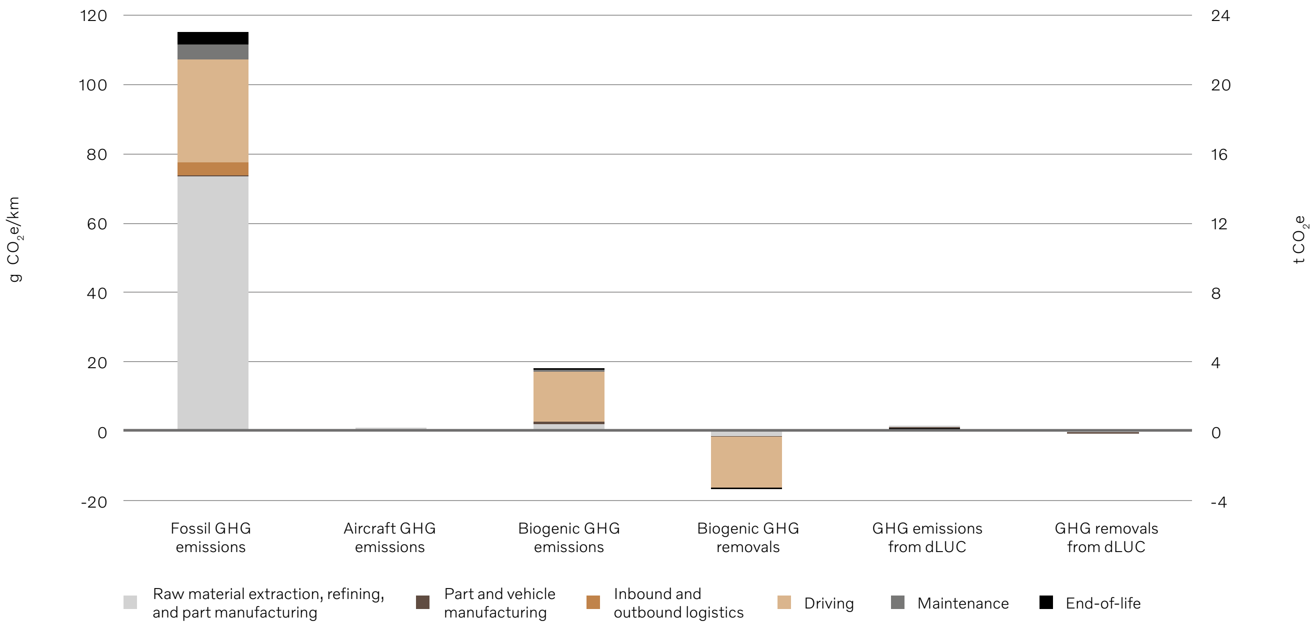


Figure 13 *Specific GHG emissions and removals for the EX60 when charging with European electricity mix.*

Table 9 *Specific GHG emissions and removals for the EX60 when charging with European electricity mix.*

[g CO_2e/km]	Fossil GHG emissions	Aircraft GHG emissions	Biogenic GHG emissions	Biogenic GHG removals	GHG emissions from dLUC	GHG removals from dLUC
Raw material extraction, refining, and part manufacturing	7.4E+01	5.5E-03	1.6E+00	-1.3E+00	1.8E-01	-6.4E-04
Part and vehicle manufacturing	1.4E-01	0.0E+00	3.5E-01	-6.2E-02	3.5E-01	0.0E+00
Inbound and outbound logistics	3.9E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Driving	2.9E+01	0.0E+00	1.5E+01	-1.5E+01	1.2E-02	0.0E+00
Maintenance	4.6E+00	2.6E-07	5.2E-01	-4.1E-02	7.0E-03	-1.6E-05
End-of-life	3.2E+00	1.1E-08	1.9E-01	-8.2E-02	5.1E-03	0.0E+00
Total	**1.1E+02**	**5.5E-03**	**1.7E+01**	**-1.6E+01**	**5.4E-01**	**-6.6E-04**

4. Interpretation

In this chapter, the results are presented and discussed in different contexts, thereby providing new perspectives and enabling a deeper understanding.

4.1 Sensitivity analyses

The purpose of the sensitivity analysis is to assess how uncertainties and variations in the parameters affect the final results.

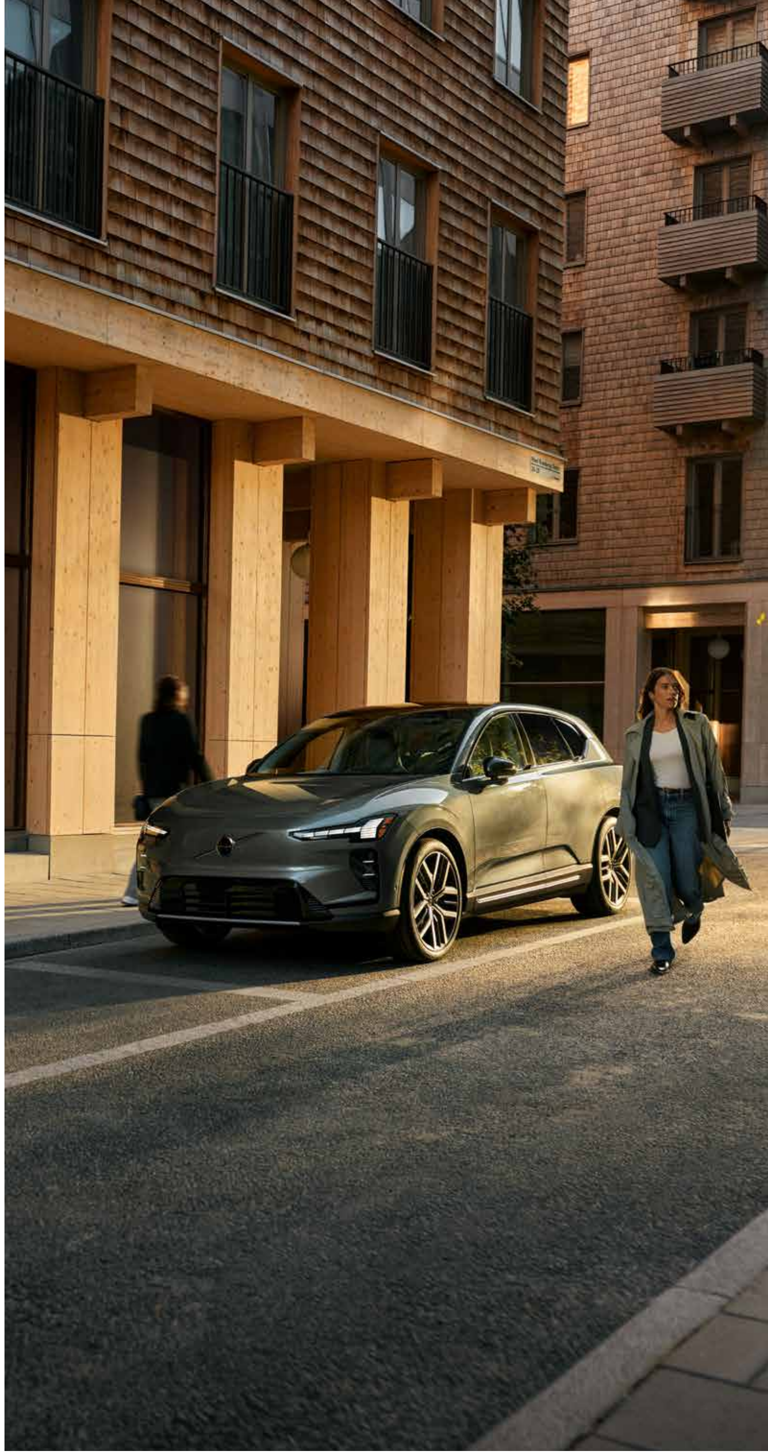
4.1.1 Changes in electricity generation

Predictions of changes in electricity generation inherently involve uncertainties. To explore the implications, two additional IEA scenarios were used to model the electricity mixes for charging. All scenarios are described in Table 10.

Table 10 *Definitions and objectives of IEA scenarios[5].*

	Stated Policies Scenario (STEPS)	**Announced Pledges Scenario (APS)**	**Net Zero Emissions by 2050 Scenario (NZE)[a]**
Definitions	This reflects current policy, based on sector by sector and country by country assessment of current policies, as well as those announced by national governments.	This assumes that all governmental climate commitments, including nationally determined contributions (NDCs), longer-term net zero targets, as well as targets for access to electricity and clean cooking, will be met.	A path for the global energy sector to reach net zero CO_2 emissions by 2050, without relying on emission reductions by other parties, and universal access to electricity and clean cooking by 2030.
Objectives	To provide a benchmark in assessing the potential achievements and limitations of recent energy and climate policies.	To highlight the gap between current pledges and reaching the goals of the 2015 Paris Agreement. To reveal the gap between current targets and achieving universal energy access.	To advocate action in achieving net zero CO_2 emissions from industrial processes by 2050 and meeting other energy-related sustainable development goals.

[a] *The IEA only provides NZE scenarios for World and Advanced economies (OECD, Bulgaria, Croatia, Cyprus, Malta and Romania), not for individual countries or regions.*



[5]*https://www.iea.org/reports/global-energy-and-climate-model*

Figure 14 and Table 11 indicate that changes in electricity mix make a significant impact on the carbon footprint of the EX60, with a 21 per cent difference between STEPS and NZE for the global case.

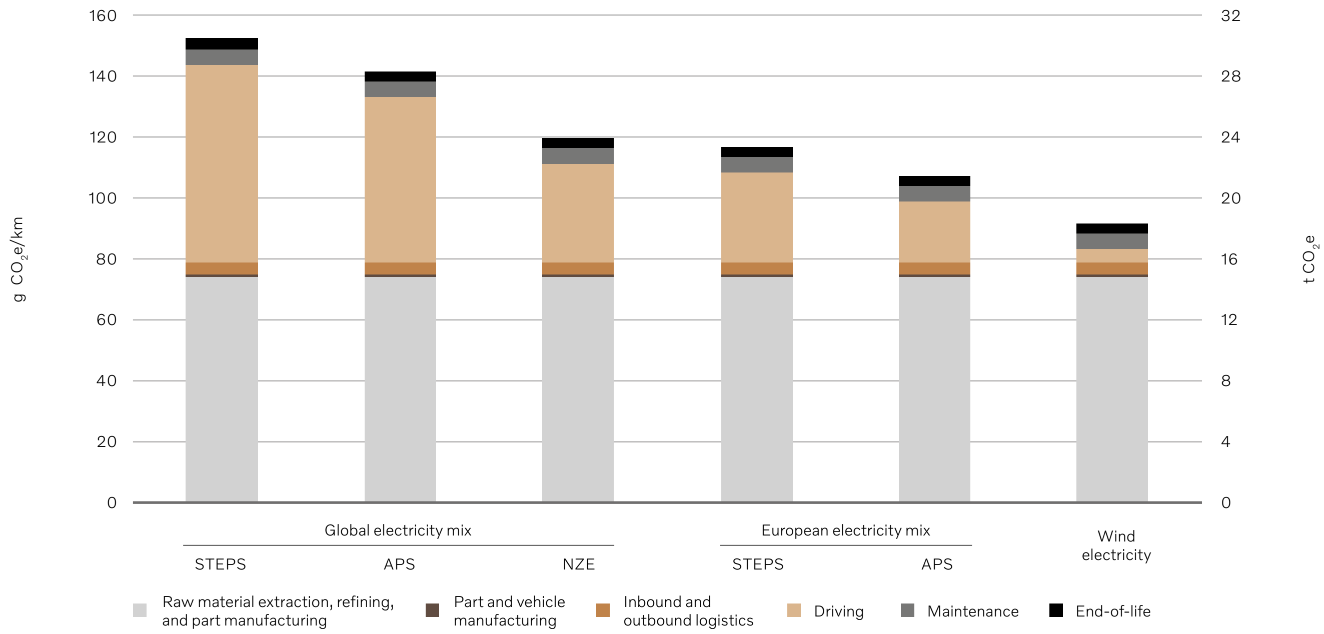


Figure 14 *The effect of changes in electricity generation on the carbon footprint of the EX60.*

Table 11 *The effect of changes in electricity generation on the carbon footprint of the EX60.*

	Global electricity mix			European electricity mix		Wind electricity
[g CO_2e/km]	**STEPS**	**APS**	**NZE**	**STEPS**	**APS**	
Raw material extraction, refining, and part manufacturing	74	74	74	74	74	74
Part and vehicle manufacturing	0.77	0.77	0.77	0.77	0.77	0.77
Inbound and outbound logistics	3.9	3.9	3.9	3.9	3.9	3.9
Driving	65	54	32	29	20	4.5
Maintenance	5.1	5.1	5.1	5.1	5.1	5.1
End-of-life	3.4	3.4	3.4	3.4	3.4	3.4
Total	**152**	**141**	**120**	**117**	**107**	**92**

4.1.2 Lifetime driving distance

The lifetime driving distance is a key parameter in the life cycle assessment of vehicles. A value of 200,000 kilometres was assumed for this study, in line with many other passenger vehicle LCAs as well as TranSensus LCA Consolidated Guidelines[6]. Since the actual outcome could be both longer and shorter, the effect of 150,000-, 250,000-, and 300,000-kilometre lifetime driving distances were assessed. In addition to the increased energy usage during driving, the number of parts replaced during routine vehicle maintenance was adjusted accordingly. The results for the different lifetime driving distances are shown in Figure 15 and Table 12.

As the distance increases, so does the absolute amount of GHG emissions during the use phase. However, since the impact is assessed per kilometre travelled, it decreases as the driving distance increases – an indication of increased vehicle utilisation and operational intensity. The opposite applies to a shorter vehicle lifetime driving distance.

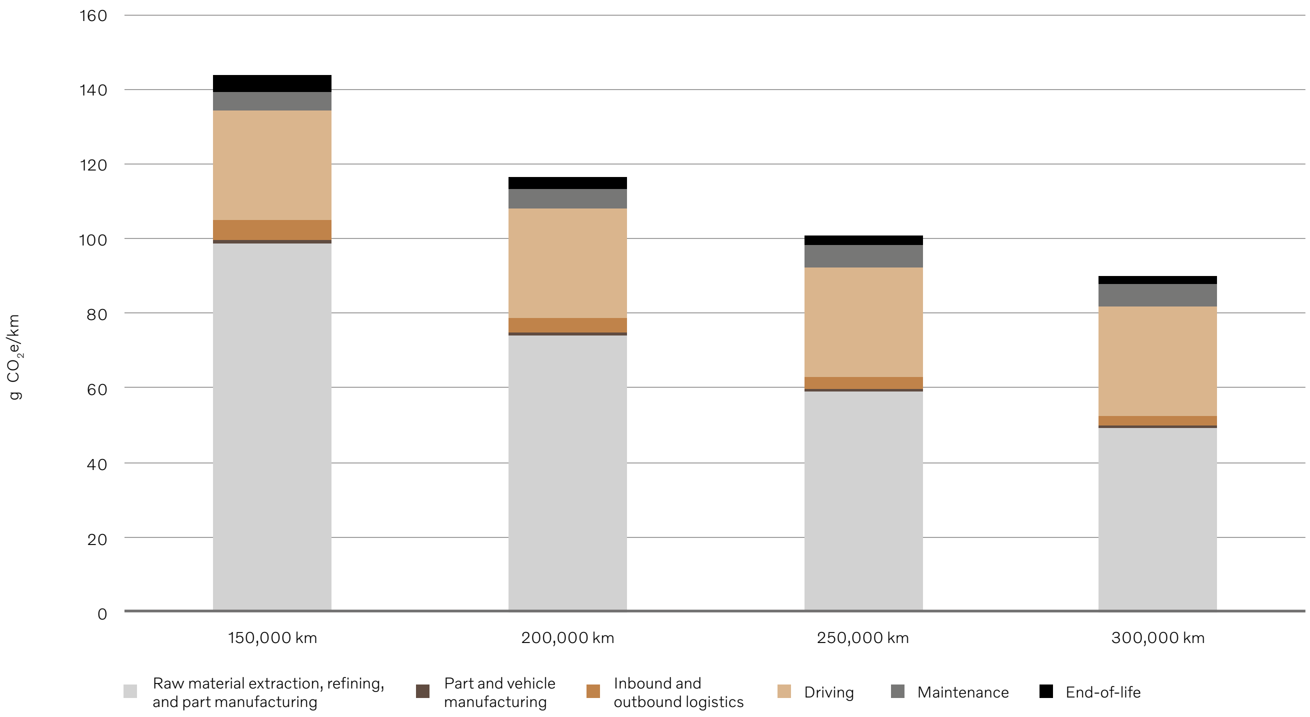


Figure 15 *The effect of the lifetime distance on the carbon footprint when charging with European electricity mix.*

Table 12 *The effect of the lifetime distance on the carbon footprint when charging with European electricity mix.*

[g CO_2e/km]	150,000 km	200,000 km	250,000 km	300,000 km
Raw material extraction, refining, and part manufacturing	99	74	59	49
Part and vehicle manufacturing	1.0	0.77	0.62	0.51
Inbound and outbound logistics	5.3	3.9	3.2	2.6
Driving	29	29	29	29
Maintenance	5.0	5.1	5.8	5.9
End-of-life	4.5	3.4	2.7	2.2
Total	**144**	**117**	**101**	**90**

[6] https://lca4transport.eu/wp-content/uploads/2025/08/TranSensus-LCA_D-5-2_Guidelines_final_revision.pdf

4.1.3 Changes in vehicle energy use

Vehicle energy use was calculated according to the WLTP. This procedure does not consider individual driver behaviour and preferences, traffic and weather conditions, road inclination, or load mass, all of which can vary significantly and have a substantial impact on the energy use. As this may lead to an underestimation of the impact in some markets, the effect of 20 and 30 per cent increases in energy use were evaluated.

