2026-06-29

Life cycle assessment

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Carbon footprint report
Polestar 4 SUV

Produced in Busan, South Korea

Model year
2027

4

Disclaimer

This report is for information only and (1) is based solely on an analysis of Polestar 4 SUV (model year 2027, the first model year) and does not include information regarding any other Polestar vehicle and (2) does not include any commitments for current or future products or carbon footprint impacts. To get a complete understanding of the methodology used to calculate the carbon footprint in this report, it is recommended to read the present report in full.

The result of this study is dependent upon agreed and, by Polestar, validated information from Polestar's suppliers and sub-suppliers. During a vehicle program life there could arise changes and non-compliances within the supply chain, should such changes or non-compliances arise, Polestar will take corrective actions to achieve the results presented in this report.

List of abbreviations

ABS: Acrylonitrile Butadiene Styrene

BEV: Battery Electric Vehicle

BOM: Bill of Materials

CN: China

EoL: End-of-Life

GEC: Global Energy and Climate

GHG: Greenhouse Gas

GWP: Global Warming Potential

IEA: International Energy Agency

IMDS: International Material Data System

IPCC: Intergovernmental Panel on Climate Change

iPCA: iPoint compliance agent CA

LCA: Life Cycle Assessment

MUD: Material Utilisation Degree

NMC: Nickel Manganese Cobalt

OEM: Original Equipment Manufacturer

PC: Polycarbonate

PCB: Printed Circuit Board

PE: Polyethylene

PET: Polyethylene Terephthalate

PP: Polypropylene

RER: Europe

RNA: North America

RoW: Rest of World

STEPS: Stated Policies Scenario

WLTP: Worldwide Harmonized Light Vehicle Test Procedure

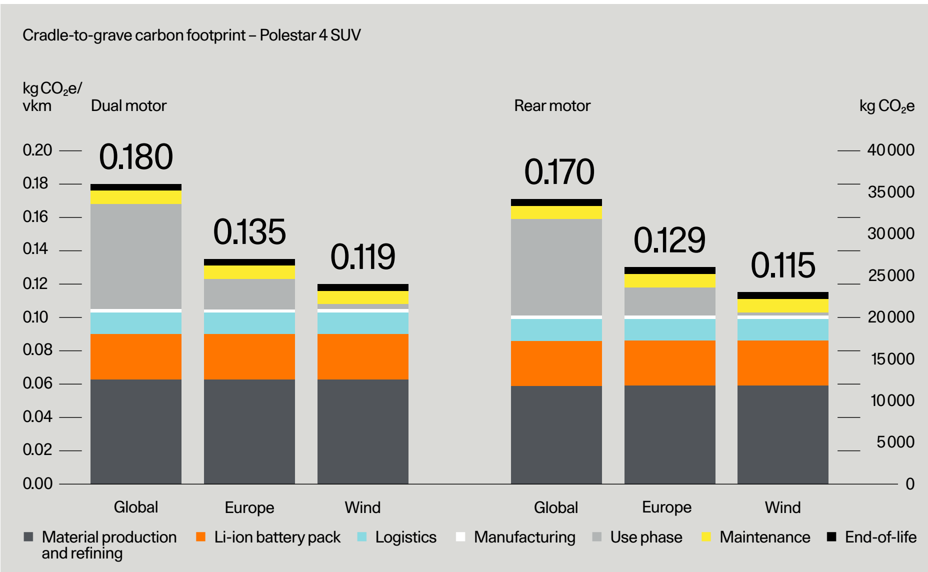
WTW: Well-to-Wheel

Polestar is dedicated to ensuring transparency regarding the environmental impact of its vehicles. This investigation aims to enhance openness by disclosing the carbon footprint associated with our passenger vehicles. The audience includes customers, Polestar employees, investors, automotive OEMs, and other stakeholders with an interest in the environmental performance of our vehicles.

The analysis conducted is a Life Cycle Assessment (LCA) focused exclusively on greenhouse gas (GHG) emissions, commonly referred to as a carbon footprint analysis. This assessment analyses the global warming potential (GWP) in accordance with ISO 14067 guidelines, utilising characterization factors established by the Intergovernmental Panel on Climate Change (IPCC, 2021). The scope of the study spans the entire life cycle of the vehicle, from the extraction and refinement of raw materials to the end-of-life stage.

This report estimates the carbon footprint of the Polestar 4 SUV, which enters manufacturing in the summer of 2026 at Renault Korea's Busan plant. The study considers a driving distance of 200 000 kilometres with a functional unit of "1 vehicle-kilometre". In general, this study adopts conservative assumptions to prevent underestimating the climate impact. There is presently no official standard for LCA for vehicles, thereby the findings of this study should be approached with caution when making comparisons with those of other OEMs. The study's objective is to comprehend the carbon footprint of the vehicle in its entire lifespan. The aim is to offer valuable insights that can help in making well-informed decisions for potential customers of Polestar vehicles but also identify opportunities of vehicle carbon footprint minimisation. From previous reports conducted by Polestar, aluminium production and battery pack manufacturing have been pointed out as highly contributing factors of greenhouse gas emissions in battery electric vehicles. Due to this, Polestar is actively working towards reducing these impacts.

In conclusion, the climate impact of the cradle-to-gate study reveals that 57.9% (Rear motor) - 59.7% (Dual motor) is due to the materials utilised in the vehicle's production (excluding battery pack), aluminium representing 37.2% (Rear motor) - 35.2% (Dual motor) of these materials emissions, and iron and steel contributing with 31.0% (Rear motor) - 31.5% (Dual motor). Following closely, the production of battery pack emerges as a significant factor, constituting 27.0% (Rear motor) - 25.9% (Dual motor) of the cradle-to-gate climate impact. More generally speaking, the battery pack climate impact as taken from the battery pack supplier LCA (though not explicitly given within this study) is considered to be relatively low in the industry: this is mainly due to the use of 100% renewable electricity in the cell production as well as the use of aluminium from smelters using renewable electricity combined with recycled aluminium in the battery pack structure. Of the cradle-to-gate emissions, 13.2% (Rear motor) - 12.6% (Dual motor) can be attributed to logistics and 1.9% (Rear motor) - 1.8% (Dual motor) to manufacturing of the vehicle (vehicle assembly).



← Figure 1

Total cradle-to-grave carbon footprint in kg CO_2e for the different electricity mixes. The axis to the left presents the functional unit of 1 vkm and the axis to the right presents the vehicle's lifetime of 200 000 km.

The results of the cradle-to-grave study, showed in figure 1, reveals a total carbon footprint for the complete life cycle of the Dual motor variant of 36.0 tonnes CO_2e (0.180 kg CO_2e/vkm) and 34.1 tonnes CO_2e (0.170 kg CO_2e/vkm) for the Rear motor variant, both with global electricity mix in the use phase. 34.3% (Rear motor) – 35.0% (Dual motor) of the total climate impact is due to the material production and refining (excluding the battery pack). Following this, the next highest share is for the use phase (global electricity mix) contributing 34.2% (Rear motor) – 35.2% (Dual motor) of the vehicle's total climate impact, and then the battery pack, constituting 16.0% (Rear motor) – 15.2% (Dual motor) of the overall climate impact.

Renewable energy sources, particularly wind power, demonstrate potential in reducing lifetime emissions during the use phase. Sensitivity analysis indicates a lower carbon footprint per kilometre for longer distances, emphasizing the importance of optimizing vehicle usage for sustainability. Promoting the prolonged use and lifespan of vehicles can be a strategic approach to curbing emissions. By extending the time a vehicle remains in service, the overall demand for new vehicles is reduced.

Key findings:

- The cradle-to-gate stage (from raw material production and refining up until the vehicle reaches the customer) for Polestar 4 SUV reveals a total carbon footprint of 21.1 tonnes CO_2e (0.106 kg CO_2e/vkm) for the Dual motor variant and 20.2 tonnes CO_2e (0.101 kg CO_2e/vkm) for the Rear motor variant. Materials utilised in the vehicle's production, excluding the battery pack, account for 59.7% of the cradle-to-gate impact for the Dual motor variant and 57.9% for Rear motor. The battery pack contribute significantly, accounting for 25.9% for Dual motor and 27.0% for Rear motor, while 12.6% is caused by logistics for Dual motor and 13.2% for Rear motor. Manufacturing (vehicle assembly) results in 1.8% for Dual motor and 1.9% for Rear motor.
- The cradle-to-grave life cycle assessment for Polestar 4 SUV, depicted in Figure 1, reveals a total carbon footprint of 36.0 tonnes CO_2e for the Dual motor variant and 34.1 tonnes CO_2e for the Rear motor variant, both with global electricity mix in the use phase. The same result using the functional unit is 0.180 kg CO_2e / vkm for the Dual motor variant and 0.170 kg CO_2e / vkm for the Rear motor variant. 34.3% (Rear motor)-35.0% (Dual motor) of the total climate impact is due to the material production and refining (excluding the battery pack). Following this, the next highest share is for the use phase (global electricity mix), contributing 34.2% (Rear motor)-35.2% (Dual motor) of the vehicle's total climate impact, and then the battery pack, constituting 15.2% (Dual motor)-16.0% (Rear motor) of the overall climate impact.
- Renewable energy sources, particularly wind power, demonstrate potential in minimising lifetime GHG emissions during the use phase. The sensitivity analysis indicates lower GHG emissions per vehicle kilometre for higher lifetime activity, meaning longer total driving distance, emphasising the importance of optimising vehicle usage.

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This chapter describes the methodology of the conducted life cycle assessment (LCA) study.

The product

Polestar only develops battery electric vehicles; the Polestar 2, Polestar 3, Polestar 4 coupé and Polestar 4 SUV). This study assesses the fifth BEV produced by Polestar, the Sport Utility Vehicle (SUV) Polestar 4 SUV. The study assesses the Polestar 4 SUV variants "Dual motor" and "Rear motor" produced by Renault Korea (hereafter referred to as Renault) factory in Busan, South Korea in 2026. Both variants are produced with several different alternative specifications/options. This study encompasses the specifications expected to have the largest sales volumes within the first year of production, based on Polestar's internal predictions on how customers will specify their vehicles. The vehicle characteristics of the vehicles assessed in this study are presented in Table 1. Polestar has previously released a vehicle called the "Polestar 4" however, from model year 2027 the previous vehicle called the "Polestar 4" (an SUV coupé) has been renamed the "Polestar 4 coupé" and the new SUV vehicle presented in this report has taken on the name "Polestar 4 SUV". These two different vehicles share most of its components, are very similar in terms of technical specifications and are produced in the same plants. They both share the same "vehicle platform", using industry terminology.

Table 1 →

Polestar 4 SUV vehicle characteristics.

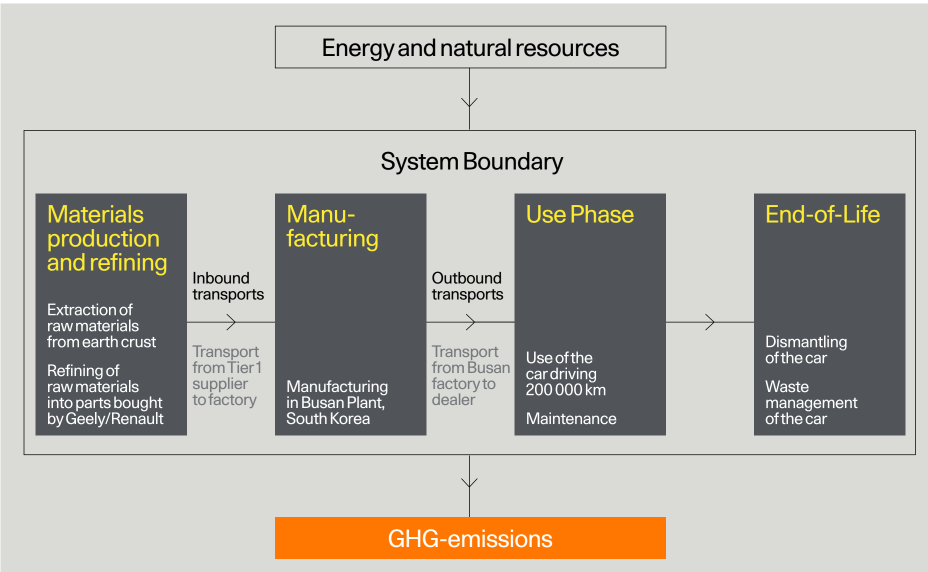
Polestar 4 SUV	Dual motor	Rear motor
Total weight vehicle	2 360 kg	2 238 kg
Li-ion battery cathode type and capacity	NMC, 100 kWh	NMC, 100 kWh
Battery Pack weight	589 kg	589 kg
Energy usage (WLTP[1])	19.0 kWh/100 km	17.5 kWh/100 km

The development of the methodology for this study was initiated jointly by Polestar and Volvo Cars Corporation when performing carbon footprint studies of Volvo XC40 Recharge and Polestar 2 in 2020. This methodology has been further developed by Polestar & Volvo Cars Corporation since then, notably in the 2024 Polestar 3 carbon footprint study, and now incorporates updates such as predicted future electricity mix in use phase, inclusion of emissions from maintenance and an updated functional unit. This will be further explained in the sections below.

Goal of study

Polestar has the ambition to become a climate neutral company by 2040 and strives to be transparent about the climate impact of Polestar vehicles. The goal of this study is to contribute to transparency by disclosing the carbon footprint of the two variants of Polestar 4 SUV. The purpose of the vehicle is to transport passengers and their belongings. The intended audience of this report are customers, employees at Polestar, investors, automotive

1 Worldwide Harmonised Light Vehicle Test Procedure



← Figure 2

System boundary of study.

OEMs (Original Equipment Manufacturers), and other stakeholders who are interested in the environmental performance of Polestar vehicles. The study was carried out to increase the knowledge about the carbon footprint of the Polestar 4 SUV, and which underlying materials and processes contribute the most to the climate impact. The aim is that this information will be utilised to make informed decisions, for example, on where to put effort in reducing greenhouse gas (GHG) emissions. This report forms the CFP study report. Its format covers four key sections which between them present the required information of a CFP report as per ISO 14067. This report is to be made public at Polestar's website from summer 2026.

Scope of study

The study has been performed according to the carbon footprint standard ISO 14067[2] and explores the global warming potential (GWP), using characterisation factors for 100-year global warming potential from the Intergovernmental Panel on Climate Change (IPCC, 2021), see Table 26 in Appendix 6. According to ISO 14067, emissions and removals in the following categories are included:

- Fossil GHG emissions and removals
- Biogenic GHG emissions and removals
- GHG emissions and removals from direct land use and land use change
- Aircraft GHG emissions

All GHG emissions and removals from the processes included in the study (see "Main assumptions and exclusions" and Figure 2) are quantified. No carbon offsetting is included. The study follows an attributional approach, i.e. it is not aimed at capturing systemic changes.

In the use phase, planned maintenance of the vehicle is considered, i.e. what is expected to be exchanged during the lifespan due to wear and tear of the vehicle is included, like change of tyres and windscreen wipers, but not changes due to accidents or other unexpected part failures which could affect only a very small percentage of vehicles. The datasets used to model the electricity consumption in the use phase include GHG emissions from electricity generation infrastructure, hence there is a climate impact associated with renewable electricity generation such as wind power.

The study includes the vehicle life cycle from cradle-to-grave, starting at the extraction and refining of raw materials and ending at the End-of-Life (EoL) of the vehicle (see Figure 2).

No cut-off criteria have been applied for the mass of the product content or energy use. In other words, the intent is that the included inventory together gives rise to the full carbon footprint and no flows have been cut-off. Mass that has not been declared as a specific material by the suppliers is still included but approximated by modelling it as polyamide (the polymer with the highest carbon footprint out of the polymer data used in the study). For more information on how this has been handled, see section 2.1 "Material production and refining".

The time boundary of the study is manufacturing of the vehicle in 2026 and operating the vehicle over 15 years from 2026 to 2040, after which EoL handling occurs. There are developments within vehicle LCA standards currently still in draft in the EU which indicate that the average lifetime of passenger

2 ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification

cars in the EU before scrappaging may have reached over 20 years. However, until such standards are finalised and in place, with the specific use period confirmed for these, Polestar will use a 15-year lifetime to retain consistency between Polestar vehicle carbon footprint studies. In general, the results contained within this report should not be compared to those from other vehicle studies, as methodological choices may differ between OEMs and practitioners.

The geographical boundary of the study is vehicle manufacturing in South Korea, and use of the vehicle in (i) the European Union (EU) and (ii) the world (i.e. average figures for the electricity mix in the EU and the world are used for the use phase in two different scenarios), and (iii) a scenario of using electricity generated from wind power. The EoL geographical system boundary is set to global. For upstream processes, i.e. before the vehicle manufacturing, generic datasets for raw material production and refining in a specific country or region have been used when it is known or likely that production/refining takes place there. The methodology for choosing generic data is further described in the Polestar 2 carbon footprint report[3] "Appendix 1: General methodology when choosing datasets for complete vehicle carbon footprints".

As aluminium has been identified as a climate impact hotspot in Polestar's previous LCA studies[4], Polestar has put in efforts to reduce the impact from the use of aluminium in the Polestar 4 SUV. Polestar's manufacturing partners Geely and Renault Korea have procured aluminium parts from suppliers which in turn procure aluminium from smelters utilizing renewable electricity. The share of aluminium originating from smelters utilizing renewable electricity in smelting has been incorporated into the present study. Use of recycled aluminium has been considered in the study, the shares of recycled aluminium per part has been given by aluminium parts suppliers directly to Polestar's manufacturing partners. The recycled aluminium share has been modelled separately to the primary aluminium share.

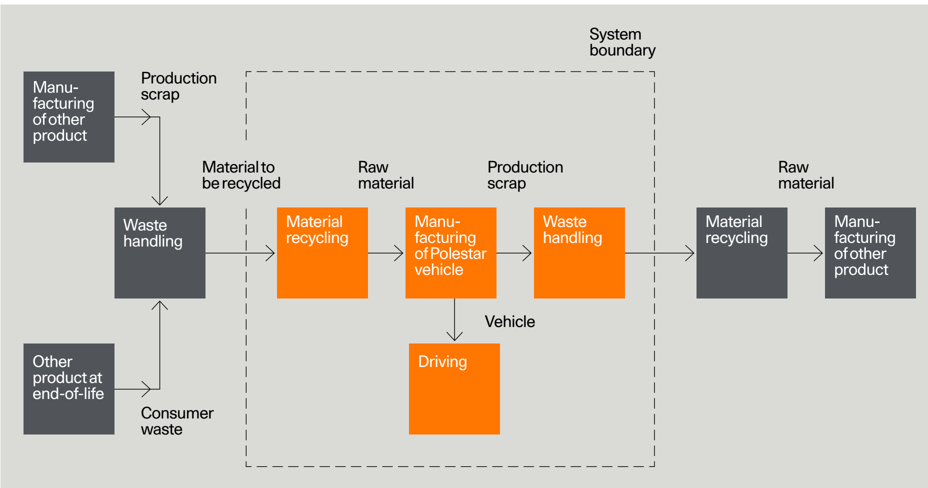
Use of recycled steel has been considered in the modelling. The dataset on steel production already contains a default percentage of 4.6% recycled content, which is not the case for the aluminium dataset. The recycled steel share has been increased to the corresponding share of recycled steel used in vehicle parts, based on information given by parts' suppliers to Polestar's manufacturing partners.

The Polestar 4 SUV contains recycled polymers which are incorporated into this study. For these parts data on recycled content has been obtained from parts suppliers. Some polymers in the Polestar 4 SUV originate from biobased raw materials, however exact quantities are not known for the complete vehicle. Biobased polymer content has therefore not been assessed in this study, instead the raw material for all polymers have been assumed to be of fossil origin. This may result in that the climate impact being slightly overestimated for polymers, but the effect on the overall result is estimated to be minor.

Generic data, as opposed to supplier-specific data, has been used for most of the upstream processes, over which Polestar does not have financial or operational control. This means that the modelling of production of components in the vehicle has been based on the material composition of the components, using generic datasets for materials and adding a generic manufacturing process for each material. Hence, there are steps in some of the manufacturing value chains, specific to vehicle components, that might not be included, such as assembly processes at tier 1 suppliers. However, the contribution of these processes to the total carbon footprint is assessed as likely to be very small.

3 https://www.polestar.com/dato-assets/11286/1600176185-20200915polestarlcafinala.pdf

4 Life Cycle Assessment (LCA) | Polestar



← Figure 3

Allocation of impacts from waste handling and recycling with the cut-off EoL allocation approach.

Processes over which Polestar has financial control or partly financial control such as manufacturing (vehicle assembly) and logistics, primary activity data has been used.