As can be derived from Figure 16 and Table 13, driving accounts for 25 per cent of the carbon footprint when charging with the European electricity mix in the base case, which increases to 31 per cent if vehicle energy use increases by 30 per cent.

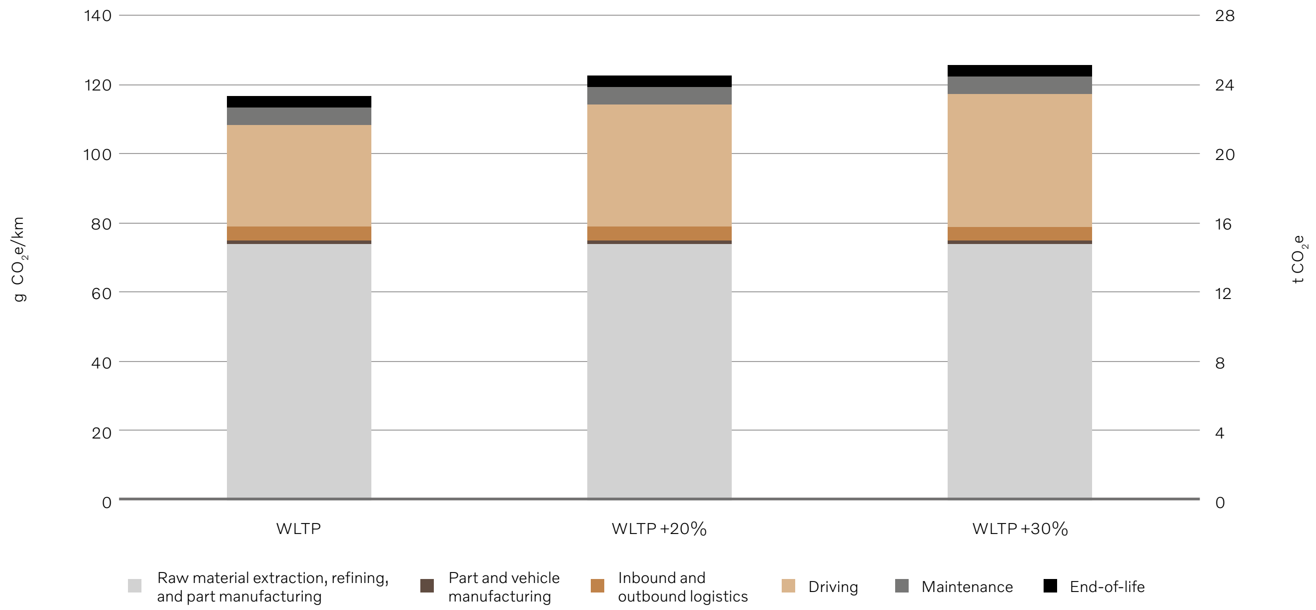


Figure 16 *Carbon footprint when applying different scenarios for energy use when driving, when charging with European electricity mix.*

Table 13 *Carbon footprint when applying different scenarios for energy use when driving, when charging with European electricity mix.*

[g CO_2e/km]	WLTP	WLTP +20%	WLTP +30%
Raw material extraction, refining, and part manufacturing	74	74	74
Part and vehicle manufacturing	0.77	0.77	0.77
Inbound and outbound logistics	3.9	3.9	3.9
Driving	29	35	38
Maintenance	5.1	5.1	5.1
End-of-life	3.4	3.4	3.4
Total	**117**	**123**	**126**

4.2 Impact of abatement initiatives and technological innovations

Much effort was spent on reducing the carbon footprint of the EX60, both within Volvo Cars and among suppliers. Figure 17 and Table 14 provide an estimation of how these reductions together contributed to a 26 per cent lower result compared to an equivalent vehicle without mitigation measures. The sections below describe each of these efforts in more detail.

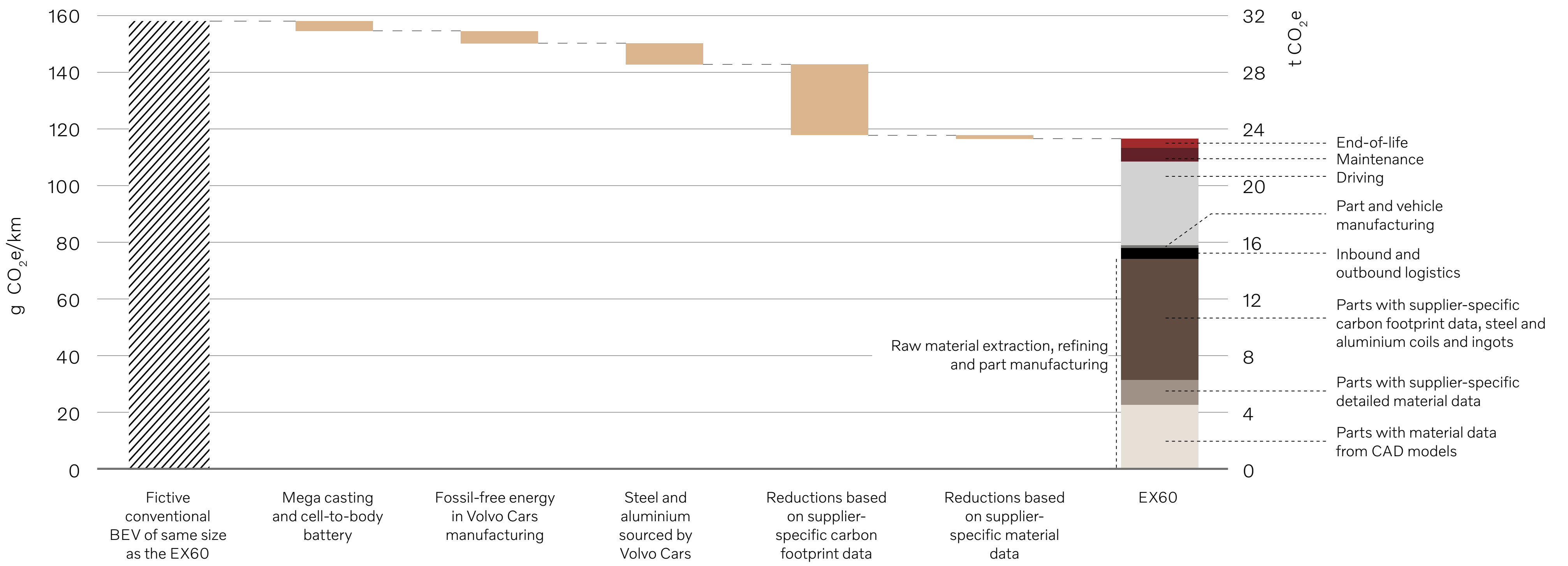


Figure 17 *The influence of abatement initiatives, specific data collection, and technological innovations on the EX60 carbon footprint when charging with European electricity mix.*

Table 14 *The influence of abatement initiatives, specific data collection, and technological innovations on the EX60 carbon footprint when charging with European electricity mix.*

Abatement initiative, technological innovation, and life cycle stage	[g CO_2e/km]	[t CO_2e]
Mega casting of rear floor	-0.17	-0.033
Cell-to-body battery design – driving	-0.30	-0.060
Cell-to-body battery design – material	-2.9	-0.58
Fossil-free energy in Volvo Cars manufacturing	-4.6	-0.91
Steel sourced by Volvo Cars	-1.2	-0.25
Aluminium sourced by Volvo Cars	-6.0	-1.2
Reductions based on supplier-specific carbon footprint data	-25	-5.0
Reductions based on supplier-specific detailed material data	-1.0	-0.2
End-of-life	3.4	0.7
Maintenance	5.1	1.0
Driving	29	5.9
Part and vehicle manufacturing	0.77	0.15
Inbound and outbound logistics	3.9	0.79
Raw material extraction, refining, and manufacturing of parts with supplier-specific carbon footprint data, and steel and aluminium coils and ingots	43	8.6
Raw material extraction, refining, and manufacturing of parts with supplier-specific detailed material data	9	1.8
Raw material extraction, refining, and manufacturing of parts with material data from CAD models	22	4.5
Total	**117**	**23**

4.2.1 Sourcing considerations and supplier-specific data collection

For sustainability purposes, suppliers have been engaged to utilise non-fossil energy sources in their operations, increase the share of recycled materials in their parts, and implement other possible measures to reduce GHG emissions along the value chains. To account for this in the study, an extensive amount of supplier-specific carbon footprint data has been collected which replaces what would otherwise have been modelled with generic data from LCI databases. The share of supplier-specific carbon footprint data was 58 per cent of the total carbon footprint for raw material extraction, refining, and part manufacturing.

The manufacturing plants operated by Volvo Cars all utilise electricity from hydropower, while heating is supplied by combustion of biomethane, heat pumps and district heating sourced from industrial waste heat and renewable energy. This setup is the result of actions to reduce operational GHG emissions, while conventional European vehicle manufacturing could be assumed to involve heating with natural gas and utilisation of electricity from the European residual grid mix.

To assess the benefit of these efforts, a reference vehicle with identical material composition was modelled with generic LCI datasets (the same approach as described in section 2.1), and the corresponding amount of heat and electricity for vehicle manufacturing was modelled with datasets for heating with natural gas and electricity supplied by the European residual grid mix. The resulting carbon footprint of this reference vehicle indicates a reduction of 38 grams CO_2e/kilometre, corresponding to 7.6 tonnes CO_2e over the complete life cycle, compared to the actual EX60 when charging with European electricity mix.

4.2.2 Mega casting of aluminium rear floor

With the EX60, a new production process is introduced for vehicles manufactured by Volvo Cars – the mega casting of aluminium body parts for the floor structure. The process is a variant of high-pressure die-casting, adapted to enable substantially larger castings than what is possible in traditional setups. This reduces complexity and improves efficiency in the manufacturing process, enables reductions in vehicle mass, and allows for greater design flexibility.

For the EX60, the rear floor is produced through mega casting, thereby replacing what, in an XC60 (a vehicle of similar size), consists of more than 80 individual steel parts joined together by welding and adhesive.

To estimate the influence of this technological innovation on the carbon footprint, the following factors were considered:

- **GHG emissions related to raw materials**
  The aluminium in the EX60 rear floor is at most 50 per cent primary, predominantly produced with low-carbon electricity in the electrolysis step, and at least 50 per cent recycled aluminium. The steel parts in the XC60 floor consists of high-quality steel alloys, including boron steel.
- **GHG emissions related to manufacturing**
  The mega casting process, part of the Torslanda plant, involves melting of aluminium with heat from biomethane combustion, while the electricity used in casting and subsequent machining is sourced from hydropower. Aluminium scrap from machining and defective parts is remelted and reutilised, resulting in almost 100 per cent material utilisation rate. For the steel floor parts, data on electricity use and material utilisation rate for associated production lines in the Olofström plant include cutting, stamping, and hot forming were collected. Again, the electricity is sourced from hydropower.

The outcome of the comparison implies a carbon footprint reduction of 16 per cent per rear floor as shown in Figure 18, corresponding to 0.033 tonnes CO_2e. However, preliminary mega casting test runs indicate that the ingoing share of recycled aluminium could potentially be increased to 94 per cent while still fulfilling applicable quality requirements. If this is implemented in production, the reduction would increase to nearly 0.13 tonnes CO_2e.

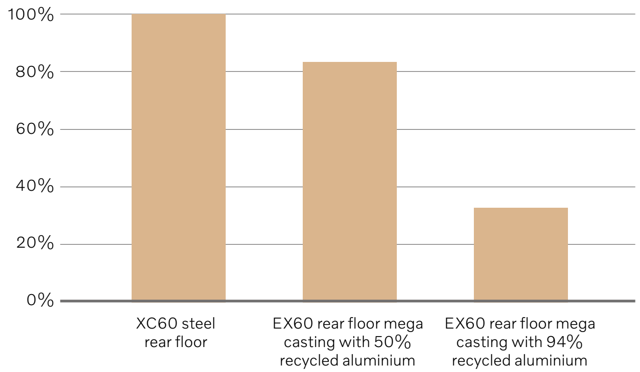


Figure 18 *Carbon footprint comparison between the mega casting of the aluminium rear floor of the EX60 and the equivalent steel floor of the XC60.*

4.2.3 Cell-to-body battery design

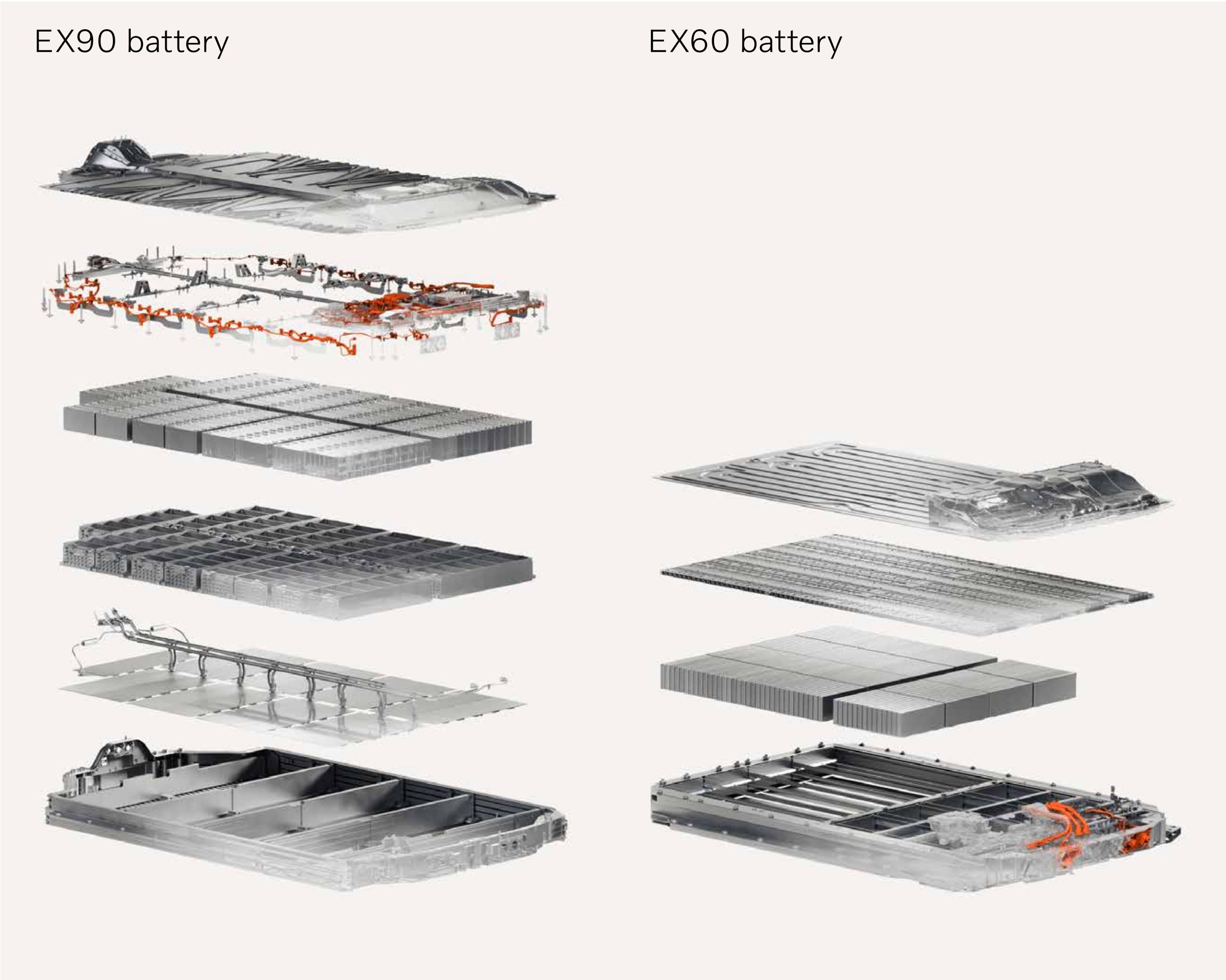
The conventional design of traction batteries for BEVs has involved grouping battery cells together into modules, which are then housed in a battery pack enclosure, together with other sub-components such as busbars and a thermal management system. The battery is typically placed within the car body under the passenger compartment as a stand-alone component.

The EX60 features a new battery concept called cell-to-body, providing several benefits compared to the conventional design, such as improved torsional stiffness, improved car ingress ergonomics, and a reduction in noise, vibration and harshness. This is achieved mainly through two design approaches:

- By placing the individual cells directly into the battery pack enclosure, materials associated with module structures in a conventional battery design are no longer needed, thereby reducing material demand, lowering vehicle mass, and allowing more battery cells to be fitted into the same space.
- The battery is also integrated into the car body structure by replacing the steel floor, leading to reduced material demand and further vehicle mass reduction. By bonding the battery cells together and to the battery enclosure through adhesives, the battery can provide the necessary structural rigidity that would otherwise be provided for by the floor.

An EX90 battery of similar size was used as a reference to evaluate the carbon footprint benefits of the cell-to-body battery in the EX60. While the setup of battery-related electronics differs, the total amount was assessed to be equivalent. The exclusion of module structures results in a reduction of 24 kg of aluminium, while the floor replacement implies a 28 kg reduction in steel. An aluminium extrusion profile dataset for China was used to model the reduced impact from aluminium. The steel type used for the floor parts in the EX90 was combined with average data on electricity use and material utilisations rate for relevant manufacturing operations in the Olofström plant.

The results from the comparison show a reduction in material-related GHG emissions of 0.58 tonnes CO_2e, of which 0.48 and 0.10 tonnes CO_2e is attributed to aluminium and steel respectively. The mass reduction also leads to improved energy efficiency when driving, which was assessed to an additional reduction of 0.060 tonnes CO_2e when charging with the European electricity mix, or 0.13 tonnes CO_2e for the global case (both assuming the energy scenario STEPS).



4.3 Reflections on related topics and limitations

The goal and scope of the study, as described in the first chapter, naturally determine what is presented and explained in this report. However, in this section some topics closely related to the study and sustainability but not within the defined scope, are elaborated upon.

4.3.1 Other environmental impact categories

The study focused on assessing the influence of the EX60 on climate change by estimating the GHG emissions and removals throughout its life cycle. While climate change is of immediate and global concern, there are many other pressing environmental issues, such as photochemical ozone formation, fine particulate matter formation, mineral resource scarcity, and freshwater use. Actions to mitigate the impact on one environmental aspect could have trade-offs involving increased impact on one or several others. It is therefore important to not solely consider climate change when implementing measures to mitigate environmental impacts of vehicles.

4.3.2 Bi-directional charging

The EX60 comes equipped with the necessary hardware for bi-directional charging. While the vehicle is parked and plugged in to a socket outlet, the battery can be enabled to help balance the electrical grid during peak hours and reduce the need for fossil-generated electricity. While this is beneficial from a climate impact perspective, it was outside the scope of this study to assess it quantitatively.

The impact is highly influenced by:

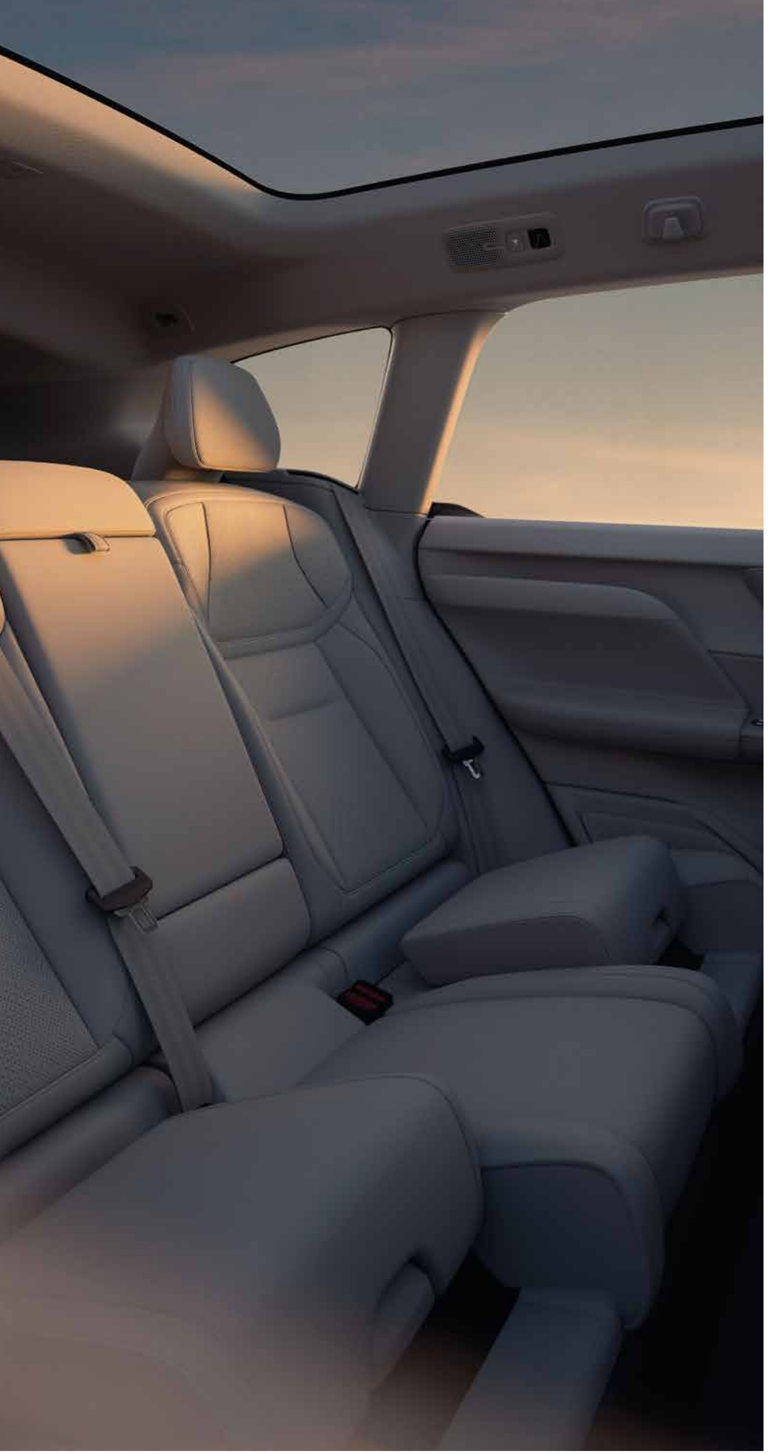
- The composition of the vehicle fleet – how many vehicles have bi-directional charging capability?
- User behaviour – what are the users' general charging habits? Do they utilise bi-directional charging, and if so, how and to what extent?
- The characteristics of the electricity grid where the vehicle is operated – what is the composition of different energy sources, where are their connection points to the electrical grid, and what power transmission limitations are there within the electrical grid?

Additionally, the consequences of bi-directional charging over time are of great interest, as it is often considered an enabler for decarbonisation, which contrasts with the attributional approach of this study. Therefore, some type of energy system analysis is probably more suitable than an attributional product LCA to evaluate the impact of bi-directional charging.

4.3.3 Volvo Cars circular economy ambitions

Within sustainability, Volvo Cars focuses on three areas – climate action, circular economy, and responsible business. While the study's purpose mainly relates to climate action, data and findings also connect to aspects related to circular economy. In particular, the utilisation of recycled materials is an essential part of circular economy, and also a prominent enabler for progress within climate action.

One of Volvo Cars' circular economy ambitions entails the utilisation of 25 per cent recycled and biobased material in new car models by 2025. With an overall recycled material share of 27 per cent for the EX60, it is aligned with fulfilling this ambition. By 2030, the ambition is for new car models to incorporate at least 35 per cent recycled and biobased material, with the long-term aim of becoming a circular business by 2040.



4.3.4 EX60 compared to vehicles with different propulsion technologies

In contrast to earlier carbon footprint studies of BEVs conducted by Volvo Cars, the scope of this study did not involve a comparison with vehicles of similar size but with different propulsion technologies based on an internal combustion engine. Based on the repeatedly consistent findings from those studies[7], the advantage of BEVs with regards to reducing the climate impact from passenger vehicles transportation is evident. These conclusions are also confirmed by studies conducted by other practitioners[8], despite differences in assumptions and data sources. Therefore, there is little doubt that this also applies to the EX60, especially considering the various efforts spent to further reduce the carbon footprint of sourced energy, materials and parts.

The methodology used in carbon footprint studies conducted by Volvo Cars has been refined and improved with each study to reduce uncertainty and increase accuracy, primarily by refining assumptions and collecting more specific data. Additionally, the LCI databases utilised in the studies are continuously updated, reflecting evolving industries and societies. Therefore, the results presented in the published reports are not directly comparable, which needs to be considered when interpreting a potential comparison.

Readers still interested in carrying out such an exercise is recommended to examine the EX90 carbon footprint report (in which the EX90 is compared with the XC90 long-range plug-in hybrid and the XC90 mild hybrid), since the study was conducted fairly recently and the vehicles in the study are relatively close in vehicle size and shape to the EX60. Notable aspects to keep in mind include the difference in traction battery capacity and resulting carbon footprint of battery modules in EX90 versus battery cells in EX60, how differences in vehicle energy use influence on the impact from driving, and the effect of the various abatement initiatives combined with specific data collection.

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[7]Reports available at https://www.volvocars.com/intl/sustainability/climate-action/

[8]For example, this study by the ICCT, https://theicct.org/wp-content/uploads/2025/07/ID-392-%E2%80%93-Life-cycle-GHG_report_final.pdf

5. Conclusions

For the EX60 carbon footprint, a combination of technological innovations and value chain emission reduction initiatives has resulted in a significantly lower outcome than would otherwise have been the case.

These mitigation measures include mega casting of the aluminium rear floor, a cell-to-pack battery design, the use of renewable energy in industrial operations, and the utilisation of recycled materials. The collection of supplier-specific carbon footprint data has made it possible to account for the benefits of these efforts.

Raw materials extraction, refining, and part manufacutring contribute the most to the carbon footprint, followed by GHG emissions related to charging. Charging with wind-generated electricity significantly reduces the carbon footprint compared with global and European electricity mixes.

The primary carbon footprint contributors related to materials are aluminium, steel and iron, and polymers. Among individual parts, the battery cells are major contributors, especially the active materials in the cathodes and anodes. When looking at specific GHG emissions and removals, fossil GHG emissions are clearly the most significant, with the largest contribution coming from raw material extraction, refining, and part manufacturing.

Sensitivity analyses were conducted to assess how changes in some of the study's assumptions affect the carbon footprint, such as future energy scenarios reflecting faster decarbonisation, different lifetime driving distances and vehicle energy use variations.

The integration of sustainability performance and data collection in sourcing processes will strengthen the possibility of increasing the use of recycled materials and materials produced with renewable energy or low-carbon technology throughout the vehicle, which is essential to effectively reduce the vehicle carbon footprint of future models even further.

The findings in this carbon footprint study, as well as those of other Volvo BEVs, support Volvo Cars' commitment to full electrification. To achieve the aim of reaching net-zero GHG emissions by 2040, cross-company collaboration will play a key role. No single company can solve this challenge on its own. Strategic partnerships and collaborations with suppliers, energy providers, technology pioneers, and policymakers will be critical to achieve the necessary emission reductions across the ecosystem.

Appendices

Appendix 1 – Completeness, consistency, and sensitivity checks

Checks were performed on the results in this study to ensure validity, completeness, consistency, and sensitivity.

- Completeness checks verify the adequacy of information to meet the goal and scope of the life cycle assessments.
- Consistency checks verify that assumptions, methods, and data are consistently applied in accordance with the goal and scope of the life cycle assessments.
- Sensitivity checks verify the relevance of sensitivity analysis in reaching conclusions and making recommendations.

The methodology used and assumptions made in this life cycle assessment are adequately explained in relation to its goal and scope. Before extracting results from LCA modelling software and calculation tools, modelling checks were carried out to ensure that all processes were within the system boundary of the study. The modelling was verified for alignment with the assumptions, and goal and scope of the study.

- For parts with supplier-specific carbon footprint data, all raw material extraction, refining, part manufacturing, and logistics from suppliers' plants are included and reported in accordance with the goal and scope of this study.
- All raw material extraction, refining, and part manufacturing for material categories used in the modelling are included and reported in accordance with the goal and scope of this study.
- All manufacturing processes at Volvo Cars' manufacturing plants are included and reported in accordance with the goal and scope of this study.
- All emissions from Volvo Cars' logistics operations are included and reported in accordance with the goal and scope of this study.
- All use-phase emissions are included and reported in accordance with the goal and scope of this study.
- All maintenance-related emissions are included and reported in accordance with the goal and scope of this study.
- All end-of-life treatment processes are included and reported in accordance with the goal and scope of this study.

All modelling was conducted according to the goal and scope of this study. A detailed sensitivity analysis was carried out to evaluate the assumptions made in this study and ensure that the conclusions are valid. The methodology used in this study was evaluated by IVL Swedish Environmental Research Institute through a third-party review. All completeness, consistency, and sensitivity checks were successfully completed for this study.

Appendix 2 – List of material categories

Table 15 *Material types and categories.*

Material type	Material category	Material group
Aluminium	Aluminium current collector, for Li-ion battery cathode	Aluminium current collector, for Li-ion battery cathode
Aluminium	Aluminium sheet – 1XXX series	Aluminium sheet
Aluminium	Aluminium sheet – 3XXX series	Aluminium sheet
Aluminium	Aluminium sheet – 4XXX series	Aluminium sheet
Aluminium	Aluminium sheet – 5XXX series	Aluminium sheet
Aluminium	Aluminium sheet – 6XXX series	Aluminium sheet
Aluminium	Aluminium sheet – Europe	Aluminium sheet, low-emission – Europe
Aluminium	Aluminium sheet, recycled – Europe	Aluminium sheet, recycled – Europe
Aluminium	Cast aluminium alloys – Die casting	Cast aluminium
Aluminium	Cold rolled aluminium sheet – 6XXX series	Aluminium sheet
Cathode/anode active materials	Cathode active material (NMC111)	Cathode active material (NMC111)
Cathode/anode active materials	Graphite	Graphite
Copper	Copper alloys	Copper alloys
Copper	Copper current collector, for Li-ion battery anode	Copper current collector, for Li-ion battery anode
Copper	Copper, generic	Copper
Electronics	DC-link type capacitor	DC-link type capacitor
Electronics	Electric connector	Electric connector
Electronics	Heavy computational signal electronics	Heavy computational signal electronics
Electronics	Light emitting diode	Light emitting diode
Electronics	Mixed power/signal electronics	Mixed power/signal electronics
Electronics	Optoelectronics/displays	Optoelectronics/Displays
Electronics	Populated PCB SMT 1 – 13% IC containing lead	Populated PCB SMT 1 – 13% IC containing lead
Electronics	Power electronics (PCBA)	Power Electronics (PCBA)
Electronics	SiC power modules	SiC power modules
Fluids	Brake fluid	Brake fluid
Fluids	Coolant/other glycols	Coolant/other glycols
Fluids	Electrolyte, for Li-ion battery	Electrolyte, for Li-ion battery
Fluids	R-1234yf	R-1234yf
Fluids	Washer fluid	Washer fluid
Glass	Flat glass	Flat glass
Glass	Glass fibre	Glass fibre (filler for polymers)
Natural materials	Cotton fibre	Cotton fibre
Natural materials	Wood fibre	Wood fibre
Other metals	Cast magnesium alloys	Magnesium
Other metals	Lead	Lead
Other metals	Neodymium Iron Boron (NdFeB)	Neodymium Iron Boron (NdFeB)
Other metals	Nickel	Nickel
Other metals	Zinc alloys	Zinc coatings
Other materials	Carbon black	Carbon black
Polymers	Talc (filler for polymers)	Talc (filler for polymers)
Polymers	Glass fibre	Glass fibre (filler for polymers)
Polymers	ABS filled	ABS, Talc, Glass fibre
Polymers	ABS unfilled	ABS