Function and functional unit

The functional unit is specified as 1 vehicle kilometre (1 vkm) calculated over a lifetime distance driven of 200 000km over a 15-year vehicle life. In the original Polestar 2 carbon footprint study, the vehicle lifetime mileage was used as the functional unit. The functional unit in this study of the Polestar 4 SUV has been changed since 1 vkm better captures the function of the vehicle – the mobility – and captures the effect of the lifetime mileage of the vehicle; the longer the lifetime mileage, the lower life cycle climate impact per 1 vkm. In practice, this means that the climate impact is calculated for the total life cycle and divided by the total km driven during the assumed lifetime of the vehicle. The result will also be provided cradle-to-gate per produced vehicle and cradle-to-grave for a lifetime of 200 000km distance driven. The reference flow in the study is the weight of the vehicle divided by the lifetime distance driven of 200 000 km. Table 1 shows the weight of the vehicle in the study.

Allocation

The total of assigned inputs and outputs for a unit process match the inputs and outputs of the unit process prior to allocation. For all background processes, the same allocation method used in the LCI databases are adopted.

More specifically, in terms of allocation for reuse and recycling and end-of-life approach, this study uses the cut-off EoL allocation approach, also called the recycled content method or 100/0 method. This is common practice within the automotive industry and is aligned with the polluter pays principle, whereby emissions from waste treatment are allocated to the product system that generates the waste. Figure 3 explains the cut-off EoL allocation approach. This method means that the system (Polestar vehicle) generating the waste carries the impacts of any processing required to bring the waste to the point in the product life cycle in which all the end-of-waste criteria are fulfilled. For waste materials which are ultimately recycled in another system, any impacts of processing to make the waste achieve a positive market value, at which point it then can be used by another system as an input for making a recycled material, belong to the system in which the waste is generated, whilst the user of the ultimate recycled material bears the impacts of the recycling process itself. No credits are applied to either the system using the waste or the system receiving the material made from the waste.

Allocation, in terms of partitioning of site impacts, was required to use in this study for the manufacturing facility. This has been applied though physical allocation by using the total number of completed vehicles as the allocation basis, since there is a strong correlation between the use of resources, such as electricity and gas, in the manufacturing facility and the total number of vehicles produced, irrespective of size of the vehicles.

No system expansion has been applied in this study, i.e. no credits have been given for materials being recycled and potentially avoiding other material production, or for energy generated in waste incineration potentially avoiding other energy production.

Main assumptions and exclusions

In general, assumptions have been made in a conservative fashion following the precautionary principle, to not underestimate the climate impact from unknown data. For example, when no suitable dataset has been available to represent the manufacturing process for a certain material (from raw material to finished vehicle component), the emissions from the raw material production has been multiplied by two to compensate for the emissions from further processing. This is described in 2.6. "Minor material categories, production and refining".

When it comes to material sent to recycling, the emissions from producing this material have been allocated to the vehicle. That means that, for example, the produced amount of steel and aluminium included in the carbon footprint calculation does not only include the amount of the material in the vehicle, but also the production of metal that is removed during processing and sent to recycling throughout the whole manufacturing chain.

The vehicle is manufactured in South Korea; however, components are coming from both Korean and Chinese suppliers. For components and materials known to come from South Korea, they have been modelled using datasets corresponding to the South Korean geography if available. If no datasets for South Korea were available, datasets representing Asia has been used to the largest extent possible. For other components and materials, it is assumed that they originate from China. China, South Korea or Asia specific material inventory datasets have been used as far as possible, based on availability within the ecoinvent and Sphera professional databases. For the vehicle manufacturing, emissions related to energy, industrial wastewater processing and manufacturing waste have been included and based on data for the full year of 2025 from the Busan plant. Data from 2025 is considered to be the most representative data available to reflect the conditions under which the vehicle of study is made under, even though the Polestar 4 SUV was not in production during 2025. See Appendix 1 for a detailed description of applied datasets.

The use phase considers a lifespan of 15 years of the vehicle; probable changes in the electricity mix during this time is considered in the study based on the stated policies scenario (STEPS) from the International Energy Agency's (IEA) World Energy Outlook 2024[5]. This scenario is a slightly conservative benchmark for the future, since it does not take for granted, that governments will reach their announced commitments, Nationally Determined Contributions or other long-term climate targets, but instead only considers forecasted effects of decided policies.

The energy use of the vehicle corresponds to driving according to the WLTP driving cycle; it includes losses occurring during charging and in the drivetrain during driving, and only essential auxiliary systems are run while driving (excluding e.g. infotainment, air conditioning). The energy use in the use phase is explored in a sensitivity analysis. The sensitivity analysis is included as the test cycle of WLTP assumes optimal conditions in terms of temperature, weather, road conditions and driving behaviour for vehicle efficiency, conditions that may not be achievable in for most drivers.

The lifetime mileage of the vehicle is 200 000 km. As larger personal vehicles as the one studied here can be argued to have a longer lifetime distance driven[6], the effect of this is explored in a sensitivity analysis. The battery used in the Polestar 4 SUV has been designed to last the life of the vehicle in typical use, thereby no change of battery pack is included in the study.

5 World Energy Outlook 2024 – Analysis - IEA

6 Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA

Aspect	Description	Requirements in this study
Time-related coverage	Desired age of data.	General data should represent the current situation of the date of study (2026), or as close as possible. All data should be less than 10 years old.
Geographical coverage	Area from which data for unit processes should be collected.	Material production and refining should be representative of region where the material/component is produced, when known. Vehicle manufacturing should be representative of the manufacturing site location. The use phase data should be representative of European and global average. End-of-life data should be representative of global average.
Technology coverage	Type of technology (specific or average mix).	Data should be representative of the technology used in production processes.
Representativeness	Degree to which the data set reflects the true population of interest.	Primary data that is representative of the process should be used for processes under Polestar & Geely financial or operational control. Secondary data may be used for upstream and downstream processes but fulfilling the requirements above on time-related, geographical and technology coverage.
Precision	Measure of the variability of the data values.	Data that is as representative as possible will be used. Data will be derived from credible sources, and references will be provided.
Completeness	Assessment of whether all relevant input and output data are included for each data set.	Generic data will be derived from credible sources, such as recognised LCI databases. Internal data should cover all relevant inputs and outputs. The data collected from the battery pack supplier should be verified in close collaboration with the supplier.
Consistency	Assessment of whether assumptions, methods, data sources, and modelling choices are applied uniformly throughout the study.	The same functional unit, system boundaries, allocation rules, cut off criteria, impact assessment method (GWP100), database versions, and modelling assumptions shall be applied consistently across all life cycle stages. Methodological choices shall be aligned and documented. Deviations shall be justified and transparently reported.
Reproducibility	Assessment of the method and data, and whether an independent practitioner will be able to reproduce the results.	Information about the method and data (reference source) should be provided.
Sources of the data	Assessment of the data sources used.	Data will be derived from credible sources, and references will be provided.
Uncertainty of the information	e.g. data, models, assumptions.	Data will be derived from credible sources, and references will be provided.

← Table 2

Data quality requirements used in the study.

The methodology for the end-of-life stage of the vehicle life cycle is defined in depth in Appendix 4 “End-of-life assumptions and method”. Assumptions on EoL treatment of the vehicle have been necessary as the specific treatment methods after the 15-year lifetime cannot be guaranteed. These assumptions relate to how different material groups are assumed to be treated, weather they are recycled, incinerated or landfilled.

The study does not include:

1. Non-manufacturing operations such as business travels, R&D activities or other indirect emissions.
2. Manufacturing infrastructure e.g., the production and maintenance of buildings, inventories or other equipment used in the vehicle manufacturing plant in Busan, South Korea. However, when generic datasets are used, which is the case for energy generation, transportation means, and production of ingoing materials, impacts from manufacturing electricity generation infrastructure is automatically included.
3. Construction and maintenance of roads and charging infrastructure in the use phase.

Data quality requirements

The data quality requirements used in the study are shown in Table 2. The data quality indicators used to assess the data used in the study can be found in Appendix 5, together with the quality assessment itself.

Considering the data quality requirements in Table 2, the data used in this study fulfil the requirements except that a considerable amount of the datasets used in the material production and refining are more than 10 years old and/or not representing the location of production, and that the technological coverage is insufficient for the EoL stage. This is due to both uncertainty of material origin, uncertainty of waste handling practises globally, and lack of geographical coverage in databases. For more details about the data quality assessment, see Appendix 5.

Critical review

As recommended by ISO 14067 this study has been critically reviewed by a third party, in the form of two external experts, see Appendix 8.

Way of working overview

Figure 4 shows a high-level overview of how Polestar works to derive carbon footprints of vehicles.

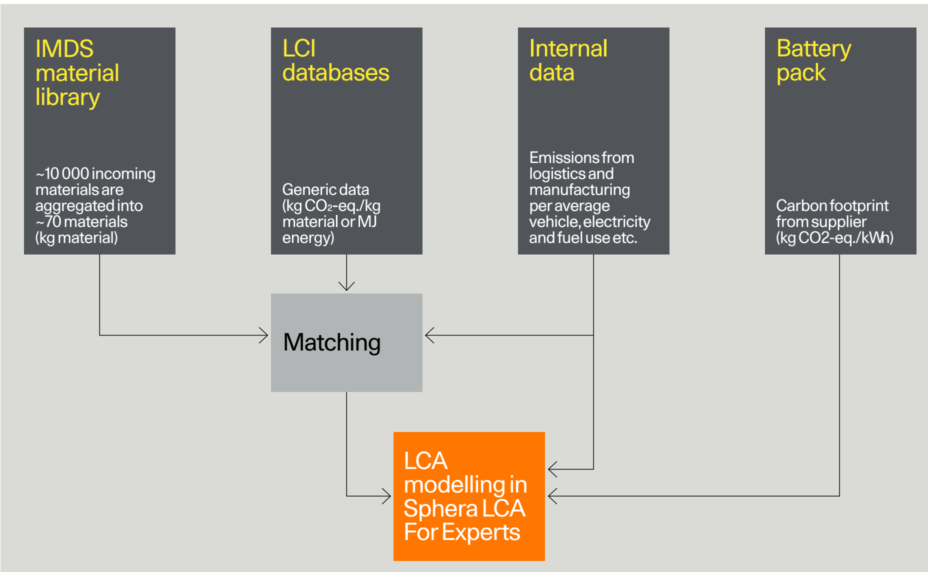
There are four main ways that data needed for the final carbon footprint are retrieved:

- IMDS[7] (International Material Data System) datasheets which contain information on material compositions of the components in a vehicle.
- LCI (Life Cycle Inventory) databases from ecoinvent[8] (version 3.12 and 3.10.1), Sphera (version 10.9.5.2)[9]. Other datasets which are not specific to Sphera or ecoinvent are taken from the Sphera professional database but are not created by Sphera. Ecoinvent was used as the primary source of LCI data. However, when datasets were unavailable in Ecoinvent, or when more relevant or up-to-date data existed in Sphera, data from Sphera were used instead.