Material type	Material category	Material group
Polymers	Adhesives, sealants	Adhesives, sealants
Polymers	Aramid textile	Aramid textile
Polymers	Elastomer	Elastomer
Polymers	EPDM rubber	EPDM
Polymers	Epoxy resin	Epoxy resin
Polymers	EVAC unfilled	EVAC
Polymers	Lacquers	Lacquers
Polymers	Natural rubber (NR)	NR
Polymers	NF-PP	NF-PP
Polymers	Nitrile butadiene rubber (NBR)	NBR
Polymers	Other duromers – epoxy	Other duromers – epoxy
Polymers	PA6 unfilled	PA6
Polymers	PA66 unfilled	PA66
Polymers	PA66-GF20	PA66, Glass fibre
Polymers	PA66-GF30	PA66, Glass fibre
Polymers	PA66-GF40	PA66, Glass fibre
Polymers	PA66-GF50	PA66, Glass fibre
Polymers	PA6-GF20	PA6, Glass fibre
Polymers	PA6-GF30	PA6, Glass fibre
Polymers	PA6-GF40	PA6, Glass fibre
Polymers	PA6-GF50	PA6, Glass fibre
Polymers	PA6-GF60	PA6, Glass fibre
Polymers	PA-GF15	PA, Glass fibre
Polymers	PA-GF30	PA, Glass fibre
Polymers	PBT average filler mix	PBT, Talc, Glass fibre

Material type	Material category	Material group
Polymers	PBT unfilled	PBT
Polymers	PBT-GF50	PBT, Glass fibre
Polymers	PC filled	PC, Talc, Glass fibre
Polymers	PC unfilled	PC
Polymers	PC+ABS filled	PC+ABS, Talc, Glass fibre
Polymers	PC+ABS unfilled	PC+ABS
Polymers	PE unfilled generic	PE
Polymers	PE unfilled, for Li-ion battery separator	PE separator
Polymers	PET filled	PET, Talc, Glass fibre
Polymers	PET unfilled	PET
Polymers	PMMA unfilled	PMMA
Polymers	Polyester textile	Polyester textile
Polymers	Polyurethane	Polyurethane
Polymers	POM filled	POM, Talc, Glass fibre
Polymers	POM unfilled	POM
Polymers	PP unfilled	PP
Polymers	PPA filled	PPA, Talc, Glass fibre
Polymers	PPA unfilled	PPA
Polymers	PP-GB30	PP, Glass fibre
Polymers	PP-GF20	PP, Glass fibre
Polymers	PP-GF30	PP, Glass fibre
Polymers	PP-GF40	PP, Glass fibre
Polymers	PP-T12	PP, Talc
Polymers	PP-T15	PP, Talc
Polymers	PP-T20	PP, Talc

Material type	Material category	Material group
Polymers	PP-T25	PP, Talc
Polymers	PP-T30	PP, Talc
Polymers	PP-T40	PP, Talc
Polymers	PVB unfilled	PVB
Polymers	PVC unfilled	PVC
Polymers	Silicone rubber	Silicone rubber
Polymers	Thermoplastic elastomers	Thermoplastic elastomers
Polymers	Unsaturated polyester	Unsaturated polyester
Steel and iron	Austenitic stainless steel 301	Steel, Stainless, Austenitic
Steel and iron	Austenitic stainless steel 304	Steel, Stainless, Austenitic
Steel and iron	Cast iron with nodular graphite/ vermicular cast iron	Cast iron
Steel and iron	Engineering steel – Bearing steel	Engineering steel
Steel and iron	Engineering steel – Case hardening steel	Engineering steel
Steel and iron	Engineering steel – Cast iron free-cutting steel	Engineering steel
Steel and iron	Engineering steel – Fasteners (bolts, screws, and studs)	Engineering steel
Steel and iron	Engineering steel – Forged	Engineering steel
Steel and iron	Engineering steel – General engineering and structural steel	Engineering steel
Steel and iron	Engineering steel – Hardened and tempered	Engineering steel
Steel and iron	Engineering steel – Spring steel	Engineering steel
Steel and iron	Engineering Steel – Steel bars and rods	Engineering steel
Steel and iron	Ferritic stainless steel 434	Steel, Stainless, Ferritic
Steel and iron	Ferritic stainless steel 441	Steel, Stainless, Ferritic
Steel and iron	Sintered and other steel	Sintered and other steel
Steel and iron	Steel sheet – Cold rolled	Steel sheet
Steel and iron	Steel sheet – Finished cold rolled	Steel sheet
Steel and iron	Steel sheet – Hot dip galvanised	Steel sheet
Steel and iron	Steel sheet – Hot rolled	Steel sheet – Hot rolled
Unspecified materials	Unknown/Mixed	N/A

Appendix 3 – LCI datasets

Table 16 *Raw material extraction, refining, and part manufacturing datasets.*

Material group	LCI dataset	Region	Type	Source
ABS	market for acrylonitrile-butadiene-styrene copolymer	GLO	agg	ecoinvent 3.11
Adhesives, sealants	market for polyurethane adhesive	GLO	agg	ecoinvent 3.10.1
Aluminium current collector, for Li-ion battery cathode[a]	market for aluminium collector foil, for Li-ion battery	GLO	agg	ecoinvent 3.10.1
Aluminium sheet	market for aluminium, wrought alloy	GLO	agg	ecoinvent 3.11
Aluminium sheet, low-emission – Europe	Aluminium ingot mix (Renew. electr. LC) – consumption mix	RER	agg	Sphera MLC 2024.2
	Aluminium sheet (Renew. electr. LC)	CN	agg	Sphera MLC 2024.2
Aluminium sheet, recycled – Europe	treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter	RER	agg	ecoinvent 3.10.1
Aluminium, recycled	treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter	RoW	agg	ecoinvent 3.10.1
Aramid textile	market for nylon 6	RER	agg	ecoinvent 3.10.1
ASA	market for acrylonitrile-butadiene-styrene copolymer	GLO	agg	ecoinvent 3.11
Brake fluid	market for ethylene glycol	RER	agg	ecoinvent 3.10.1
Carbon black	market for carbon black	GLO	agg	ecoinvent 3.10.1
Cast aluminium	Aluminium ingot mix IAI 2019	GLO	agg	Sphera MLC 2024.2
	market for aluminium, cast alloy	GLO	agg	ecoinvent 3.11
Cast iron	Cast iron part (automotive) – open energy inputs	DE	p-agg	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
	Thermal energy from hard coal	DE	agg	Sphera MLC 2024.2
	Thermal energy from natural gas	RER	agg	Sphera MLC 2024.2
Cathode active material (NMC111)[a]	market for cathode, NMC111, for Li-ion battery	RoW	agg	ecoinvent 3.10.1
Coolant/other glycols	market for ethylene glycol	RER	agg	ecoinvent 3.10.1
Copper	market for copper, cathode	GLO	agg	ecoinvent 3.11

Material group	LCI dataset	Region	Type	Source
Copper alloys	market for brass	CH	agg	ecoinvent 3.11
	market for bronze	GLO	agg	ecoinvent 3.11
	market for copper, cathode	GLO	agg	ecoinvent 3.11
	Nickel (Class 1, >99.8% Nickel) (Nickel Institute)	GLO	agg	Sphera MLC 2024.2
Copper current collector, for Li-ion battery anode[a]	market for copper collector foil, for Li-ion battery	GLO	agg	ecoinvent 3.10.1
Copper, recycled	treatment of electronics scrap, metals recovery in copper smelter-	RoW	agg	ecoinvent 3.10.1
Corrosion protective agent	market for lubricating oil	RER	agg	ecoinvent 3.10.1
Cotton fibre	market for textile, woven cotton	GLO	agg	ecoinvent 3.11
E/P	market for calcium carbonate, precipitated	RER	agg	ecoinvent 3.11
	market for polyethylene, low density, granulate	GLO	agg	ecoinvent 3.11
Elastomer	market for calcium carbonate, precipitated	RER	agg	ecoinvent 3.11
	market for carbon black	GLO	agg	ecoinvent 3.10.1
	market for lime	RER	agg	ecoinvent 3.10.1
	market for polyethylene terephthalate, granulate, amorphous	GLO	agg	ecoinvent 3.11
	market for synthetic rubber	GLO	agg	ecoinvent 3.10.1
	market for zinc oxide	GLO	agg	ecoinvent 3.11
Electric connector	market for electric connector, peripheral component interconnect buss	GLO	agg	ecoinvent 3.10.1
Electrolyte, for Li-ion battery[a]	market for electrolyte, for Li-ion battery	GLO	agg	ecoinvent 3.10.1
Engineering steel	market for steel, unalloyed	GLO	agg	ecoinvent 3.11
EPDM	market for synthetic rubber	GLO	agg	ecoinvent 3.10.1
Epoxy resin[a]	market for epoxy resin insulator, SiO2	GLO	agg	ecoinvent 3.11
EPP	market for polypropylene, granulate	GLO	agg	ecoinvent 3.11
EPS	market for polystyrene, expandable	GLO	agg	ecoinvent 3.11
EVAC	market for ethylene vinyl acetate copolymer	RER	agg	ecoinvent 3.11
Flat glass	market for flat glass, coated	RER	agg	ecoinvent 3.10.1
Glass fibre (filler for polymers)	market for glass fibre	GLO	agg	ecoinvent 3.10.1

Material group	LCI dataset	Region	Type	Source
Graphite[a]	market for graphite	GLO	agg	ecoinvent 3.10.1
Lacquers	market for polyurethane, rigid foam	RER	agg	ecoinvent 3.11
LDPE	market for polyethylene, low density, granulate	GLO	agg	ecoinvent 3.11
Lead	market for lead	GLO	agg	ecoinvent 3.10.1
Light emitting diode	market for light emitting diode	GLO	agg	ecoinvent 3.10.1
Magnesium	market for magnesium	GLO	agg	ecoinvent 3.11
NBR	market for synthetic rubber	GLO	agg	ecoinvent 3.10.1
Neodymium Iron Boron (NdFeB)	market for permanent magnet, for electric motor	GLO	agg	ecoinvent 3.10.1
NF-PP	market for polypropylene, granulate	GLO	agg	ecoinvent 3.11
	market for fibre, kenaf	GLO	agg	ecoinvent 3.11
Nickel	Nickel (Class 1, >99.8% Nickel) (Nickel Institute)	GLO	agg	Sphera MLC 2024.2
NR	market for seal, natural rubber based	GLO	agg	ecoinvent 3.10.1
Other duromers – epoxy[a]	market for epoxy resin, liquid	RER	agg	ecoinvent 3.11
PA	market for nylon 6	RER	agg	ecoinvent 3.10.1
PA6	market for nylon 6	RER	agg	ecoinvent 3.10.1
PA66	market for nylon 6-6	RER	agg	ecoinvent 3.11
Paraffin	market for paraffin	GLO	agg	ecoinvent 3.10.1
PBT	Polybutylene terephthalate granulate (PBT) mix	DE	agg	Sphera MLC 2024.2
PC	market for polycarbonate	RER	agg	ecoinvent 3.11
PC+ABS	market for acrylonitrile-butadiene-styrene copolymer	GLO	agg	ecoinvent 3.11
	market for polycarbonate	RER	agg	ecoinvent 3.11
PE	market for polyethylene, low density, granulate	GLO	agg	ecoinvent 3.11
PE separator[a]	PE separator	CN	N/A	Renshu Y. et al., 2019[b]
PET	market for polyethylene terephthalate, granulate, amorphous	GLO	agg	ecoinvent 3.11
Plastics (in polymeric compounds)	market for nylon 6	RER	agg	ecoinvent 3.10.1
PMMA	market for polymethyl methacrylate	RER	agg	ecoinvent 3.11

Material group	LCI dataset	Region	Type	Source
Polymers (all categories), recycled	market for plastic granulate, unspecified, recycled	IN	agg	ecoinvent 3.10.1
Polyester textile	market for fibre, polyester	GLO	agg	ecoinvent 3.10.1
Polyurethane	market for polyurethane, rigid foam	RER	agg	ecoinvent 3.11
POM	market for fibre, polyester	GLO	agg	ecoinvent 3.10.1
	market for polyvinyl chloride, suspension polymerised	RER	agg	ecoinvent 3.11
Populated PCB SMT 1 – 13% IC containing lead	market for printed wiring board, mounted mainboard, desktop computer, Pb containing	GLO	agg	ecoinvent 3.10.1
PP	market for polypropylene, granulate	GLO	agg	ecoinvent 3.11
PPA	market for nylon 6	RER	agg	ecoinvent 3.10.1
PS	market for polystyrene, expandable	GLO	agg	ecoinvent 3.11
PVB	Polyvinyl butyral granulate (PVB) by-product ethyl acetate	RER	agg	Sphera MLC 2024.2
PVC	market for polyvinyl chloride, suspension polymerised	RER	agg	ecoinvent 3.11
R-1234yf	production of R-1234yf	GB	N/A	ICCT, 2013[c]
SBR	Styrene-butadiene rubber (S-SBR) mix	DE	agg	Sphera MLC 2024.2
Silica sand	market for silica sand	GLO	agg	ecoinvent 3.10.1
Silicone rubber	market for silicone product	RER	agg	ecoinvent 3.11
	market for synthetic rubber	GLO	agg	ecoinvent 3.10.1
Sintered and other steel	market for steel, unalloyed	GLO	agg	ecoinvent 3.11
Steel BF-BOF, recycled	BF- BOF steel billet 100% RC, Responsible Steel level 1	GLO	agg	Responsible Steel, 2024[d]
Steel sheet	market for steel, unalloyed	GLO	agg	ecoinvent 3.11
Steel sheet – Hot rolled	market for steel, unalloyed	GLO	agg	ecoinvent 3.11
Steel, Stainless, Austenitic	Stainless steel cold rolled (304) (Eurofer)	RER	p-agg	Sphera MLC 2024.2
Steel, Stainless, Ferritic	Stainless steel cold rolled (430) (Eurofer)	RER	p-agg	Sphera MLC 2024.2
Steel, Unalloyed	market for steel, unalloyed	GLO	agg	ecoinvent 3.11
Talc (filler for polymers)	market for dolomite	RER	agg	ecoinvent 3.10.1
	market for silica sand	GLO	agg	ecoinvent 3.10.1

Material group	LCI dataset	Region	Type	Source
Thermoplastic elastomers	market for polypropylene, granulate	GLO	agg	ecoinvent 3.11
	market for synthetic rubber	GLO	agg	ecoinvent 3.10.1
Unsaturated polyester	market for isophthalic acid based unsaturated polyester resin	RER	agg	ecoinvent 3.11
Washer fluid	market for ethanol, without water, in 99.7% solution state, from fermentation, vehicle grade	CH	agg	ecoinvent 3.10.1
Wood fibre	market for cellulose fibre	CH	agg	ecoinvent 3.11
Zinc coatings	market for zinc, coils	GLO	agg	ecoinvent 3.11

[a] *Used to model the reference case described in Section 4.2.*

[b] *Renshu Y., Shuhan H., Yang Y. (2019) "Life cycle inventories of the commonly used materials for lithium-ion batteries in China" Journal of Cleaner Production 227 pp. 960-971 – https://www.sciencedirect.com/science/article/abs/pii/S0959652619312661.*

[c] *The Ohio State University (2013) Upstream climate impacts from production of R-134a and R-1234yf refrigerants used in mobile air conditioning systems. Washington, DC: International Council on Clean Transportation – https://theicct.org/sites/default/files/publications/ICCT_RefrigerantsImpacts_20130909.pdf*

[d] *Responsible Steel (2024) Responsible Steel International Production Standard V2.1.1 [Online] Available at: https://www.responsiblesteel.org/standards (Accessed: 9 December 2025).*

Table 17 Manufacturing process datasets.

Material group	LCI dataset	Region	Type	Source
Aluminium sheet	market for sheet rolling, aluminium	GLO	agg	ecoinvent 3.11
	Aluminium sheet deep drawing	DE	u-so	Sphera MLC 2024.2
	Aluminium sheet – open input aluminium rolling ingot	RER	p-agg	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
Aluminium sheet, low-emission – Europe	sheet rolling, aluminium	RER	agg	ecoinvent 3.11
	Aluminium sheet deep drawing	DE	u-so	Sphera MLC 2024.2
	Aluminium sheet – open input aluminium rolling ingot	RER	p-agg	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
Aluminium sheet, recycled – Europe	sheet rolling, aluminium	RER	agg	ecoinvent 3.11
	Aluminium sheet deep drawing	DE	u-so	Sphera MLC 2024.2
	Aluminium sheet – open input aluminium rolling ingot	RER	p-agg	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
Carbon black	Vulcanisation of synthetic rubber (without additives)	GLO	u-so	Sphera MLC 2024.2
Cast aluminium	Aluminium die-cast part	DE	u-so	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
	Process steam from natural gas 95%	RER	agg	Sphera MLC 2024.2
	Process steam from hard coal 95%	RER	agg	Sphera MLC 2024.2
Copper	market for wire drawing, copper	GLO	agg	ecoinvent 3.11
Cotton fibre	market for injection moulding	GLO	agg	ecoinvent 3.11
Engineering steel	market for hot rolling, steel	GLO	agg	ecoinvent 3.11
	market for forging, steel	GLO	agg	ecoinvent 3.11

Material group	LCI dataset	Region	Type	Source
Engineering steel – General engineering and structural steel	market for hot rolling, steel	GLO	agg	ecoinvent 3.11
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11
Glass fibre (filler for polymers)	market for injection moulding	GLO	agg	ecoinvent 3.11
Lacquers	market for injection moulding	GLO	agg	ecoinvent 3.11
Lead	Steel cast part alloyed (automotive)	DE	p-agg	Sphera MLC 2024.2
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23
	Thermal energy from hard coal	RER	agg	Sphera MLC 2024.2
	Thermal energy from natural gas	RER	agg	Sphera MLC 2024.2
Magnesium	magnesium casting process	Not identified	N/A	German Aerospace Center e.V., 2020
Polymers (all categories) manufacturing	market for injection moulding	GLO	agg	ecoinvent 3.11
SBR	Vulcanisation of synthetic rubber (without additives)	GLO	u-so	Sphera MLC 2024.2
Sintered and other steel	market for hot rolling, steel	GLO	agg	ecoinvent 3.11
	market for sheet rolling, steel	GLO	agg	ecoinvent 3.11
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11
Steel sheet	market for hot rolling, steel	GLO	agg	ecoinvent 3.11
	market for sheet rolling, steel	GLO	agg	ecoinvent 3.11
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11
Steel sheet – Hot rolled	market for hot rolling, steel	GLO	agg	ecoinvent 3.11
	market for sheet rolling, steel	GLO	agg	ecoinvent 3.11
Steel, Stainless, Austenitic	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11
Steel, Stainless, Ferritic	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11
Wood fibre	market for injection moulding	GLO	agg	ecoinvent 3.11
Zinc coatings	market for deep drawing, steel, 10000 kN press, single stroke	GLO	agg	ecoinvent 3.11

Table 18 *Electronics datasets.*

Electronics component	LCI dataset	Region	Type	Source
DC-link type capacitor[a]	Supplier-specific data – confidential			
Heavy computational signal electronics	Assembly line SMD (1SP, 2CS, 1CP, 1R, 1Rf) throughput 300/h – open input printed circuit board	GLO	agg	Sphera MLC 2024.2
	Capacitor ceramic MLCC 0201 (0.17mg) 0.6x0.3x0.3 (Precious Metals)	GLO	agg	Sphera MLC 2024.2
	Coil multilayer chip 1812 (108mg) 4.5x3.2x1.5	GLO	agg	Sphera MLC 2024.2
	Diode power DO214/219 (93mg) 4.3x3.6x2.3	GLO	agg	Sphera MLC 2024.2
	IC BGA 144 (360mg) 13x13mm MPU generic (130 nm node)	GLO	agg	Sphera MLC 2024.2
	IC BGA 78 (446 mg) 8x10mm 1GB DDR4 RAM (57 nm node)	GLO	agg	Sphera MLC 2024.2
	IC DFN 10 (22.3 mg) 3x3mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC PLCC 20 (751mg) 9x9mm CMOS logic (250 nm node)	GLO	agg	Sphera MLC 2024.2
	IC PLCC 44 (2.6g) 16.6x16.6mm CMOS logic (250 nm node)	GLO	agg	Sphera MLC 2024.2
	IC QFN 24 (61.6 mg) 4x6mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC QFP 32 (184mg) 7x7mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 20 (530mg) 12.8x7.5mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 8 (76mg) 4.9x3.9mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SSOP 24 (123mg) 8.2x5.3mm CMOS logic (65 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSOP 32 (373mg) 8x20mm flash (45 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 16 (59mg) 4.4x5.0mm DRAM (57 nm node)	GLO	agg	Sphera MLC 2024.2
	IC WLP CSP 196 (209mg) 12x12x1.41mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC WLP CSP 425 (4.78g) 19x19x1.5mm flash (45 nm node)	GLO	agg	Sphera MLC 2024.2
	Oscillator crystal (500mg) 11.05x4.65x2.5	GLO	agg	Sphera MLC 2024.2
	Printed Wiring Board 8-layer rigid FR4 with chem-elec AuNi finish (Subtractive method)	GLO	agg	Sphera MLC 2024.2
	Resistor THT MBA 0204 (125mg) D1.6x3.6	GLO	agg	Sphera MLC 2024.2
	Transistor THT TO92 (250mg) D4.8x5.3	GLO	agg	Sphera MLC 2024.2

Electronics component	LCI dataset	Region	Type	Source
Mixed power/signal electronics	Assembly line SMD (1SP, 2CS, 1CP, 1R, 1Rf) throughput 300/h – open input printed circuit board	GLO	agg	Sphera MLC 2024.2
	Coil multilayer chip 1812 (108mg) 4.5x3.2x1.5	GLO	agg	Sphera MLC 2024.2
	IC DFN 10 (22.3 mg) 3x3mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC PLCC 20 (751mg) 9x9mm CMOS logic (250 nm node)	GLO	agg	Sphera MLC 2024.2
	IC QFP 32 (184mg) 7x7mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 20 (530mg) 12.8x7.5mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 8 (76mg) 4.9x3.9mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SSOP 24 (123mg) 8.2x5.3mm CMOS logic (65 nm node)	GLO	agg	Sphera MLC 2024.2
	Printed Wiring Board 8-layer rigid FR4 with chem-elec AuNi finish (Subtractive method)	GLO	agg	Sphera MLC 2024.2
	Capacitor Al-capacitor SMD (1.29g) D10x10.2	GLO	agg	Sphera MLC 2024.2
	Capacitor Al-capacitor SMD (300mg) D6.3x5.4	GLO	agg	Sphera MLC 2024.2
	Capacitor ceramic MLCC 0603 (6mg) 1.6x0.8x0.8 (Base Metals)	GLO	agg	Sphera MLC 2024.2
	Capacitor ceramic MLCC 1210 (50mg) 3.2x2.5x1.6 (Precious Metals)	GLO	agg	Sphera MLC 2024.2
	Coil multilayer chip 0402 (1mg) 1x0.5x0.5	GLO	agg	Sphera MLC 2024.2
	Diode power THT DO35 (150mg) D1.76x3.77	GLO	agg	Sphera MLC 2024.2
	Diode signal SOD123/323/523 (1.59mg) 0.8x0.75x1.6 with Au-Bondwire	GLO	agg	Sphera MLC 2024.2
	Diode signal SOD123/323/523 (9.26mg) 2.4x1.6x1 with Au-Bondwire	GLO	agg	Sphera MLC 2024.2
	IC TQFP 44 (272mg) 10x10mm MPU generic (130 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 16 (59mg) 4.4x5.0mm flash (45 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 48 (187mg) 6.1x12.5mm DRAM (57 nm node)	GLO	agg	Sphera MLC 2024.2
	IC WLP CSP 196 (209mg) 12x12x1.41mm MPU generic (130 nm node)	GLO	agg	Sphera MLC 2024.2
	LED SMD high-efficiency with lens max 1A (60mg) Au bondwire 3.5x3.5x2.0	GLO	agg	Sphera MLC 2024.2
	LED SMD low-efficiency max 50mA (35mg) without Au 3.2x2.8x1.9	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 0402 (0.75mg)	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 0603 (2.1mg)	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 1206 (8.9mg)	GLO	agg	Sphera MLC 2024.2
	Thermistor SMD NTC 0402 (4mg)	GLO	agg	Sphera MLC 2024.2

Electronics component	LCI dataset	Region	Type	Source
Mixed power/signal electronics	Thermistor SMD PTC (400mg) 6.3x8x3.3	GLO	agg	Sphera MLC 2024.2
	Transistor signal SOT23 3 leads (10mg) 1.4x3x1	GLO	agg	Sphera MLC 2024.2
	Transistor signal SOT23 8 leads (18mg) 1.4x3x2	GLO	agg	Sphera MLC 2024.2
Optoelectronics/Displays	Magnesium	CN	agg	Sphera MLC 2024.2
	market for backlight, for liquid crystal display	GLO	agg	ecoinvent 3.10
Power Electronics (PCBA)	Assembly line SMD (1SP, 2CS, 1CP, 1R, 1Rf) throughput 300/h – open input printed circuit board	GLO	agg	Sphera MLC 2024.2
	Diode power DO214/219 (93mg) 4.3x3.6x2.3	GLO	agg	Sphera MLC 2024.2
	IC DFN 10 (22.3 mg) 3x3mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC QFN 24 (61.6 mg) 4x6mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 20 (530mg) 12.8x7.5mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SO 8 (76mg) 4.9x3.9mm CMOS logic (90 nm node)	GLO	agg	Sphera MLC 2024.2
	IC SSOP 24 (123mg) 8.2x5.3mm CMOS logic (65 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 16 (59mg) 4.4x5.0mm DRAM (57 nm node)	GLO	agg	Sphera MLC 2024.2
	IC WLP CSP 196 (209mg) 12x12x1.41mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	Oscillator crystal (500mg) 11.05x4.65x2.5	GLO	agg	Sphera MLC 2024.2
	Printed Wiring Board 8-layer rigid FR4 with chem-elec AuNi finish (Subtractive method)	GLO	agg	Sphera MLC 2024.2
	Capacitor ceramic MLCC 0603 (6mg) 1.6x0.8x0.8 (Base Metals)	GLO	agg	Sphera MLC 2024.2
	Diode signal SOD123/323/523 (9.26mg) 2.4x1.6x1 with Au-Bondwire	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 16 (59mg) 4.4x5.0mm flash (45 nm node)	GLO	agg	Sphera MLC 2024.2
	LED SMD low-efficiency max 50mA (35mg) without Au 3.2x2.8x1.9	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 0402 (0.75mg)	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 0603 (2.1mg)	GLO	agg	Sphera MLC 2024.2
	Resistor thick film flat chip 1206 (8.9mg)	GLO	agg	Sphera MLC 2024.2
	Transistor signal SOT23 3 leads (10mg) 1.4x3x1	GLO	agg	Sphera MLC 2024.2
	Capacitor Al-capacitor axial THT (300mg) D3.3x11	GLO	agg	Sphera MLC 2024.2
	Capacitor ceramic MLCC 1210 (50mg) 3.2x2.5x1.6 (Base metals)	GLO	agg	Sphera MLC 2024.2

Electronics component	LCI dataset	Region	Type	Source
Power Electronics (PCBA)	Capacitor film-capacitor boxed RM27.5 (20.4g) 31x21x31	GLO	agg	Sphera MLC 2024.2
	Diode signal DO214/219 (14.8mg) 3.9x1.9x1	GLO	agg	Sphera MLC 2024.2
	IC BGA 256 (4g) 27x27mm CMOS logic (45 nm node)	GLO	agg	Sphera MLC 2024.2
	IC TSSOP 8 (23mg) 3x3mm DRAM (57 nm node)	GLO	agg	Sphera MLC 2024.2
	IC WLP CSP 49 (10.2mg) 3.17x3.17x0.55mm CMOS logic (14 nm node)	GLO	agg	Sphera MLC 2024.2
	LED SMD high-efficiency with lens max 0.5A (59mg) Au bondwire 3.5x3.5x2.0	GLO	agg	Sphera MLC 2024.2
	Solder paste SnAg3Cu0.5 (SAC-Lot)	GLO	agg	Sphera MLC 2024.2
	Transistor signal SOT223 3 leads (110mg) 3.8x7.65x2.3	GLO	agg	Sphera MLC 2024.2
SiC power modules[a]	Supplier-specific data – confidential			

[a] *Used to model the reference case described in Section 4.2.*

Table 19 *End-of-life datasets*

Material or activity	LCI dataset	Region	Type	Source
Transport	Truck, Diesel, Euro VI A-C, 28–32t gross weight	GLO	u-so	Sphera MLC 2024.2
	Diesel mix at refinery	RER	agg	Sphera MLC 2024.2
Fluids	treatment of waste mineral oil, hazardous waste incineration	Europe without Switzerland	agg	ecoinvent 3.11
Plastic	Plastic waste on landfill	RER	agg	Sphera MLC 2024.2
	Waste incineration of plastics (unspecified) fraction in municipal solid waste (MSW)	EU-28	p-agg	Sphera MLC 2024.2
Glass	Glass/inert waste on landfill	EU-28	agg	Sphera MLC 2024.2
Tyre	treatment of used tyre	GLO	agg	ecoinvent 3.11

Table 20 *Parts for which specific carbon footprint data were collected from suppliers.*

Parts
AC compressor
AC lines
Air heater
Anti roll and suspension
Battery cells
Battery enclosures
Battery tray extrusions
Body structures extrusions
Brake calipers
Brake control module
Brake discs
Climate unit
Contact system-cell
Cooling fan
Door module
Drive shaft
Electro steel
Gears
Heat pump
Hot formed parts
Inverter
Knuckles
Link arms
Overhead console
Power box

Parts
Reinforcement parts
Seat structures
Spring towers
Stamped parts
Steering gear
Subframes
Toe links
Transmission housing
Trim mouldings
User experience computer
Vehicle computational unit (VCU)
Wheel bearings
Wheels

Table 21 Parts for which detailed material data were collected from suppliers.

Parts	Parts	Parts
Accelerator pedal	Fender reinforcements	Seat backrests
Aero deflectors	Floor hatch	Seat belt
Air guide	Front carriers	Seat bolster
Airbag	Front floor	Seat carriers
A-pillar	Front side door	Seat covers
Armrest	Front wiper	Seat latch
Audio system	Frunk	Seat panels
Backrest upholstery	Gears	Seat rim
Battery 12V	Head restraint upholstery	Seat structure
Battery box	Hinge releaser	Sill mouldings
Battery structural hardware	Hood hinge	Spoiler
Boot panel	Instrument panel	Steering column
B-pillar	Insulation front fender	Storage tray
Brake calipers	Lamps	Tailgate panel
Brake line	Level sensor	Telematic control module
Bumpers	Number plate holder	Trim mouldings
Cable channel	NVH panel	Tyres
Carpets	Outer handle	Under floor panel
Center console	Park assist camera	Undershield
Climate unit	Pillar panels	User experience computer
Control panels	Rear cable system	Water pump
Cover panel	Rear lamps	Wheel arch liners
C-pillar	Rear plate	Wheel guards
Crossmember	Rear seat striker	Wheel housing
Dampers & tuning parts	Rear view mirror	

Table 22 Electricity datasets.

Energy source	LCI dataset	Region	Type	Source
Electricity from solar PV	Electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	FR	agg	ecoinvent 3.11
Electricity from wind	Electricity production, wind, 1-3MW turbine, onshore	AT	agg	ecoinvent 3.11
Electricity from hydropower	Electricity production, hydro, reservoir, alpine region	FR	agg	ecoinvent 3.11
Electricity from bioenergy	Heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014	DE	agg	ecoinvent 3.11
Electricity from geothermal	Electricity production, deep geothermal	FR	agg	ecoinvent 3.11
Electricity from nuclear	Electricity production, nuclear, boiling water reactor	DE	agg	ecoinvent 3.11
Electricity from coal	Electricity production, hard coal	DE	agg	ecoinvent 3.11
Electricity from natural gas	Electricity production, natural gas, combined cycle power plant	FR	agg	ecoinvent 3.11
Electricity from oil	Electricity production, oil	IT	agg	ecoinvent 3.11
Electricity from CSP	Electricity production, solar thermal parabolic trough, 50MW	US-WECC	agg	ecoinvent 3.11
Electricity from marine	Electricity production, wind, 1-3MW turbine, offshore	GB	agg	ecoinvent 3.11
Electricity from BECCS	No dataset, assumed net zero climate impact			
Electricity from hydrogen and ammonia	Electricity production, wind, 1-3MW turbine, onshore	AT	agg	ecoinvent 3.11
Electricity from coal and natural gas with CCUS	Electricity production, wind, 1-3MW turbine, onshore	AT	agg	ecoinvent 3.11

Datasets to represent all variations of electricity generation from specific energy sources were selected among European geographies (when available). For each energy source, the dataset with median impact score for GWP-100 among available geographies was selected. If the impact score of a large country did not deviate more than 5 per cent from the median, and the median value was from a small country, it was selected instead.

Table 23 Energy mixes used for manufacturing processes and end-of-life (EOL) modelling.