7 IMDS, www.mdsystem.com

8 Ecoinvent, www.ecoinvent.org

9 Sphera LCA databases https://sphera.com/solutions/product-stewardship/life-cycle-assessment-software-and-data/



Material type	Number of material categories	Share of total weight of Polestar 4 SUV Dual motor	Share of total weight of Polestar 4 SUV Rear motor
Steel & iron	5	48.9%	48.0%
Aluminium	3	19.0%	19.3%
Polymers	35	18.2%	18.7%
Fluids & undefined	15	7.7%	8.0%
Tyres	2	3.6%	3.9%
Copper	2	1.7%	1.3%
Natural materials	3	0.5%	0.4%
Other metals	3	0.2%	0.3%
Electronics	1	0.2%	0.2%

← Figure 4

A high-level overview of how Polestar works to derive data on which carbon footprints are calculated for vehicles.

← Table 3

Material categories and share of total weight per vehicle variant. Note that Li-ion battery pack is treated separately and therefore not included in the table.

- Data from operations controlled by Polestar or a partner, such as manufacturing plants and logistics.
- Carbon footprint of Li-ion battery pack, performed by the supplier with guidance and support from Polestar.

Methodology to define vehicle material composition

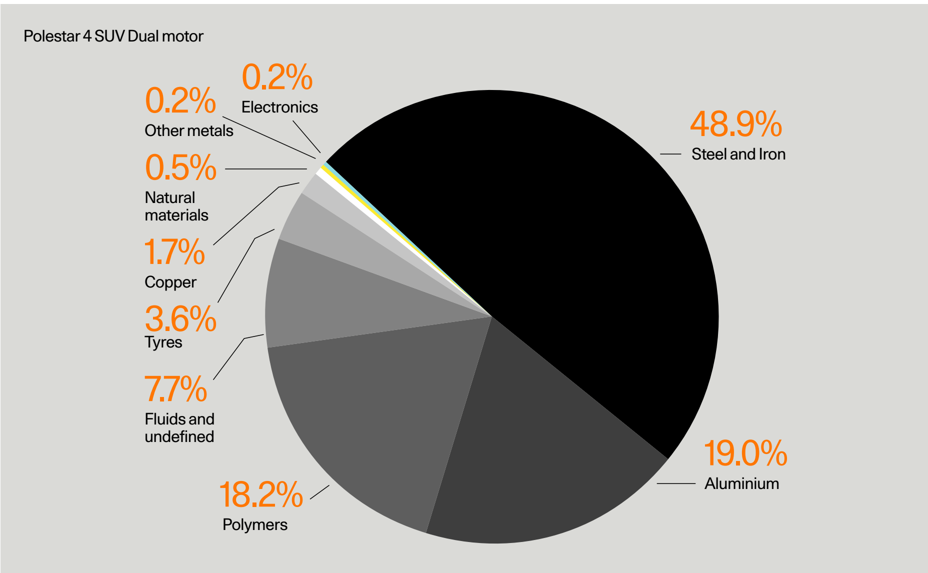
The Bill of Materials (BoM) is an important component of the LCA and consists of the parts used in the vehicle and their respective weights and materials composition. The "part number vehicle BoM" is extracted from the product data management system. However, this BoM cannot be used as direct input to the LCA-model in LCA for Experts but must be processed and aggregated in several steps to a suitable "material BoM".

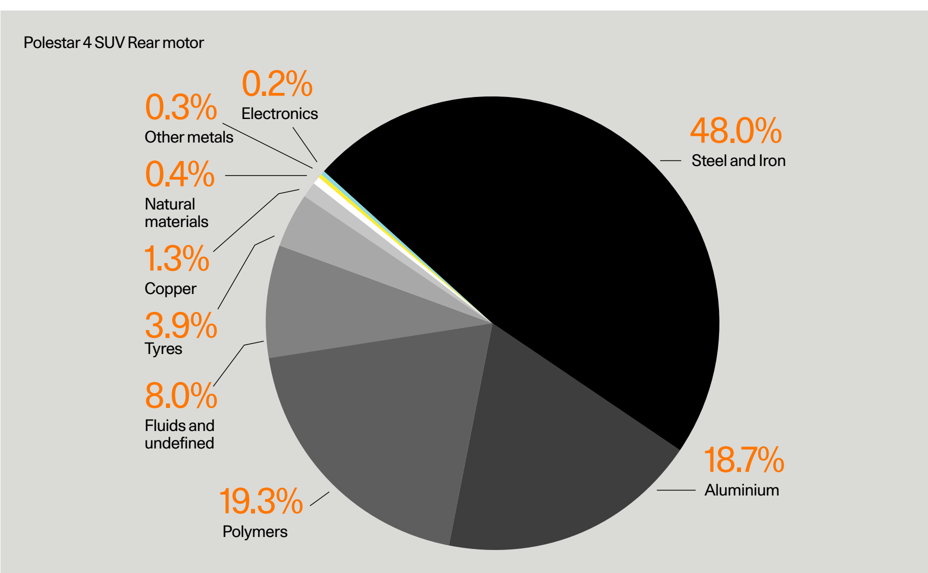
The material information, except for the Li-ion battery pack, comes from datasheets in IMDS. A complete vehicle in IMDS consists of about 10 000 different materials. To make the number of materials manageable in LCA for Experts, they are aggregated to over 70 defined material categories in a material library developed by Volvo Cars Corporation (IMDS ML). The "part number BoM" from the product data management system is uploaded to the IMDS ML system iPoint Compliance Agent (iPCA). In iPCA a "material BoM" is generated that is imported to IMDS ML where all materials are mapped against the 70 defined material categories.

To have an efficient and systematic approach, this mapping is done in an automated way. The rules to categorise the materials are set up based on IMDS material category, material name and substance content. It is also possible to manually allocate materials in the IMDS ML, however, this is done in the most restrictive way possible. For this carbon footprint study, IMDS ML release 9 is used with the material categories listed in Table 3. For the complete list of material categories, see Appendix 2.

The "material BoM" has been modelled in LCA for Experts with relevant manufacturing process datasets. To follow the ISO 14067 standard, emission factors for the five impact categories have been calculated from the model in LCA for Experts for each material type including processes and refining and then extracted into a excel document. This is done for emission factors related to materials, both materials used in the vehicle when it leaves the manufacturing facility and materials added to the vehicle during maintenance, and for EOL emission factors. After this is done, each components emission is calculated by its respective mass.

For the Li-ion battery pack, specific supplier carbon footprint data was used instead of IMDS data. The variety and accuracy of generic datasets for Li-ion batteries is limited, but through the collaboration with the battery pack supplier the risk of inaccuracies has been minimised to the best of efforts.





← Figure 5

Shares of material categories of vehicle weight excluding battery pack, Polestar 4 SUV Dual motor.

← Figure 6

Shares of material categories of vehicle weight excluding battery pack, Polestar 4 SUV Rear motor.

This chapter describes the life cycle inventory of the study. The life cycle inventory was validated by applying mass balance checks to ensure that inputs and outputs were consistent.

Material production and refining

Material production and refining is based on a BoM containing material composition and material weight. The BoM used for modelling in LCA for Experts is specifically developed to be used for the LCA modelling in LCA for Experts and states the composition of the vehicle based on more than 70 material categories. Each material category has an identified mass. The total weight of all material categories is then compared with the total weight of the vehicle. See Figure 5 and 6 for share of material categories for the vehicle.

In LCA for Experts each material has been coupled with one or several datasets (containing LCI-data) representing the production and refining of the material in each specific material category. See Appendix 1 – Chosen datasets.

The material production and refining are modelled using datasets from Sphera Professional database and ecoinvent 3.12 data. The datasets have been chosen according to the Polestar methodology for choosing generic datasets (described in Appendix 1 in the Polestar 2 carbon footprint report[10]).

The material content corresponding to the entire weight of the vehicle is included in the LCA, but a small number of materials have been categorised as “fluids & undefined material” in the material library. The share of undefined material of the total vehicle weight (excluding battery pack) for Polestar 4 SUV Dual motor is 0.24%. Since the undefined category (a subcategory to “fluids & undefined”) contain mostly undefined polymers, a dataset for Polyamide (Nylon 6) has been used as approximation. This assumption is made since polyamide is the polymer with the highest Carbon Footprint, out of the polymer data used in the LCA.

All filled polymers have been assumed to contain 78% polymer resin, 14% glass fibre and 8% talc representing an average of filled polymers as reported in the IMDS for Polestar vehicles.

In most cases, datasets that include both production of raw material as well as component manufacturing ready to be assembled in the vehicle are not available. Therefore, several datasets representing the refining and production of parts have been used for most material categories. The datasets used to represent further refining and manufacturing of parts are listed in Appendix 1.

For most database datasets representing materials production and refining processes it has not been possible to modify the electricity mix, i.e. the built-in electricity mix has been used. Some material manufacturing processes from databases are country or region specific but specific to other regions than China or South Korea. Thereby the exact manufacturing situation for Polestar 4 SUV parts may not be accurately represented. These datasets do however give the possibility to apply country specific energy inputs. In these cases, Chinese or South Korean energy inputs have been applied to the manufacturing of parts using these datasets depending on the known origin of the materials as discussed in the Section “Main assumptions and exclusions”. These manufacturing processes are for steel, aluminium and polymers, displayed in Table 16 in Appendix 1. Material utilisation degrees (MUDs) for the production of automotive parts have been applied in the modelling of the emission factors for each material. Thereby the emission factors account for material losses. Material utilisation degrees are presented in Appendix 3.

10 https://www.polestar.com/dato-assets/11286/1600176185-20200915polestarlcafinala.pdf

When the materials have been categorised and then modelled in LCA for Experts, the emission factor for each material group has been multiplied by the weight corresponding to that material group. This has been done for all five impact categories according to ISO 14067, for manufacturing and for end-of-life treatment and applies to all materials entering the vehicle.

Some materials within the "natural materials" category such as wood and cotton hold biogenic carbon removed from the atmosphere; these removals are assumed to occur and be released at the point of vehicle manufacturing (i.e., the beginning of the assessment period). At the point of vehicle end-of-life, after 15 years in operation, these removals would be released in reality. These materials concern a very small percentage of the vehicle total mass, 0.5% for the Dual motor variant and 0.4% for the Rear motor variant.