Energy source	STEPS, Global, 2024, for manufacturing processes	STEPS, Global, 2033, for EOL of maintenance parts	STEPS, Global, 2041, for EOL of vehicle	Source
Electricity from solar PV	7%	14%	20%	IEA, WEO 2022
Electricity from wind	9%	16%	19%	IEA, WEO 2022
Electricity from hydropower	15%	14%	14%	IEA, WEO 2022
Electricity from bioenergy	3%	3%	4%	IEA, WEO 2022
Electricity from geothermal	0%	<0.5%	<0.5%	IEA, WEO 2022
Electricity from nuclear	10%	9%	9%	IEA, WEO 2022
Electricity from coal	32%	23%	16%	IEA, WEO 2022
Electricity from natural gas	22%	18%	15%	IEA, WEO 2022
Electricity from oil	2%	1%	1%	IEA, WEO 2022
Electricity from CSP	0%	<0.5%	<0.5%	IEA, WEO 2022
Electricity from marine	0%	<0.5%	<0.5%	IEA, WEO 2022
Electricity from BECCS	0%	<0.5%	<0.5%	IEA, WEO 2022
Electricity from hydrogen and ammonia	0%	<0.5%	<0.5%	IEA, WEO 2022
Electricity from coal and natural gas with CCUS	0%	<0.5%	<0.5%	IEA, WEO 2022

IEA World Energy Outlook (WEO) 2022 datapoints for future years are typically provided for every fifth year. Linear interpolation between those datapoints were utilised to estimate energy source shares for individual years.

Table 24 *European residual electricity mix used for reference case described in Section 4.2.*

Energy source	European residual mix 2024	Source
Electricity from solar PV	5%	AIB, 2025
Electricity from wind[a]	2%	AIB, 2025
Electricity from hydropower	2%	AIB, 2025
Electricity from bioenergy	1%	AIB, 2025
Electricity from geothermal	0.05%	AIB, 2025
Electricity from nuclear	34%	AIB, 2025
Electricity from coal[b]	20%	AIB, 2025
Electricity from natural gas	23%	AIB, 2025
Electricity from oil[c]	12%	AIB, 2025

[a] *Also includes "RE unspecified"*
[b] *Includes "FO Hard Coal" and "FO Lignite"*
[c] *Also includes "FO unspecified"*

Table 25 Energy datasets used for vehicle manufacturing.

Energy source	LCI dataset	Region	Type	Source
Electricity from hydropower	electricity production, hydro, reservoir, non-alpine region	SE	agg	ecoinvent 3.11
Heat from biomethane	market for biomethane, low pressure	CH	agg	ecoinvent 3.11
Heat from biomass (via district heating)	heat production, hardwood chips from forest, at furnace 5000kW	CH	agg	ecoinvent 3.11
Heat from natural gas[a]	heat production, natural gas, at industrial furnace >100kW	Europe without Switzerland	agg	ecoinvent 3.11

Inbound and outbound logistics

The calculations cover transport operations managed and paid for by Volvo Cars related to the transports of materials and parts to its facilities, as well as delivery of produced cars from the vehicle manufacturing plant – in this case, the Torslanda plant – to dealers.

An internal system for calculating logistics was used which is in line with the ISO 14083 standard and the recommendations of the GLEC Framework (version 3.0). Since the EX60 was not yet in production when the study was conducted, data for inbound transport was calculated using actual data for other car models already in production at the same manufacturing sites and extrapolated based on costs. Outbound emissions were calculated as a weighted average, based on planned sales volumes indicating to which markets the car model was expected to be distributed.

Emission factors were obtained from the Network of Transport Measures (NTM)[9] database. An average value of GHG emissions for packaging, reflecting their contribution to total transport mass, was included. Aligned with the ISO 14067 standard, the impact from high altitude emissions from aircraft was not adjusted with any radiative forcing index factor.

[a] *Used to model the reference case described in Section 4.2.*

[9] *https://www.transportmeasures.org/en/wiki/evaluation-transport-suppliers/*

Appendix 4 – Data quality assessment

Table 26 lists the data quality indicators used in this study. Each datapoint has received a score from 1 (best) to 5 (worst), based on five correlation aspects. Table 27 and Table 28 score data used for raw material extraction, refining, and part manufacturing, and Table 29 summarises the results for all life cycle stages.

For materials in general, the temporal, geographical and technological correlation scores vary. Representativeness and precision get better scores, thanks to credible LCI databases and supplier-specific data. Steel and iron, aluminium and electronics score higher in technological correlation compared to previous studies, thanks to supplier-specific data.

Based on the results presented below, overall, data quality is considered sufficient concerning Volvo Cars operations and the vehicles' use phase. Data quality for raw material extraction, refining, and part manufacturing, and end-of-life varies widely, but is considered better for directly sourced materials and parts with specific data, which covers most of the climate impact.

Table 26 *Data quality gradation.*

Aspect	1	2	3	4	5
Temporal correlation (time related coverage)	Less than three years before date of study	Less than six years before date of study	Less than 10 years before date of study	Less than 15 years before date of study	Age of data unknown or more than 15 years before date of study
Geographical correlation	Data from enterprises, processes and materials under study	Average processing data from area that includes area of origin	Data from area with comparable production conditions	Processing data from unknown areas	Data from areas with different production conditions
Technological correlation	Processing and material data from enterprises under study	Processing and material data from other enterprises or groups	Processing and material data from enterprises under study, using different technology	Processing and material data for equivalent technology	Processing and material data for different or unknown technology
Representative	Data of adequate sample size over an adequate time period, including future projections (if necessary)	Data from a small sample over an adequate time period	Data of adequate sample size over a shorter time period	Data from a small sample and shorter time period or incomplete data of adequate sample size and time	Unknown or incomplete data from a small sample and/or shorter time period
Precision	Verified data based on measurements	Verified data based partly on assumptions or non-verified data based on measurements	Non-verified data based partly on assumptions	Qualified estimates (e.g. by industrial expert)	Non-qualified estimates

Table 27 Data quality assessment, materials.

Material	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
ABS	market for acrylonitrile-butadiene-styrene copolymer	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Adhesives, sealants	market for polyurethane adhesive	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Aluminium current collector, for Li-ion battery cathode	market for aluminium collector foil, for Li-ion battery	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Aluminium sheet	market for aluminium, wrought alloy	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Aluminium sheet, low-emission – Europe	Aluminium ingot mix (Renew. electr. LC) – consumption mix	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
	Aluminium sheet (Renew. electr. LC)	CN	2024	Sphera MLC 2024.2	1	4	2	1	1
Aluminium sheet, recycled – Europe	treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
Aluminium, recycled	treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter	RoW	2023	ecoinvent 3.10.1	1	5	2	1	1
Aramid textile	market for nylon 6	RER	2023	ecoinvent 3.10.1	1	3	4	1	1
ASA	market for acrylonitrile-butadiene-styrene copolymer	GLO	2024	ecoinvent 3.11	1	4	4	1	1
Brake fluid	market for ethylene glycol	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
Carbon black	market for carbon black	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Cast aluminium	Aluminium ingot mix IAI 2019	GLO	2019	Sphera MLC 2024.2	3	4	2	1	1
	market for aluminium, cast alloy	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Cast iron	Cast iron part (automotive) – open energy inputs	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
	Electricity mix for manufacturing processes	GLO	2024	See Table 22 and 23	1	4	2	1	1
	Thermal energy from hard coal	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
	Thermal energy from natural gas	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
Cathode active material (NMC111)	market for cathode, NMC111, for Li-ion battery	RoW	2023	ecoinvent 3.10.1	1	4	2	1	1
Coolant /other glycols	market for ethylene glycol	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
Copper	market for copper, cathode	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Copper alloys	market for brass	CH	2024	ecoinvent 3.11	1	3	2	1	1
	market for bronze	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for copper, cathode	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	Nickel (Class 1, >99.8% Nickel) (Nickel Institute)	GLO	2020	Sphera MLC 2024.2	2	4	2	1	1

Material	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Copper collector foil, for Li-ion battery	market for copper collector foil, for Li-ion battery	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Copper, recycled	treatment of electronics scrap, metals recovery in copper smelter	RoW	2023	ecoinvent 3.10.1	1	4	2	1	1
Corrosion protective agent	market for lubricating oil	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
Cotton fibre	market for textile, woven cotton	GLO	2024	ecoinvent 3.11	1	4	2	1	1
E/P	market for calcium carbonate, precipitated	RER	2024	ecoinvent 3.11	1	3	2	1	1
	market for polyethylene, low density, granulate	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Elastomer	market for calcium carbonate, precipitated	RER	2024	ecoinvent 3.11	1	3	2	1	1
	market for carbon black	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
	market for lime	RoW	2023	ecoinvent 3.10.1	1	4	2	1	1
	market for polyethylene terephthalate, granulate, amorphous	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for synthetic rubber	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
	market for zinc oxide	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Electric connector	market for electric connector, peripheral component interconnect buss	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Electrolyte, for Li-ion battery	market for electrolyte, for Li-ion battery	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Engineering steel	market for steel, unalloyed	GLO	2024	ecoinvent 3.11	1	4	2	1	1
EPDM	market for synthetic rubber	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Epoxy resin	market for epoxy resin insulator, SiO2	GLO	2024	ecoinvent 3.11	1	4	2	1	1
EPP	market for polypropylene, granulate	GLO	2024	ecoinvent 3.11	1	4	4	1	1
EPS	market for polystyrene, expandable	GLO	2024	ecoinvent 3.11	1	4	2	1	1
EVAC	market for ethylene vinyl acetate copolymer	RER	2024	ecoinvent 3.11	1	3	2	1	1
Flat glass	market for flat glass, coated	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
Glass fibre (filler for polymers)	market for glass fibre	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Graphite	market for graphite	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Heavy computational signal electronics	Electronics type	GLO	2024	Sphera MLC 2024.2	1	4	4	1	1
Lacquers	market for polyurethane, rigid foam	RER	2024	ecoinvent 3.11	1	3	2	1	1
LDPE	market for polyethylene, low density, granulate	GLO	2024	ecoinvent 3.11	1	4	2	1	1

Material	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Lead	market for lead	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Light emitting diode	market for light emitting diode	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Magnesium	market for magnesium	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Mixed power/signal electronics	Electronics type	GLO	2024	Sphera MLC 2024.2	1	4	4	1	1
NBR	market for synthetic rubber	GLO	2023	ecoinvent 3.10.1	1	4	4	1	1
Neodymium Iron Boron (NdFeB)	market for permanent magnet, for electric motor	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
NF-PP	market for polypropylene, granulate	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for fibre, kenaf	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Nickel	Nickel (Class 1, >99.8% Nickel) (Nickel Institute)	GLO	2020	Sphera MLC 2024.2	2	4	2	1	1
NR	market for seal, natural rubber based	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Optoelectronics/displays	Electronics type	GLO and CN	2024	Sphera MLC 2024.2	1	4	4	1	1
Other duromers – epoxy	market for epoxy resin, liquid	RER	2024	ecoinvent 3.11	1	3	2	1	1
PA	market for nylon 6	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
PA6	market for nylon 6	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
PA66	market for nylon 6-6	RER	2024	ecoinvent 3.11	1	3	2	1	1
Paraffin	market for paraffin	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
PBT	Polybutylene terephthalate granulate (PBT) mix	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
PC	market for polycarbonate	RER	2024	ecoinvent 3.11	1	3	2	1	1
PC+ABS	market for acrylonitrile-butadiene-styrene copolymer	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for polycarbonate	RER	2024	ecoinvent 3.11	1	3	2	1	1
PE	market for polyethylene, low density, granulate	GLO	2024	ecoinvent 3.11	1	4	2	1	1
PE separator	PE separator	CN	2019	Renshu Y. et al., 2019	3	3	2	1	1
PET	market for polyethylene terephthalate, granulate, amorphous	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Plastics (in polymeric compounds)	market for nylon 6	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
PMMA	market for polymethyl methacrylate	RER	2024	ecoinvent 3.11	1	3	2	1	1
Polymers (all categories), recycled	market for plastic granulate, unspecified, recycled	IN	2023	ecoinvent 3.10.1	1	4	3	1	1

Material	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Polyester textile	market for fibre, polyester	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Polyurethane	market for polyurethane, rigid foam	RER	2024	ecoinvent 3.11	1	3	2	1	1
POM	market for fibre, polyester	GLO	2024	ecoinvent 3.10.1	1	4	2	1	1
	market for polyvinyl chloride, suspension polymerised	RER	2024	ecoinvent 3.11	1	3	2	1	1
Populated PCB SMT 1 – 13% IC containing lead	market for printed wiring board, mounted mainboard, desktop computer, Pb containing	GLO	2023	ecoinvent 3.10.1	1	4	4	1	1
Power electronics (PCBA)	Electronics type	GLO	2024	Sphera MLC 2024.2	1	4	4	1	1
PP	market for polypropylene, granulate	GLO	2024	ecoinvent 3.11	1	4	2	1	1
PPA	market for nylon 6	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
PS	market for polystyrene, expandable	GLO	2024	ecoinvent 3.11	1	4	2	1	1
PVB	Polyvinyl butyral granulate (PVB) by-product ethyl acetate	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
PVC	market for polyvinyl chloride, suspension polymerised	RER	2024	ecoinvent 3.11	1	3	2	1	1
R-1234yf	production of R-1234yf	GB	2013	ICCT, 2013	4	3	2	1	1
SBR	Styrene-butadiene rubber (S-SBR) mix	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
Silica sand	market for silica sand	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Silicone rubber	market for silicone product	RER	2024	ecoinvent 3.11	1	3	2	1	1
	market for synthetic rubber	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1
Sintered and other steel	market for steel, unalloyed	GLO	2024	ecoinvent 3.11	1	4	3	1	1
Steel BF-BOF, recycled	BF- BOF steel billet 100% RC, Responsible Steel level 1	GLO	2024	Responsible Steel, 2024	1	4	2	1	1
Steel sheet	market for steel, unalloyed	GLO	2024	ecoinvent 3.11	1	4	3	1	1
Steel sheet – Hot rolled	market for steel, unalloyed	GLO	2024	ecoinvent 3.11	1	4	3	1	1
Steel, Stainless, Austenitic	Stainless steel cold rolled (304)	RER	2019	Eurofer 2019	3	3	2	1	1
Steel, Stainless, Ferritic	Stainless steel cold rolled (430)	RER	2019	Eurofer 2019	3	3	2	1	1
Steel, Unalloyed	market for steel, unalloyed	GLO	2024	ecoinvent 3.11	1	4	3	1	1
Talc (filler for polymers)	market for dolomite	RER	2023	ecoinvent 3.10.1	1	3	2	1	1
	market for silica sand	GLO	2023	ecoinvent 3.10.1	1	4	2	1	1

Material	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Thermoplastic elastomers	market for polypropylene, granulate	GLO	2024	ecoinvent 3.11	1	4	4	1	1
	market for synthetic rubber	GLO	2023	ecoinvent 3.10.1	1	4	4	1	1
Unsaturated polyester	market for isophthalic acid based unsaturated polyester resin	RER	2024	ecoinvent 3.11	1	3	2	1	1
Washer fluid	market for ethanol, without water, in 99.7% solution state, from fermentation, vehicle grade	RoW	2023	ecoinvent 3.10.1	1	3	4	1	1
Wood fibre	market for cellulose fibre	CH	2024	ecoinvent 3.11	1	3	2	1	1
Zinc coating	market for zinc, coils	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Supplier specific component data			2025	Supplier data	1	1	1	1	2

Table 28 Data quality assessment, manufacturing.