Aluminium production and refining

In previous Polestar vehicle carbon footprint reports the share of aluminium that is cast aluminium and wrought aluminium has been assumed to be 65% cast aluminium and 35% wrought aluminium, based on the report "Aluminium content in European passenger cars"[11]. However, after the Polestar 5 LCA[12], published in 2025, Polestar has continued to identify different sorts of aluminium used in the vehicle. The wrought aluminium share has been divided into "extrusions" and "pressings". Using IMDS-data and expert judgement from Polestar vehicle engineers the aluminium composition has been estimated to the numbers displayed in Table 4. These values exclude the weight of the aluminium in the battery pack as this aluminium content is accounted for in the carbon footprint report provided by the battery pack supplier, more on this is described in Section 2.8.

Table 4 →

Shares of aluminium types, excluding battery pack, sums may not total 100% due to individual rounding.

Aluminium type	Type share of total aluminium, Polestar 4 SUV Dual motor	Type share of total aluminium, Polestar 4 SUV Rear motor
Castings	62.2%	58.8%
Extrusions	21.8%	23.7%
Pressings	16.0%	17.5%

All aluminium pressings have been assumed to go through the process of making aluminium sheets and all aluminium extrusions have been assumed to go through the process of aluminium extrusion. The cast aluminium goes through a process for die-casting aluminium.

The material losses occurring in the processes of making the aluminium parts for the vehicle are included in the carbon footprint, and the total footprint of such additional materials are allocated to the vehicle even though the aluminium scrap is sent to recycling and used in other products and not in the vehicle. The material utilisation rate for the manufacturing processes of all three aluminium types can be seen in Appendix 3.

11 Aluminium Content of European Passenger Cars

12 Polestar 5 LCA 2025

All aluminium is assumed to be produced in China. The assumption is based on an expert judgement by Polestar logistics specialists as well as the fact that South Korea has very limited aluminium smelter capacity. As Polestar has identified aluminium as a climate impact hotspot, tough requirements on aluminium parts suppliers have been set by Polestar towards its manufacturing partners. These requirements are part of the contractual manufacturing agreements between Polestar and its manufacturing partners. The manufacturing partners in-turn have set up agreements between them and aluminium parts suppliers which stipulate the minimum renewable electricity usage allowed at the raw material supplier (the aluminium smelting facility). Thereby aluminium used in parts of the vehicle comes from renewable electricity smelters. This share has been modelled with an emission factor representing aluminium smelting using electricity from hydropower plants in China. Hydropower is used as electricity source as this is the source of renewable electricity at the raw material supplier, based on supplier contracts. The emission factor was obtained through Polestar's own investigations and is a conservative assumption; however, the other emission factors were not provided (like biogenic emissions, aircraft emissions etc.). For these components Polestar obtains contracts between its manufacturing partners and parts suppliers.

Recycled aluminium is included in some parts of the Polestar 4 SUV. This share has been modelled using the disaggregated unit process "RNA: Aluminum, secondary, ingot, at plant USLCI" available in Sphera Professional Database and applying Chinese electricity mix and natural gas mix to the production of the aluminium ingot for the "Recycled aluminium" share of the recycled content. The RNA dataset has been applied due to the unavailability of a dataset representing Asia in either Sphera Professional or ecoinvent 3.12. The standard Chinese aluminium share has been modelled using the Sphera dataset "CN: Aluminium ingot mix IAI 2019".

The different aluminium categories and corresponding shares of total aluminium content, excluding battery pack, is displayed in Table 5.

To determine the category of aluminium, as described in Table 5, first-hand information has been gathered from suppliers of aluminium parts to the Polestar 4 SUV by Polestar's manufacturing partners. Through this supplier engagement process information on aluminium smelter location as well as recycled content has been gathered and assessed. Thereby Polestar has been able to retrieve information on electricity sources to these aluminium smelters to determine renewable electricity usage in smelting operations.

Table 5 →

Shares of different aluminium categories, excluding battery pack.

Aluminium category	Share of total aluminium, Polestar 4 SUV Dual motor	Type share of total aluminium, Polestar 4 SUV Rear motor
Virgin aluminium from renewable electricity smelters	34.4%	37.4%
Recycled aluminium	22.2%	16.9%
Standard Chinese aluminium	43.4%	45.7%

Steel production and refining

The raw material dataset used for the material category “unalloyed steel” has an output of rolled and galvanised steel. A processing process has then been added to all steel. Which processing type that is chosen depends on whether the steel is stamped in the factory or not. Hence, the steel categorised as unalloyed steel in the material library is divided into two sub-groups depending on the manufacturing process following the rolling and galvanising of the steel:

1. The steel that is processed and stamped in Renault Korea controlled manufacturing. The material utilisation degree is confidential.
2. The rest of the steel, which is distributed in various components of the car. The material utilisation degree is according to the chosen database dataset, i.e. literature value.

The losses occurring in the processes of making the steel parts for the vehicle, independent of processes, are included in the carbon footprint. The material utilisation degree for the manufacturing processes of steel can be seen in Appendix 3. All steel is assumed to be produced in China and South Korea, however it is represented by an Asian average dataset due to the lack of country specific datasets. The assumption is based on an expert judgement by Polestar logistics specialists.

Electronics production and refining

The material category called “electronics” includes printed circuit boards (PCB) and the components mounted on them. It does not include chassis, cables or other parts that are present in electronic components. All materials that are used in electronic devices that are not PCBs have been sorted into other categories, such as copper or different types of polymers.

For the category “electronics” a generic data set from ecoinvent 3.12 has been used. This dataset represents the production of mounted PCBs.

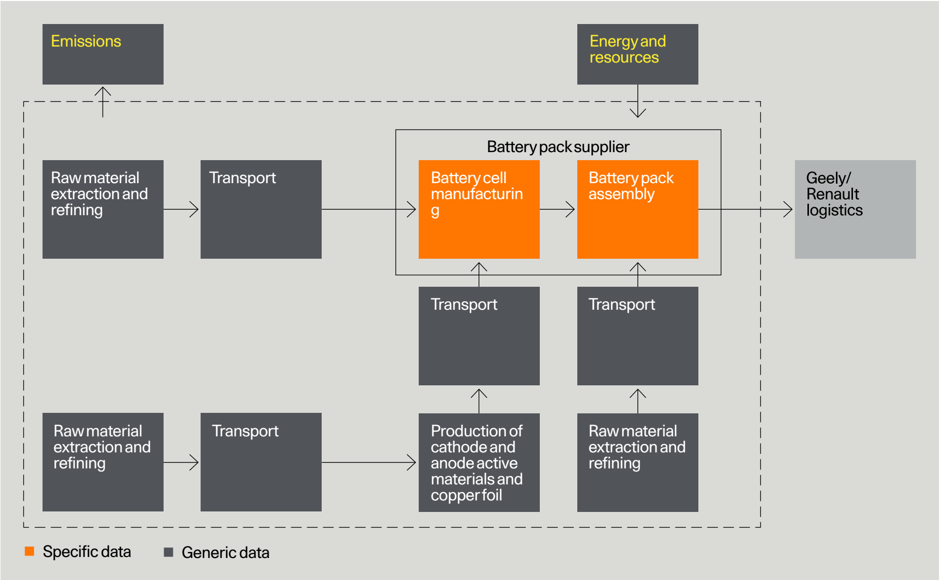
Plastics production and refining

For polymer materials, an injection moulding process has been used to represent the processing of plastic parts from a polymer raw material. The material utilisation degree for the manufacturing processes of plastics can be seen in Appendix 3.

Approximately 30.2 kg of the plastics in Polestar 4 SUV are recycled plastics, as identified from the IMDS-data. This share has been modelled with a dataset for mechanically recycled plastics.

Minor material categories, production and refining

There are raw materials for which data on processing is missing in the LCA-databases. In those cases, the material weight was doubled as an estimation for the processing. This means that the processing process is assumed to have the same carbon footprint as the production of the raw material itself. This has been applied only for materials of lower mass.



← Figure 7

Flowchart for battery pack manufacturing.

Electricity use in materials production and refining

Most of the datasets used for materials production and refining have built-in electricity grid mix corresponding to the region the dataset is compiled for. In the few partially aggregated processes in the Sphera databases where it is possible to add an electricity mix by choice, a Chinese or South Korean electricity grid mix is applied, depending on if it was known if the part was produced in South Korea or not.

Battery pack

Polestars manufacturing partner, Geely, purchases the Li-ion battery pack from a battery supplier who, in collaboration with Polestar, conducted a cradle-to-gate carbon footprint study of their battery pack (up until Geely and Renault logistics take over). See Figure 7 for the flowchart of battery manufacturing, representing system boundaries and primary activities. The battery pack has therefore been removed from the BoM based on IMDS data and is modelled separately in the complete vehicle LCA. The total weight for the battery pack is 589 kg with 110 cells in total weighing 407 kg and other materials being 182 kg. The highest weight share for the battery pack, excluding the cells, are allocated to the aluminium tray, in which the cells sit, and high-voltage cables.

For cell and pack production the production of the supplier purchases renewable electricity certificates to cover the complete Polestar production volume. These are in the form of Chinese Green Electricity Certificates (GECs). This has been in effect since the production of the original Polestar 4 (now called Polestar 4 coupé) began in 2023 and the battery pack is the same as the battery pack used in the coupé variant.

The carbon footprint study conducted by the battery supplier has not been third-party reviewed. This is due to the report being commissioned in 2023 to comply with ISO 14044:2006 and ISO 14040:2006 which do not explicitly specify a third-party review for supplier provided data. Additionally, no significant change has been made to the battery pack since its start of production in 2023, when significant changes occur, new battery carbon footprint studies are to be commissioned which Polestar will actively seek to have third-party reviewed.

The report from the battery supplier adheres to LCA standards such as ISO 14044:2006 and ISO 14040:2006, and the assessment's system boundary is from cradle to gate. The impact categories considered include the Global Warming Potential (GWP) over 100 years, following the IPCC's 6th Assessment Report (AR6), with consideration given to all GHG, not just CO_2. The unit of measurement utilised is kg CO_2e. The functional units assessed in the battery carbon footprint report are the capacity of a finalised battery cell (measured in kWh) and the capacity of a finalised battery pack (measured in kWh). The assessment's time boundary was set at 2023, capturing the climate impact within that specific timeframe. The battery pack utilised in the Polestar 4 SUV is the same as have been used since the original Polestar 4 model started manufacturing in the end of 2023. The supplier has used the Sphera tool LCA For Experts to model the impacts of the battery pack. Supplier specific data has been used for energy input at the pack supplier. The cell manufacturing and pack assembly uses 100% renewable electricity through GECs, as previously stated, and natural gas for heating. The battery used in the Polestar 4 SUV has been designed to last the life of the vehicle in typical use, thereby no change of battery pack is included in the study.