Material group	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Aluminium sheet	market for sheet rolling, aluminium	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	Aluminium sheet deep drawing	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
	Aluminium sheet – open input aluminium rolling ingot	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23	1	4	2	1	1
Aluminium sheet, low-emission – Europe	sheet rolling, aluminium	RER	2024	ecoinvent 3.11	1	3	2	1	1
	Aluminium sheet deep drawing	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
	Aluminium sheet – open input aluminium rolling ingot	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
	Electricity mix for manufacturing processes	GLO	N/A	See Table 22 and 23	1	4	2	1	1
Carbon black	Vulcanisation of synthetic rubber (without additives)	GLO	2024	Sphera MLC 2024.2	1	4	4	1	1
Cast aluminium	Aluminium die-cast part	DE	2024	Sphera MLC 2024.2	1	3	2	1	1
	Electricity mix for manufacturing processes	GLO	2024	See Table 22 and 23	1	4	2	1	1
	Process steam from natural gas 95%	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
	Process steam from hard coal 95%	RER	2024	Sphera MLC 2024.2	1	3	2	1	1
Copper	market for wire drawing, copper	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Cotton fibre	market for injection moulding	GLO	2024	ecoinvent 3.11	1	4	4	1	1
Engineering steel	market for hot rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for forging, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Engineering steel – General engineering and structural steel	market for hot rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Glass fibre (filler for polymers)	market for injection moulding	GLO	2024	ecoinvent 3.11	1	4	4	1	1
Lacquers	market for injection moulding	GLO	2024	ecoinvent 3.11	1	4	4	1	1

Material group	LCI dataset	Region	Year	Source	Time	Geo.	Tech.	Repr.	Prec.
Lead	Steel cast part alloyed (automotive)	DE	2024	Sphera MLC 2024.2	1	3	4	1	1
	Global electricity mix production 2024	GLO	2024	IEA	1	4	4	1	1
	Thermal energy from hard coal	RER	2024	Sphera MLC 2024.2	1	3	4	1	1
	Thermal energy from natural gas	RER	2024	Sphera MLC 2024.2	1	3	4	1	1
Magnesium	magnesium casting process	Not identified	2020	German Aerospace Center e.V., 2020	2	5	2	1	1
Polymers (all categories) manufacturing	market for injection moulding	GLO	2024	ecoinvent 3.11	1	4	4	1	1
SBR	Vulcanisation of synthetic rubber (without additives)	GLO	2024	Sphera MLC 2024.2	1	4	2	1	1
Sintered and other steel	market for hot rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for sheet rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Steel sheet	market for hot rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for sheet rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Steel sheet – Hot rolled	market for hot rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
	market for sheet rolling, steel	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Steel, Stainless, Austenitic	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Steel, Stainless, Ferritic	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	2	1	1
Wood fibre	market for injection moulding	GLO	2024	ecoinvent 3.11	1	4	4	1	1
Zinc coatings	market for deep drawing, steel, 10000 kN press, single stroke	GLO	2024	ecoinvent 3.11	1	4	4	1	1

Table 29 *Quality assessment score summary of quality assessed data.*

Life cycle stage of data	Time	Geo.	Tech.	Repr.	Prec.
Raw material extraction, refining and part manufacturing	1–5	1–5	1–5	1	1
Part and vehicle manufacturing	1	1	1	1–3	1
Inbound and outbound logistics	1	1	2	1	2
Driving	1	2	1	1–2	2
Maintenance	1–5	1–5	1–5	1	2
End-of-life	4	3	3	5	4

Appendix 5 – Maintenance

Table 30 *Parts replaced due to routine vehicle maintenance, and number of replacements.*

Part	150,000 km	200,000 km	250,000 km	300,000 km
Wiper blade	30	39	48	60
Tyres	12	16	24	28
Brake fluid (l)	3	4.2	5	6
Brake pads	4	4	8	8
Brake discs	0	0	0	2
12 V Battery	2	3	4	5
Steering joint	0	1	1	1
Link arm	2	2	2	4
Condenser	0	1	1	1
AC fluid	1.5	2	2.5	3
Cabin filter	9	12	15	18

Appendix 6 – Global warming potential characterisation factors

The Sixth Assessment Report (AR6) published by the Intergovernmental Panel on Climate Change (IPCC) lists various properties for greenhouse gasses in Working Group I (WGI) Chapter 7 Supplementary Material, Table 7.SM.7. Characterisation factors for GWP-100 from it is presented in Table 31.

Table 31 *GWP-100 characterisation factors from AR6.*

Name	Acronym	Formula	GWP-100
Carbon dioxide		CO2	1
Methane, fossil (from Table 7.15 in AR6 WGI)		CH4	29.8
Methane, non-fossil (from Table 7.15 in AR6 WGI)		CH4	27
Nitrous oxide		N2O	273
Trichlorofluoromethane	CFC-11	CCl3F	6230
Dichlorodifluoromethane	CFC-12	CCl2F2	12500
Chlorotrifluoromethane	CFC-13	CClF3	16200
1,1,2,2-tetrachloro-1,2-difluoroethane	CFC-112	CCl2FCCl2F	4620
1,1,1,2-tetrachloro-2,2-difluoroethane	CFC-112a	CCl3CClF2	3550
1,1,2-trichloro-1,2,2-trifluoroethane	CFC-113	CCl2FCClF2	6520
1,1,1-trichloro-2,2,2-trifluoroethane	CFC-113a	CCl3CF3	3930
1,2-dichloro-1,1,2,2-tetrafluoroethane	CFC-114	CClF2CClF2	9430
1,1-dichloro-1,2,2,2-tetrafluoroethane	CFC-114a	CCl2FCF3	7420
1-chloro-1,1,2,2,2-pentafluoroethane	CFC-115	CClF2CF3	9600
(1s,2s)-1,2-dichloro-1,2,3,3,4,4-hexafluorocyclobutane	E-R316c	trans cyc (-CClFCF2CF2CClF-)	4230
(1r,2s)-1,2-dichloro-1,2,3,3,4,4-hexafluorocyclobutane	Z-R316c	cis cyc (-CClFCF2CF2CClF-)	5660
(e)-1,2-dichloro-1,2-difluoroethene	CFC 1112	CClF=CClF	0.126

Name	Acronym	Formula	GWP-100
1,1-dichloro-2,2-difluoroethene	CFC 1112a	CCl2=CF2	0.021
Dichlorofluoromethane	HCFC-21	CHCl2F	160
Chlorodifluoromethane	HCFC-22	CHClF2	1960
Chlorofluoromethane	HCFC-31	CH2ClF	79.4
1,1,2,2-tetrachloro-1-fluoroethane	HCFC-121	CHCl2CCl2F	58.3
1,2,2-trichloro-1,1-difluoroethane	HCFC-122	CHCl2CClF2	56.4
1,1,2-trichloro-1,2-difluoroethane	HCFC-122a	CHClFCCl2F	245
2,2-dichloro-1,1,1-trifluoroethane	HCFC-123	CHCl2CF3	90.4
1,2-dichloro-1,1,2-trifluoroethane	HCFC-123a	CHClFCClF2	395
2-chloro-1,1,1,2-tetrafluoroethane	HCFC-124	CHClFCF3	597
1-chloro-1,1,2,2-tetrafluoroethane	HCFC-124a	CHF2CClF2	2070
1,2-dichloro-1,2-difluoroethane	HCFC-132	CHClFCHClF	122
1,1-dichloro-2,2-difluoroethane	HCFC-132a	CHCl2CHF2	70.4
1,1-dichloro-1,2-difluoroethane	HCFC-132c	CH2FCCl2F	342
2-chloro-1,1,1-trifluoroethane	HCFC-133a	CH2ClCF3	388
1,2-dichloro-1-fluoroethane	HCFC-141	CH2ClCHClF	46.6
1,1-dichloro-1-fluoroethane	HCFC-141b	CH3CCl2F	860
1-chloro-1,1-difluoroethane	HCFC-142b	CH3CClF2	2300
3,3-dichloro-1,1,1,2,2-pentafluoropropane	HCFC-225ca	CHCl2CF2CF3	137
1,3-dichloro-1,1,2,2,3-pentafluoropropane	HCFC-225cb	CHClFCF2CClF2	568
(e)-1-chloro-3,3,3-trifluoroprop-1-ene	HCFO-1233zd(E)	(E)-CF3CH=CHCl	3.88
1-chloro-3,3,3-trifluoroprop-1-ene	HCFO-1233zd(Z)	(Z)-CF3CH=CHCl	0.454
(e)-1-chloro-2-fluoroethene		(E/Z)-CHCl=CHF	0.004
Trifluoromethane	HFC-23	CHF3	14600
Difluoromethane	HFC-32	CH2F2	771
Fluoromethane	HFC-41	CH3F	135
1,1,1,2,2-pentafluoroethane	HFC-125	CHF2CF3	3740

Name	Acronym	Formula	GWP-100
1,1,2,2-tetrafluoroethane	HFC-134	CHF2CHF2	1260
1,1,1,2-tetrafluoroethane	HFC-134a	CH2FCF3	1530
1,1,2-trifluoroethane	HFC-143	CH2FCHF2	364
1,1,1-trifluoroethane	HFC-143a	CH3CF3	5810
1,2-difluoroethane	HFC-152	CH2FCH2F	21.5
1,1-difluoroethane	HFC-152a	CH3CHF2	164
Fluoroethane	HFC-161	CH3CH2F	4.84
1,1,1,2,2,3,3-heptafluoropropane	HFC-227ca	CF3CF2CHF2	2980
1,1,1,2,3,3,3-heptafluoropropane	HFC-227ea	CF3CHFCF3	3600
1,1,1,2,2,3-hexafluoropropane	HFC-236cb	CH2FCF2CF3	1350
1,1,1,2,3,3-hexafluoropropane	HFC-236ea	CHF2CHFCF3	1500
1,1,1,3,3,3-hexafluoropropane	HFC-236fa	CF3CH2CF3	8690
1,1,2,2,3-pentafluoropropane	HFC-245ca	CH2FCF2CHF2	787
1,1,1,2,2-pentafluoropropane	HFC-245cb	CF3CF2CH3	4550
1,1,2,3,3-pentafluoropropane	HFC-245ea	CHF2CHFCHF2	255
1,1,1,2,3-pentafluoropropane	HFC-245eb	CH2FCHFCF3	325
1,1,1,3,3-pentafluoropropane	HFC-245fa	CHF2CH2CF3	962
1,1,1-trifluoropropane	HFC-263fb	CH3CH2CF3	74.8
2,2-difluoropropane	HFC-272ca	CH3CF2CH3	599
1,1,1,2,2,3,3,4,4-nonafluorobutane	HFC-329p	CHF2CF2CF2CF3	2890
1,1,1,3,3-pentafluorobutane	HFC-365mfc	CH3CF2CH2CF3	914
1,1,1,2,2,3,4,5,5,5-decafluoropentane	HFC-43-10mee	CF3CHFCHFCF2CF3	1600
Trifluoroethylene	HFO-1123	CHF=CF2	0.005
1,1-difluoroethene	HFO-1132a	CH2=CF2	0.052
Fluoroethene	HFO-1141	CH2=CHF	0.024
(z)-1,2,3,3,3-pentafluoroprop-1-ene	HFO-1225ye(Z)	(Z)-CF3CF=CHF	0.344
(e)-1,2,3,3,3-pentafluoroprop-1-ene	HFO-1225ye(E)	(E)-CF3CF=CHF	0.118

Name	Acronym	Formula	GWP-100
(z)-1,3,3,3-tetrafluoroprop-1-ene	HFO-1234ze(Z)	(Z)-CF3CH=CHF	0.315
(e)-1,3,3,3-tetrafluoroprop-1-ene	HFO-1234ze(E)	(E)-CF3CH=CHF	1.37
2,3,3,3-tetrafluoroprop-1-ene	HFO-1234yf	CF3CF=CH2	0.501
(e)-1,1,1,4,4,4-hexafluorobut-2-ene	HFO-1336mzz(E)	(E)-CF3CH=CHCF3	17.9
(z)-1,1,1,4,4,4-hexafluorobut-2-ene	HFO-1336mzz(Z)	(Z)-CF3CH=CHCF3	2.08
3,3,3-trifluoroprop-1-ene	HFO-1243zf	CF3CH=CH2	0.261
3,3,4,4,4-pentafluorobut-1-ene	HFO-1345zfc	CF3CF2CH=CH2	0.182
3,3,4,4,5,5,6,6,6-nonafluorohex-1-ene		n-C4F9CH=CH2	0.204
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooct-1-ene		n-C6F13CH=CH2	0.162
3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluorodec-1-ene		n-C8F17CH=CH2	0.141
3,3,3-trifluoro-2-(trifluoromethyl)prop-1-ene		(CF3)2C=CH2	0.377
1,1,2,2,3,3-hexafluorocyclopentane		cyc (-CF2CF2CF2CH2CH2-)	120
1,1,2,2,3,3,4-heptafluorocyclopentane		cyc (-CF2CF2CF2CHFCH2-)	231
1,3,3,4,4,5,5-heptafluorocyclopentene		cyc (-CF2CF2CF2CF=CH-)	45.1
(4s,5s)-1,1,2,2,3,3,4,5-octafluorocyclopentane		trans-cyc (-CF2CF2CF2CHFCHF-)	258
(e)-1,3,4,4,4-pentafluoro-3-(trifluoromethyl)but-1-ene	HFO-1438ezy(E)	(E)-(CF3)2CFCH=CHF	8.22
3,3,4,4,5,5,5-heptafluoropent-1-ene	HFO-1447fz	CF3(CF2)2CH=CH2	0.235
1,3,3,4,4-pentafluorocyclobutene		cyc (-CH=CFCF2CF2-)	92.4
3,3,4,4-tetrafluorocyclobutene		cyc (-CH=CHCF2CF2-)	25.6
1,1,1-trichloroethane	Methyl chloroform	CH3CCl3	161
Tetrachloromethane	Carbon tetrachloride	CCl4	2200
Chloromethane	Methyl chloride	CH3Cl	5.54
Dichloromethane	Methylene chloride	CH2Cl2	11.2
Trichloromethane	Chloroform	CHCl3	20.6
Chloroethane		CH3CH2Cl	0.481
1,2-dichloroethane		CH2ClCH2Cl	1.3

Name	Acronym	Formula	GWP-100
1,1,2-trichloroethene		CHCl=CCl2	0.044
1,1,2,2-tetrachloroethene		CCl2=CCl2	6.34
2-chloropropane		CH3CHClCH3	0.181
1-chlorobutane		CH3(CH2)2CH2Cl	0.007
Bromomethane	Methyl bromide	CH3Br	2.43
Dibromomethane	Methylene bromide	CH2Br2	1.51
Bromodifluoromethane	Halon-1201	CHBrF2	380
Dibromodifluoromethane	Halon-1202	CBr2F2	216
Bromochlorodifluoromethane	Halon-1211	CBrClF2	1930
Bromotrifluoromethane	Halon-1301	CBrF3	7200
2-bromo-1,1,1-trifluoroethane	Halon-2301	CH2BrCF3	177
2-bromo-2-chloro-1,1,1-trifluoroethane	Halon-2311	CHBrClCF3	45
2-bromo-1,1,1,2-tetrafluoroethane	Halon-2401	CHBrFCF3	201
1,2-dibromo-1,1,2,2-tetrafluoroethane	Halon-2402	CBrF2CBrF2	2170
Tribromomethane		CHBr3	0.25
Bromochloromethane	Halon-1011	CH2BrCl	4.74
Bromoethane		CH3CH2Br	0.487
1,2-dibromoethane	EDB	CH2BrCH2Br	1.02
1-bromopropane		CH3CH2CH2Br	0.052
2-bromopropane		CH3CHBrCH3	0.126
Nitrogen trifluoride		NF3	17400
Pentadecafluorotriethylamine		N(C2F5)3	10300
Perfluorotripropylamine	PTPA	N(CF2CF2CF3)3	9030
Heptacosafluorotributylamine	PFTBA	N(CF2CF2CF2CF3)3	8490
Perfluorotripentylamine		N(CF2CF2CF2CF2CF3)3	7260
Heptafluoroisobutyronitrile		(CF3)2CFCN	2750
Sulfur hexafluoride		SF6	25200

Name	Acronym	Formula	GWP-100
Pentafluoro(trifluoromethyl)-lambda6-sulfane		SF5CF3	18500
Sulfuryl fluoride		SO2F2	4630
Tetrafluoromethane	PFC-14	CF4	7380
Hexafluoroethane	PFC-116	C2F6	12400
Octafluoropropane	PFC-218	C3F8	9290
Hexafluorocyclobutene		cyc (-CF=CFCF2CF2-)	126
Octafluorocyclobutane	PFC-C-318	cyc (-CF2CF2CF2CF2-)	10200
Decafluorobutane	PFC-31-10	n-C4F10	10000
Octafluorocyclopentene		cyc (-CF2CF2CFCF2CF2-)	78.1
Dodecafluoropentane	PFC-41-12	n-C5F12	9220
Tetradecafluorohexane	PFC-51-14	n-C6F14	8620
Hexadecafluoroheptane	PFC-61-16	n-C7F16	8410
Octadecafluorooctane	PFC-71-18	n-C8F18	8260
1,1,2,2,3,3,4,4,4a,5,5,6,6,7,7,8,8,8a-octadecafluoronaphthalene	PFC-91-18	C10F18	7480
1,1,2,2,3,3,4,4,4a,5,5,6,6,7,7,8,8,8a-octadecafluoronaphthalene		Z-C10F18	7800
1,1,2,2,3,3,4,4,4a,5,5,6,6,7,7,8,8,8a-octadecafluoronaphthalene		E-C10F18	7120
1,1,2,2-tetrafluoroethene	PFC-1114	CF2=CF2	0.004
1,1,2,3,3,3-hexafluoroprop-1-ene	PFC-1216	CF3CF=CF2	0.09
1,1,2,3,4,4-hexafluorobuta-1,3-diene		CF2=CFCF=CF2	0.004
Octafluoro-1-butene		CF3CF2CF=CF2	0.102
Octafluoro-2-buene		CF3CF=CFCF3	1.97
Difluoromethoxy(trifluoro)methane	HFE-125	CHF2OCF3	14300
Difluoromethoxy(difluoro)methane	HFE-134	CHF2OCHF2	6630
Trifluoro(methoxy)methane	HFE-143a	CH3OCF3	616
1,1,1,2-tetrafluoro-2-(trifluoromethoxy)ethane	HFE-227ea	CF3CHFOCF3	7520
2-chloro-1-(difluoromethoxy)-1,1,2-trifluoroethane	HCFE-235ca2	CHF2OCF2CHFCl	654
2-chloro-2-(difluoromethoxy)-1,1,1-trifluoroethane	HCFE-235da2	CHF2OCHClCF3	539