Tyres

The climate impact of tyres fitted to the Polestar 4 SUV from the factory has been calculated by the tyre manufacturer in accordance with ISO 14 044. The combined weight of the four summer tyres is 61.9 kg. The tyre manufacturer has used primary activity data for their operations in the specific factory producing tyres to the Polestar 4 SUV. The LCA report was not specific to the Polestar 4 SUV tyres but for another tyre of similar dimensions produced in 2023 for a vehicle of similar weight to the Polestar 4 SUV. The report has not been verified by a third-party. The system boundary of the report from the tyre supplier is from cradle to gate. The impact category considered is Global Warming Potential (GWP) over 100 years, following the IPCC's 6th Assessment Report (AR6), with consideration given to all GHGs, not just CO_2. The functional unit utilised is kg CO_2e per kg finished tyre.

Logistics

For the inbound logistics of Polestar 4 SUV, GHG emissions data has been provided by Geely and Renault Korea in the form of average GHG emissions per Polestar vehicle produced in the Busan plant. These have been calculated by Geely and Renault Korea and reviewed by Polestar. Calculations are based on the weights of the components and packaging and the specific supply routes to the Busan plant from suppliers combined with emission factors from the Global Logistics Emissions Council[13] (GLEC).

Volvo Cars Corporation handles outbound logistics, hence data on GHG emissions has been provided by Volvo Cars Corporation. Data has been provided in the form of estimated GHG emissions per vehicle transported from South Korea to specific markets, this has been combined with predicted sales figures of Polestar 4 SUV per market during the full year 2026 to calculate the average GHG emissions per transported Polestar 4 SUV vehicle. Emission factors from the Network for Transport Measures (NTM)[14] has been used as a basis for calculations. The climate impact for both inbound and outbound logistics is not specified into emission categories, such as biogenic emission or fossil emissions and therefore has conservatively been assumed to only be associated with fossil emissions. The methodology to calculate emissions is developed in line with the ISO Standard 14083.

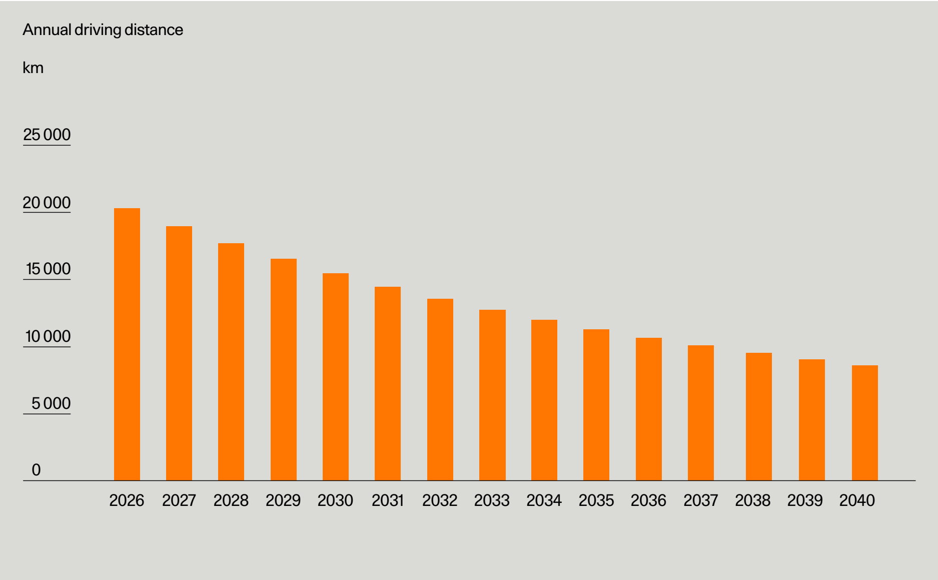
Manufacturing

The Polestar 4 SUV assessed in this report is produced in Renault Koreas plant in Busan, a plant which is owned by both Renault Group and Geely Auto[15]. To model the carbon footprint of the manufacturing, actual electricity and natural gas consumption per manufactured vehicle for the full year of 2025 has been used. From 2026 51% of the electricity used for Polestar's production share is expected to be covered by renewable electricity through renewable energy certifications, these certificates will be purchased by Renault Korea during 2026 and shared with Polestar at the end of 2026 as part of contractual agreements with Polestar. While there are currently limitations in the availability of renewable electricity in the South Korean market, Polestar aims to increase the share of renewable electricity over time with the ambition of reaching 100% renewable electricity supply in the years following 2026. The carbon footprint from electricity has been modelled using the Sphera dataset "KR: Electricity from photovoltaic" and "KR: Electricity grid mix 1kV-60kV".

13 Global Logistics Emissions Council

14 https://www.transportmeasures.org/en/

15 Busan Plant (RKM) - Renault Group



← Figure 8

Assumed annual driving distances (km) during the lifetime of the vehicle.

Solar electricity has been used for the renewable electricity share of 51% since it covers the majority of renewable electricity supply in South Korea[16] and Renault Korea has communicated that this is the most likely source of renewable electricity to be procured. No publicly available statistic exists for the share of renewable electricity claims in South Korea. For this reason, the country grid mix has been used as per the most available Sphera dataset, which has a low solar generated electricity portion (<5%). It is recognised that there may be some double counting of any modelled solar from grid electricity but this should have a low impact on the overall results and outcomes of the study due to a combination of (a) the low solar electricity portion modelled in the Sphera grid mix for South Korea and (b) the relatively low contribution from electricity in manufacturing of 0.592% per functional unit result for the Dual motor variant. The difference in GHG emissions per 1kWh of South Korean grid electricity compared to that of 1kWh of modelled Busan plant electricity (51% solar + 49% South Korean grid) is 49% lower. In future studies this same approach to Busan site electricity is likely to be used due to the reliance on renewable energy certificates which can be procured by Renault Korea throughout the specific model year.

The natural gas usage has been modelled using "CN: Thermal energy from natural gas" due to the unavailability of South Korean data on thermal energy from natural gas in Sphera.

There is other climate impacts associated with the manufacturing of the vehicle, such as emissions from water processing and production waste, these have been accounted for by using the average volume (water) and mass (waste) per produced car in the Busan plant during 2025. Emissions associated with the wastewater processing have been calculated using the ecoinvent 3.12 dataset " RoW: treatment of wastewater, average, wastewater treatment" and end-of-life treatment of other production related waste have been treated in the same manner as the EoL treatment for the vehicle, as outlined in Appendix 4. The RoW dataset was used as no specific dataset to South Korea or Asia was available in the ecoinvent or Sphera databases. Emissions to air occur from the plant, however aside from the use of natural gas, which is accounted for, these emissions to air are not greenhouse gases.

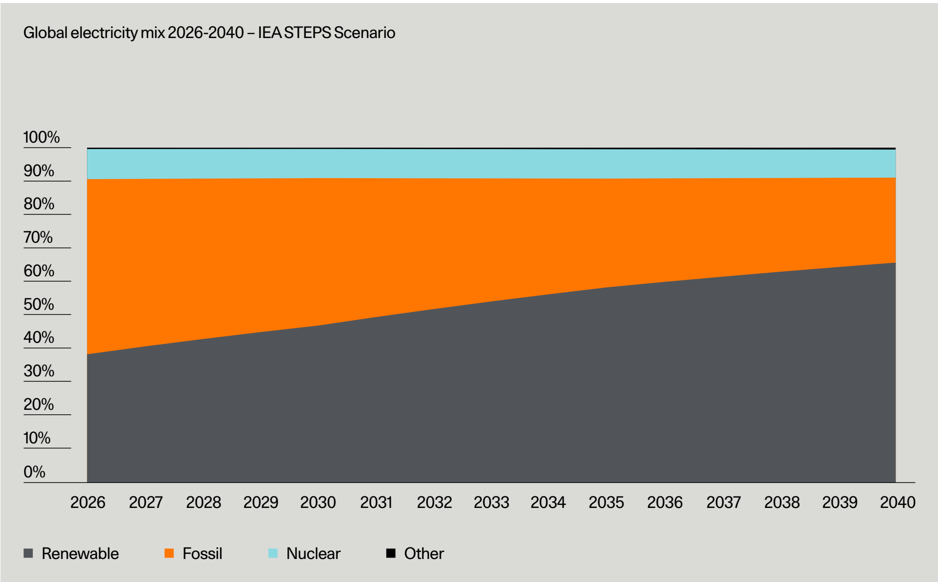
Use phase

Use – electricity consumption for driving

To be able to calculate the emissions in the use phase of the vehicle, the distance driven is required, in combination with the energy use, as well as emissions from electricity production. The vehicle lifetime driving distance for Polestar vehicles has been set to 200 000 km, energy consumption is set to 19.0 kWh/100km for the Dual motor variant and 17.5 kWh/100km for the Rear motor variant both according to the WLTP driving cycle, the complete lifetime driving distance is covered in 15 years' time from 2026 to 2040. The consumption figure has not been certified at the time of writing this report and may be subject to change after vehicle certification.

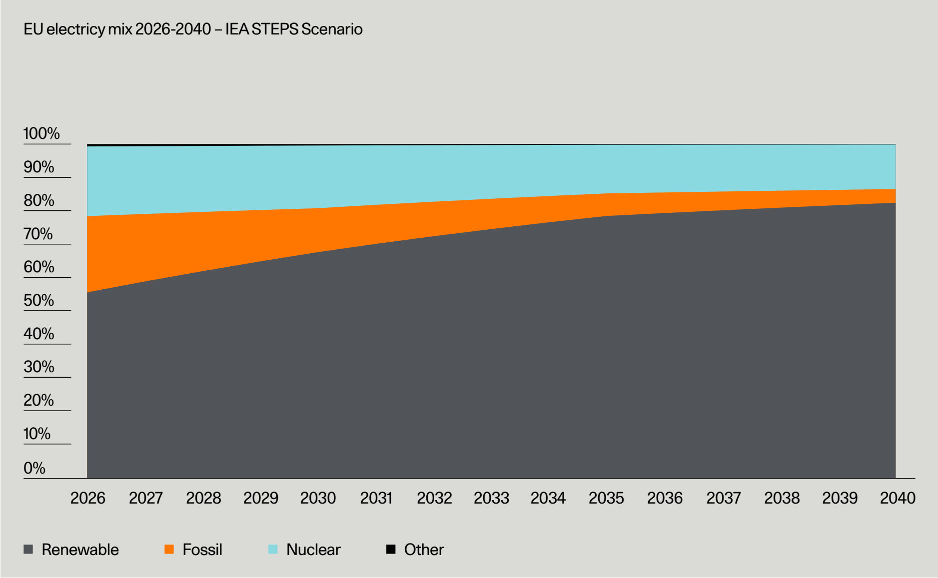
Electricity production is modelled according to three cases: (i) Use in the EU, using EU average electricity, (ii) use globally, using global average electricity, (iii) using electricity generated from wind. Wind was chosen as it is one of the electricity sources which result in very low life cycle GHG emissions, to demonstrate the full use phase potential of the Polestar 4 SUV. The chosen datasets for the use phase are presented in Appendix 1. Current and future global and EU electricity generation mixes are based on the World Energy

16 Korea - Countries & Regions - IEA



← Figure 9

Predicted share of energy production sectors in the Stated Policies Scenario STEPS for global energy mix.