Name	Acronym	Formula	GWP-100
2-(difluoromethoxy)-1,1,1,2-tetrafluoroethane	HFE-236ea2	CHF2OCHFCF3	2590
1,1,1-trifluoro-2-(trifluoromethoxy)ethane	HFE-236fa	CF3CH2OCF3	1100
1,1,1,2,2-pentafluoro-2-methoxyethane	HFE-245cb2	CF3CF2OCH3	747
1,1-difluoro-2-(trifluoromethoxy)ethane	HFE-245fa1	CHF2CH2OCF3	934
2-(difluoromethoxy)-1,1,1-trifluoroethane	HFE-245fa2	CHF2OCH2CF3	878
2,2,3,3,3-pentafluoropropan-1-ol		CF3CF2CH2OH	34.3
1,1,2,2-tetrafluoro-1-methoxyethane	HFE-254cb1	CH3OCF2CHF2	328
1,1,1-trifluoro-2-methoxyethane	HFE-263mf	CF3CH2OCH3	2.06
Trifluoromethoxyethane	HFE-263m1	CF3OCH2CH3	29.2
3,3,3-trifluoropropan-1-ol		CF3CH2CH2OH	0.62
1,1,1,2,2-pentafluoro-2-(1,1,2,2-tetrafluoroethoxy)ethane	HFE-329mcc2	CHF2CF2OCF2CF3	3770
2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane	HFE-338mmz1	(CF3)2CHOCHF2	3040
1,1,1,2,2-pentafluoro-2-(2,2,2-trifluoroethoxy)ethane	HFE-338mcf2	CF3CH2OCF2CF3	1040
1,1,1,3,3,3-hexafluoro-2-(fluoromethoxy)propane	HFE-347mmz1	(CF3)2CHOCH2F	195
1,1,1,2,2,3,3-heptafluoro-3-methoxypropane	HFE-347mcc3	CH3OCF2CF2CF3	576
1-(2,2-difluoroethoxy)-1,1,2,2,2-pentafluoroethane	HFE-347mcf2	CHF2CH2OCF2CF3	963
1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane	HFE-347pcf2	CHF2CF2OCH2CF3	980
1,1,1,2,3,3,3-heptafluoro-2-methoxypropane	HFE-347mmy1	(CF3)2CFOCH3	392
1,1,1,2,3,3-hexafluoro-3-methoxypropane	HFE-356mec3	CH3OCF2CHFCF3	264
1,1,1-trifluoro-2-(2,2,2-trifluoroethoxy)ethane	HFE-356mff2	CF3CH2OCH2CF3	24.4
1-(2,2-difluoroethoxy)-1,1,2,2-tetrafluoroethane	HFE-356pcf2	CHF2CH2OCF2CHF2	831
3-(difluoromethoxy)-1,1,2,2-tetrafluoropropane	HFE-356pcf3	CHF2OCH2CF2CHF2	484
1,1,2,2,3,3-hexafluoro-1-methoxypropane	HFE-356pcc3	CH3OCF2CF2CHF2	277
1,1,1,3,3,3-hexafluoro-2-methoxypropane	HFE-356mmz1	(CF3)2CHOCH3	8.13
1,1,1,2,2-pentafluoro-3-methoxypropane	HFE-365mcf3	CF3CF2CH2OCH3	1.6
1-ethoxy-1,1,2,2-tetrafluoroethane	HFE-374pc2	CHF2CF2OCH2CH3	12.5
4,4,4-trifluorobutan-1-ol		CF3(CH2)2CH2OH	0.049

Name	Acronym	Formula	GWP-100
2,2,3,3,4,4,5,5-octafluorocyclopentan-1-ol		cyc (-(CF2)4CH(OH)-)	13.6
1-(difluoromethoxy)-2-[difluoromethoxy(difluoro)methoxy]-1,1,2,2-tetrafluoroethane	HFE-43-10pccc124	CHF2OCF2OCF2CF2OCHF2	3220
1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane	HFE-449s1	C4F9OCH3	460
1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane	n-HFE-7100	CF3CF2CF2CF2OCH3	544
2-(difluoromethoxymethyl)-1,1,1,2,3,3,3-heptafluoropropane	i-HFE-7100	(CF3)2CFCF2OCH3	437
1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane	HFE-569sf2	C4F9OC2H5	60.7
1-ethoxy-1,1,2,3,3,3-hexafluoro-2-(trifluoromethyl)propane	i-HFE-7200	(CF3)2CFCF2OCH2CH3	34.3
1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane	HFE-7300	(CF3)2CFCFOC2H5CF2CF2CF3	405
4-ethoxy-1,1,1,2,2,3,3,4,5,6,6,6-dodecafluoro-5-(trifluoromethyl) hexane	HFE-7500	n-C3F7CFOC2H5CF(CF3)2	13
Bis(difluoromethoxy)-difluoromethane	HFE-236ca12	CHF2OCF2OCHF2	6060
1,2-bis(difluoromethoxy)-1,1,2,2-tetrafluoroethane	HFE-338pcc13	CHF2OCF2CF2OCHF2	3320
1,1,1,3,3,3-hexafluoropropan-2-ol	HFIP	(CF3)2CHOH	206
1-(difluoromethoxy)-2-[2-(difluoromethoxy)-1,1,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoroethane	HG-02	CHF2(OCF2CF2)2OCHF2	5730
1,1,3,3,4,4,6,6,7,7,9,9,10,10,12,12-hexadecafluoro-2,5,8,11-tetraoxadodecane	HG-03	CHF2(OCF2CF2)3OCHF2	5350
2-ethenoxy-1,1,1-trifluoroethane	Fluroxene	CF3CH2OCH=CH2	0.058
2-ethoxy-3,3,4,4,5-pentafluorotetrahydro-2,5-bis[1,2,2,2-tetrafluoro-1-(trifluoromethyl)ethyl]-furan		C12H5F19O2	48.7
Difluoro(methoxy)methane		CH3OCHF2	136
1,1,2,2-tetrafluoro-1,2-dimethoxyethane	HG'-01	CH3OCF2CF2OCH3	202
1,1,2,2-Tetrafluoro-1-methoxyethane	HG'-02	CH3O(CF2CF2O)2CH3	229
1,1,2,2-tetrafluoro-1-methoxy-2-[1,1,2,2-tetrafluoro-2-(1,1,2,2-tetrafluoro-2-methoxyethoxy)ethoxy]ethane	HG'-03	CH3O(CF2CF2O)3CH3	219
1,1,1,2,3,3-hexafluoro-3-(trifluoromethoxy)propane	HFE-329me3	CF3CFHCF2OCF3	4390
3,3,4,4,5,5,6,6,7,7,7-undecafluoroheptan-1-ol		CF3(CF2)4CH2CH2OH	0.533
3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-pentadecafluorononan-1-ol		CF3(CF2)6CH2CH2OH	0.449
3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,11-nonadecafluoroundecan-1-ol		CF3(CF2)8CH2CH2OH	0.273

Name	Acronym	Formula	GWP-100
2-chloro-1,1,2-trifluoro-1-methoxyethane		CH3OCF2CHClF	136
1-(difluoro(trifluoromethoxy)methoxy)-1,1,2,3,3,3-hexafluoro-2-(trifluoromethoxy)propane	PFPMIE	CF3OCFCF3CF2OCF2OCF3	10300
1,1,2-trifluoro-2-(trifluoromethoxy)ethene	HFE-216	CF3OCF=CF2	0.01
Perfluoroethyl formate		CF3CF2OCHO	597
2,2,2-trifluoroethyl formate		CF3CH2OCHO	54.8
Formic acid;1,1,1,3,3,3-hexafluoropropan-2-ol		(CF3)2CHOCHO	269
Ethenyl 2,2,2-trifluoroacetate		CF3COOCH=CH2	0.008
Ethyl 2,2,2-trifluoroacetate		CF3COOCH2CH3	1.58
Prop-2-enyl 2,2,2-trifluoroacetate		CF3COOCH2CH=CH2	0.007
Methyl 2,2,2-trifluoroacetate		CF3COOCH3	82.3
2,2,3,3,4,4,4-heptafluorobutan-1-ol		CF3CF2CF2CH2OH	36.5
1,1,2-trifluoro-2-(trifluoromethoxy)ethane		CHF2CHFOCF3	1260
1-ethoxy-1,1,2,3,3,3-hexafluoropropane		CF3CHFCF2OCH2CH3	26.4
1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane		CF3CF2CF2OCHFCF3	6630
2,2,3,3-tetrafluoropropan-1-ol		CHF2CF2CH2OH	14.4
2,2,3,4,4,4-hexafluorobutan-1-ol		CF3CHFCF2CH2OH	30.5
1,1,2,2-tetrafluoro-3-methoxypropane		CHF2CF2CH2OCH3	1.68
1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)pentan-3-one		CF3CF2COCF(CF3)2	0.114
3,3,3-trifluoropropanal		CF3CH2CHO	0.025
2-fluoroethanol		CH2FCH2OH	0.53
2,2-difluoroethanol		CHF2CH2OH	6.18
2,2,2-trifluoroethanol		CF3CH2OH	35.7
	HG-04	CHF2O(CF2CF2O)4CHF2	4380
Methyl-perfluoroheptene-ethers		CH3OC7F13	15.1
1,1,1-trifluoropropan-2-one		CF3COCH3	0.09
1,1,1-trifluorobutan-2-one		CF3COCH2CH3	0.095

Name	Acronym	Formula	GWP-100
1-chloro-2-ethenoxyethane	2ClEVE	ClCH2CH2OCH=CH2	0
Ethane		C2H6	0.437
Propane		C3H8	0.02
Butane		n-C4H10	0.006
2-methylpentan-3-one		CH3CH2COCH(CH3)2	0.2
Ethyl methyl ether		CH3CH2OCH3	0.01
2,2,3,3,4,4,5,5-octafluorooxolane	Octafluorooxolane	c-C4F8O	13900
Crotonaldehyde		CH3CH=CHCHO	0
Methyl vinyl ketone	MVK	CH3COCH=CH2	0
Allyl ether	AE	(CH2=CHCH2)2O	0
Allyl ethyl ether	AEE	CH3CH2OCH2CH=CH2	0
(z)-hex-2-en-1-ol		CH3CH2CH2CH=CHCH2OH	0.003
(e)-hex-2-en-1-ol		CH3CH2CH2CH=CHCH2OH	0.002
3-butenenitrile	Allyl cyanide	CH2=CHCH2CN	0
Hexamethyldisiloxane		C6H18OSi2	0.476
Octamethyltrisiloxane		C8H24O2Si3	0.325
Decamethyltetrasiloxane		C10H30O3Si4	0.176
Dodecamethylpentasiloxane		C12H36O4Si5	0.122
Hexamethylcyclotrisiloxane		C6H18O3Si3	1.15
Octamethylcyclotetrasiloxane		C8H24O4Si4	0.739
Decamethylcyclopentasiloxane		C10H30O5Si5	0.289
Dodecamethylcyclohexasiloxane		C12H36O6Si6	0.142

Appendix 7 – Critical review

Review statement letter.

Swedish Environmental Research Institute

Date	Your date
Gothenburg, January 2026	
Our reference.	Your reference
Håkan Stripple	Jonas Otterheim

Volvo Car Corporation
Jonas Otterheim
Assar Gabrielssons väg
SE-405 31 Göteborg
Sweden

Review of study: Carbon Footprint Report - Carbon footprint of the Volvo EX60

LCA/carbon footprint study for review and verification
Carbon Footprint Report - Carbon footprint of the Volvo EX60,
Version 1.0, 21 of January 2026

Authors
The LCA/carbon footprint study is performed by Rei Palm, Karl-Henrik Hagdahl, and Lisbeth Dahllöf at Global Sustainability Team at Volvo Cars.

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Study commissioned by:
Volvo Car Corporation, Sweden.
Swedish company registration number: 556074-3089

Date of the study:
21 of January 2026

Verifiers
Håkan Stripple and Julia Lindholm at IVL Swedish Environmental Research Institute Ltd. were the verifiers of this study. Håkan Stripple is an LCA reviewer and an independent individual verifier in the International EPD system[1].

[1] https://www.environdec.com/resources/verifiers

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Ownership and responsibility of the LCA/Carbon footprint study
Volvo Car Corporation (556074-3089), Sweden has the sole ownership, liability, and responsibility for the LCA/Carbon footprint study.

Background and Scope
The study under review concerns Volvo Cars' ongoing work on assessing and reporting the environmental performance of its battery electric vehicles (BEVs). Volvo Cars has, for an extended period, articulated ambitions related to sustainability, including long-term goals of reducing greenhouse gas (GHG) emissions, promoting circular economy principles, and ensuring responsible business practices. As part of its corporate strategy to transition to a fully electric vehicle portfolio, the company has committed to publishing a life cycle assessment (LCA) of the carbon footprint for each BEV model released.

The present report evaluates the carbon footprint of the fully electric Volvo EX60, scheduled to enter production in 2026. The assessment focuses on a rear-wheel-drive configuration equipped with an 83 kWh battery, which is anticipated to represent a commonly sold variant. Manufacturing of the EX60 involves three Volvo Cars production facilities in Sweden, located in Torslanda, Olofström, and Floby.

The assessment examines global warming potential (GWP), according to ISO 14067 guidelines with characterization factors determined by the Intergovernmental Panel on Climate Change (IPCC). The scope includes the cradle-to-grave vehicle life cycle, from extracting and refining raw materials to end-of-life treatment. The results are not directly comparable with those of other studies, except where the same methodology and assumptions have been applied.

The results are intended to be used internally and externally to increase knowledge about environmental impacts of Volvo Cars' products. Intended audience are thus Volvo Cars' employees as well as its customers and other stakeholders.

The task of the verifiers has been to review the study including layout and method used in the study, the LCA report of the study, the LCA model and calculations, the LCA background information, underlying data, and general calculations. Some plausibility checks regarding emissions and materials data were also included. The verification is performed in order to check and verify the calculations and validity of the system boundaries chosen and model defined, as well as consistency with the steering documents. In this case, the calculation method used are based on ISO 14067:2018.

Review process

Volvo Cars at Gothenburg, Sweden has developed this study and calculation method according to their procedures and with their updated internal databases covering their production as well as general LCA databases. The review was based on the written materials from the study (the LCA report) and sample checks of other materials. Thus, not all data and calculations were checked in detail. The review statement and conclusions are given with regard to the current state of art and the information, which has been received from Volvo Cars. The comments and corrections are documented directly in the documents. The information in the review process is thus traceable throughout the entire review process.

The report *Carbon Footprint Report - Carbon footprint of the Volvo EX60, Version 1.0, 21 of January 2026* was reviewed. The documentation was sent to the verifiers for review by e-mail. After reading and comments, the different remarks were discussed and commented by Volvo Cars personnel via internet.

The report explains the goal and scope, methodologies, and main assumptions. After discussions and request in the review process, including editorial aspects and layout, methodology of the study, completeness of the study, choice of vehicle, bill of material (BOM) for the vehicle, functional unit, electric drive line including battery, maintenance of the vehicle (standard service used and no battery change during lifetime of the vehicle), electric break charging, end-of-life/recycling of the vehicle including battery, calculations for the use phase using Worldwide Harmonised Light Vehicle Test Procedure (WLTP), CO_2 and CO_2e (GWP) calculations, specific and generic data used, extended LCA information compared to EPD/PEF to give comprehensive environmental information, energy/electricity use as specific information, electricity mix used in the scenarios, electricity losses in the grid distribution system, and emission calculations, satisfactory changes were made.

The reviewer has checked the entire product chain including upstream data, core processes, and downstream data. The reviewer has checked the product specifications, the product systems and calculations, the data gaps and cut offs, the methodology applied, the data used, and assumptions made in the study, electricity production data, end-of-life treatment and the reasonableness of the data used and the results. The procedure for calculations and the selection of studied product has also been checked. The review process also includes minor editorial changes.

All remarks were accounted for in a satisfactory manner in the revised versions of the LCA calculations, LCA report, and comparative statements.

Statement

The verification covers the above-mentioned study *Carbon Footprint Report - Carbon footprint of the Volvo EX60, Version 1.0, 21 of January 2026*. The verifier verifies that the attached study LCA report is in consistency with the steering documents identified under the above-mentioned scope of this review and has relevant data sources and calculation methods. Also, the sample checks of methodology and calculations are reasonable and acceptable.

IVL Swedish Environmental Research Institute Ltd.

Håkan Stripple	Julia Lindholm
LCA expert and scientific reviewer	LCA expert automotive

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