← Figure 10

Predicted share of energy production sectors in the Stated Policies Scenario STEPS for EU energy mix.

Outlook 2024 Extended Dataset[17] from the IEA. Amounts of electricity from different energy sources have in this study been paired with appropriate LCI datasets from Sphera professional database (see Table 19 in Appendix 1) to determine the total climate impacts from different electricity generation mixes, both direct (at the site of electricity generation) and upstream. An additional specific electricity source in the form of solar power is available in Appendix 7. For Global, EU and wind electricity mix, RER-datasets have been used due to the unavailability of global and EU datasets for specific electricity generation sources. Grid infrastructure losses from transmission and distribution have been accounted for by using the transmission and distribution loss figure from the Sphera dataset "RER: Electricity grid mix 1kV-60kV".

The total driving distance of 200,000 kilometres was assumed over a 15-year lifetime, with the annual driving distance distribution based on the TranSensus LCA Consolidated Guidelines[18], as illustrated in Figure 8.

IEA uses the Global Energy and Climate (GEC) Model to explore possible future energy related scenarios based on different assumptions. For this study, STEPS has been used to determine the electricity generation mixes used to charge the vehicles in the use phase. STEPS reflects current policy settings based on a sector-by-sector and country by country assessment of the specific policies that are in place, as well as those that have been announced by governments around the world.

Figures 9 and 10 visually represent the development of electricity source mix. It is evident that the generation of electricity from fossil sources is expected to diminish, gradually being replaced by renewable sources based on the IEA STEPS data.

The well-to-wheel (WTW) emission data for the electricity usage for the vehicle is based on regulatory type-approval testing according to WLTP (World-wide Harmonised Light Vehicle Test Procedure - used for certification of vehicles in the EU). Losses during charging are included in the electricity use of the vehicle, as these are part of the WLTP. The electricity use of the vehicles is 19.0 kWh/100 km for the Dual motor variant and 17.5 kWh/100 km for the Rear motor variant.

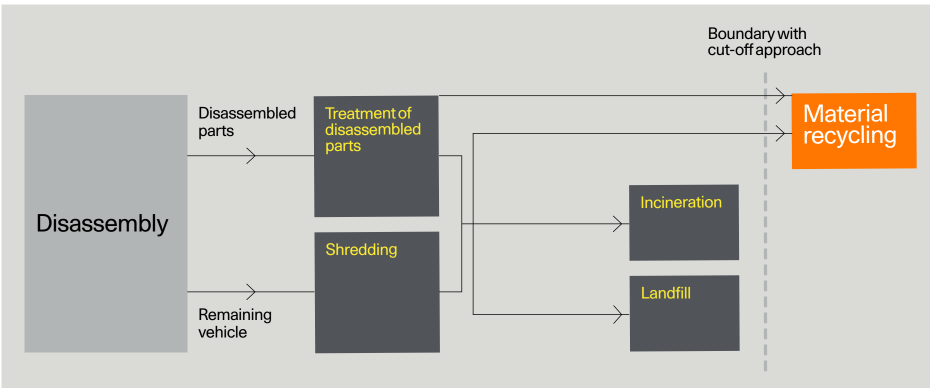
The energy use in the use phase is modelled based on the WLTP test as that is a global standard. WLTP does not, however, take all driving conditions into account, and, for example, assumes a driving condition where heating or cooling is not necessary and no use of infotainment in use. This could, especially for certain markets, lead to an underestimated energy use figure. To explore the impact of the consumption figure has on the overall life cycle carbon footprint, a sensitivity analysis is performed in Section 3.3.3.

Use – Maintenance

For the 15 years lifespan of the vehicle, it is assumed that some vehicle parts are required to be replaced. The data for maintenance of the vehicle is based on data for maintenance of a typical Polestar vehicle and not specific to the Polestar 4 SUV, as the specific maintenance scheme was not available at the time of writing this report. The maintenance scheme is the same for both variants of the vehicle. The maintenance list is presented in Table 6. The table represents the number of items replaced during vehicle lifetime. The vehicle tyres are designed to last 40 000 km. It is assumed that the tyres are not changed just before EoL, therefore 16 tyres need to be changed during the vehicle lifetime. For each part the corresponding item is found in the BoM and specific material data is used together with the corresponding dataset, in the

17 World Energy Outlook 2024 Extended Dataset - Data product - IEA

18 TranSensus LCA Consolidated Guidelines



← Figure 11

End-of-Life flow chart.

Table 6 →

Maintenance parts changed during the lifetime of the vehicle.

same way as material production and refining. However, only standard materials are used for the maintenance parts meaning that no share of recycled or lower carbon materials is assumed to be used in the maintenance of the vehicle. This is since Polestar cannot control if the users of the vehicles choose to maintain their vehicle using original Polestar parts or other manufacturer parts which may or may not contain recycled content. The 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.

Vehicle part	# Replacements
Wiper blades	39
Tyres	16
Brake fluid (l)	4
Brake pads	4
Brake discs	0
Battery, 12 V	3
Steering joint	1
Link arm	2
Condenser	1
AC fluid	2
Cabin filter	12

End-of-life treatment

It is assumed that all vehicles, at their EoL, are collected and sent to EoL treatment. The same end-of-life allocation approach as described in Section 1.5 Allocation is applied. Focusing on the point of lowest market value, according to the polluter pays principle, implies inclusion of steps like dismantling and pre-treatment (like shredding and specific component pre-treatment), but it does not include material separation, refining, or any credit for reuse in another product system, see Figure 11.

The EoL was modelled to represent global average situations as far as possible, meaning that also in the EU use scenario the EoL treatment was modelled on a global scale. The handling consists of a disassembly step to remove hazardous components and components that are candidates for specific recycling efforts. After this the disassembled parts are treated, and the remaining vehicle is shredded. According to material type the resulting fractions go either to material recycling, incineration or landfill. For further details on the EoL treatment, see Appendix 4.

In the disassembly stage, hazardous and/or valuable components are assumed to be removed from the vehicle including:

- batteries, wheels, tyres
- liquids: coolants, antifreeze, brake fluid, air-conditioning fluid, shock absorber fluid and windscreen washer fluid
- airbags and seat belt pretensioners removed or set off

From a global perspective, the treatment of coolant generally implies incineration. 55% of the tires are assumed to be salvaged for rubber recovery[19], and the rest to be incinerated. The 12V lead battery is assumed to be salvaged for lead recovery. Airbags and seat belt pretensioners, which are disassembled for safety reasons rather than the potential recycling value, are assumed to be incinerated. The assumption is that the Li-ion battery pack will be removed from the vehicle and sent to recycling due to the presence of valuable materials inside the pack. This is due to the resource-intensive and economically costly processes involved in extracting and refining these materials. Additionally, it is anticipated that recycling legislation will become more stringent, particularly as the vehicle approaches the end of its life. No recycling process is assumed for the Li-ion battery pack as the lowest point of economic value is considered to be after shredding of the battery pack, after which recycling process commences.

All other parts of the vehicle are sent to shredding. In this process, the materials in the vehicle are shredded and then divided into fractions, depending on different physical and magnetic properties. Typical fractions are:

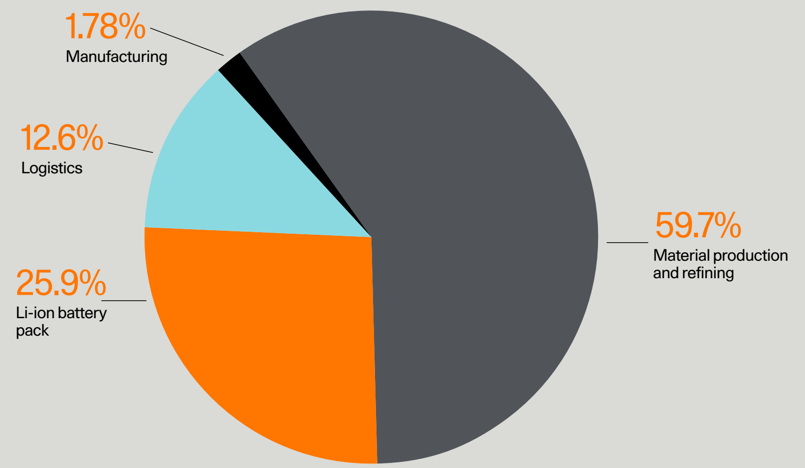
- ferrous metals (steel, cast iron, etc.)
- non-ferrous metals (aluminium, copper, etc.)
- shredder light fraction (plastics, ceramics, etc.)

The metal fractions can be sent for further refining and, in the end, material recycling. The combustible part of the light fraction can be incinerated for energy, or the entire fraction can end up in a landfill. For the purposes of this study, it is assumed the combustible streams of materials are incinerated, while the non-combustible materials are landfilled. For plastics specifically it is assumed that 50% is incinerated and 50% is sent to landfill.

No energy recovery is included for the incineration steps, even though in some Polestar markets, there is indeed energy recovery from incineration of waste. This somewhat conservative assumption has been made since there are many markets with no energy recovery, and data on how common the case with energy recovery is for the combustible streams is unknown. Assessment of material losses after shredding and refining are outside the system boundaries set by the cut-off EoL allocation approach. Further information on the EoL treatment is available in Appendix 4.

19 https://weibold.com/europe-collected-and-recycled-94-percent-of-endoflife-tires-in-2019#:~:text=According%20to%20ETRMA%2C%2094%25%20of,between%2092%25%20and%2095%25.

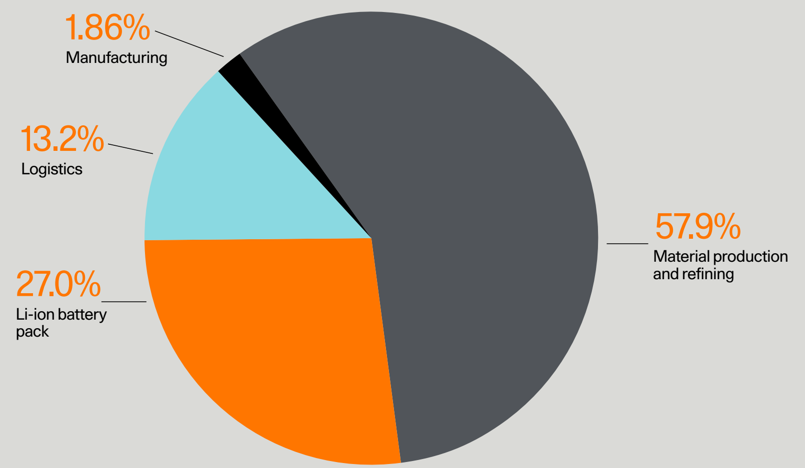
Polestar 4 SUV Dual motor



← Figure 12

Share of cradle-to-gate emissions per life cycle step per Polestar 4 SUV Dual motor. Note: "Material production and refining" includes all non-battery pack related materials.

Polestar 4 SUV Rear motor



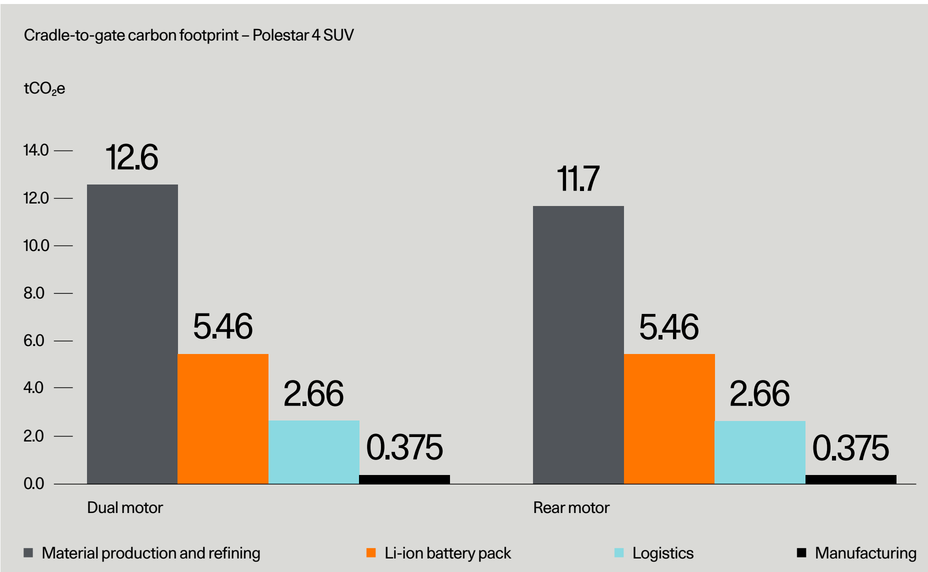
← Figure 13

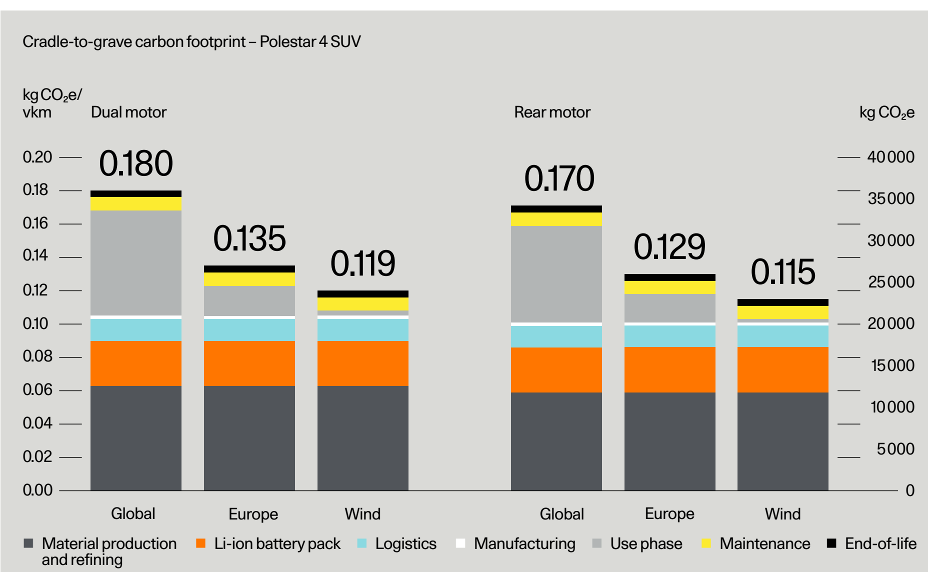
Share of cradle-to-gate emissions per life cycle step per Polestar 4 SUV Rear motor. Note: "Material production and refining" includes all non-battery pack related materials.

In the subsequent sections, the findings of the study starting with cradle-to-gate results are presented followed by cradle-to-grave results. Sensitivity analyses are also included. In accordance with ISO standards, the quantified results within this report have been rounded to three significant digits. This practice serves to improve clarity and maintain consistency throughout the report. Rounding the figures aids in enhancing readability and acknowledges the inherent uncertainties associated with the results. Mass allocation has been applied in the allocation of manufacturing flows included. Note that some differences in results may occur if allocation was applied on another basis such as economic value. However, this is outside of the scope of the study and manufacturing impacts are not demonstrated to be a key driver of the results.

Cradle-to-gate

The results showcased in Figure 12 (Dual motor) and Figure 13 (Rear motor) displays the shares of total cradle-to-gate carbon footprint that are attributed per value chain step concerning the production of 1 vehicle. The largest share of impact, constituting 57.9%-59.7% of the total, comes from the variety of materials utilised in the vehicle's production (excluding the battery pack). The battery pack contributes significantly as the next highest share, accounting for 25.9%-27.0% of the cradle-to-gate climate impact, while 12.6%-13.2% is associated with logistics and 1.78%-1.86% stemming from the vehicle manufacturing processes occurring in the Busan plant in South Korea, primarily due to a 51% of the electricity used being renewable electricity.





← Figure 14

Cradle-to-gate total climate impact in tCO_2e.

Table 7 presents the climate impact in tonnes CO_2e throughout the cradle-to-gate life cycle of the vehicle. The total cradle-to-gate climate impact amounts to 21.1 tonnes CO_2e (0.106 kg CO_2e/vkm) for 1 Dual motor vehicle and 20.2 (0.101 kg CO_2e/vkm) tonnes CO_2e for 1 Rear motor vehicle, material production and refining is the category with the largest share of impact. See visualisation of results in Figure 14.

Table 7 →

Cradle-to-gate total climate impact in tonne CO_2e.

Polestar 4 SUV	Dual motor	Rear motor
Materials production and refining	12.6	11.7
Li-ion battery modules	5.46	5.46
Logistics	2.66	2.66
Manufacturing	0.375	0.375
Total	21.1	20.2

Cradle-to-grave

The results of the comprehensive study for the vehicle, considering three distinct electricity mixes for the use stage, are presented in Figure 15 for the cradle-to-grave study.

The life cycle stages with the most significant climate impact for the global electricity mix are materials production and refining and the use phase. Depending on the electricity mixes for the use phase, the climate impacts differ.

During the use phase, large variations are observed depending on the electricity sources employed for driving. Wind power electricity exhibits the least climate impact during the use phase, followed by EU electricity mix.

← Figure 15

Total carbon footprint cradle- to-grave in kg CO_2e. The axis to the left presents the functional unit of 1 vkm and the axis to the right presents the vehicle's lifetime of 200 000km.

Polestar 4 SUV Dual motor	Global electricity		EU electricity		Wind power electricity	
FU	tCO_2e per vehicle	gCO_2e per vkm	tCO_2e per vehicle	gCO_2e per vkm	tCO_2e per vehicle	gCO_2e per vkm
Materials production and refining	12.6	63.1	12.6	63.1	12.6	63.1
Li-ion battery pack	5.46	27.3	5.46	27.3	5.46	27.3
Logistics	2.66	13.3	2.66	13.3	2.66	13.3
Manufacturing	0.375	1.88	0.375	1.88	0.375	1.88
Use phase	12.7	63.3	3.70	18.5	0.539	2.69
Maintenance	1.50	7.50	1.50	7.50	1.50	7.50
End-of-Life	0.729	3.64	0.729	3.64	0.729	3.64
Total	36.0	180	27.0	135	23.9	119

← Table 8

Cradle-to-grave climate impact with different energy mix during use phase for the functional unit 1 vkm measured in gCO_2e, and for the entire life cycle of 1 vehicle with driving distance 200 000 km measured in tonnes CO_2e.

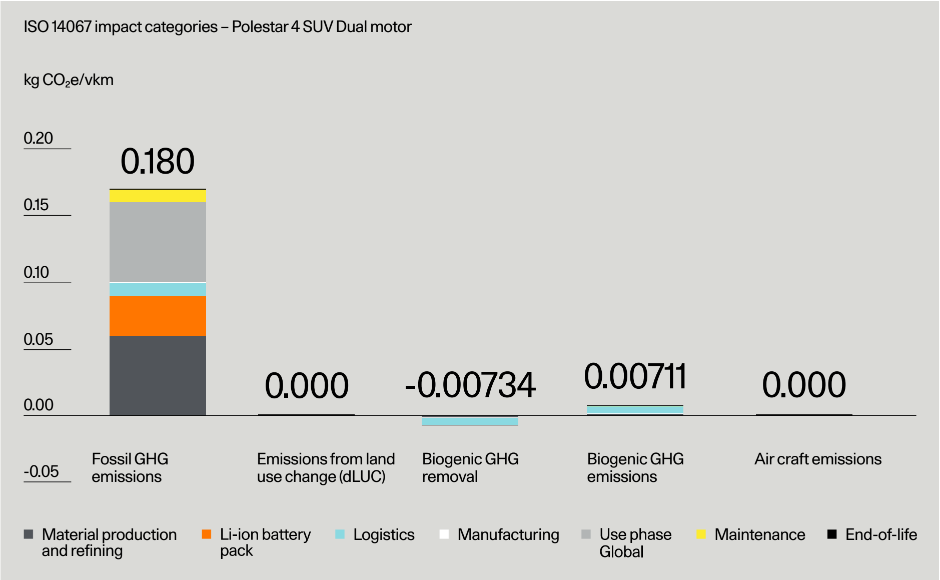
Tables 8 and 9 presents the climate impact in tonnes CO_2e and gCO_2e / vkm throughout the life cycle of the vehicle, for different electricity mixes during use phase. The total climate impact amounts to 36.0 tonnes CO_2e (0.180 kg CO_2e/vkm) for 1 Dual motor vehicle over its entire life with global electricity mix, with the material production and refining and use phase being the categories with the largest carbon footprint impact. For 1 Rear motor vehicle the total impact over its entire life with global electricity mix the results amount to 34.1 tonnes CO_2e (0.170 kg CO_2e/vkm).

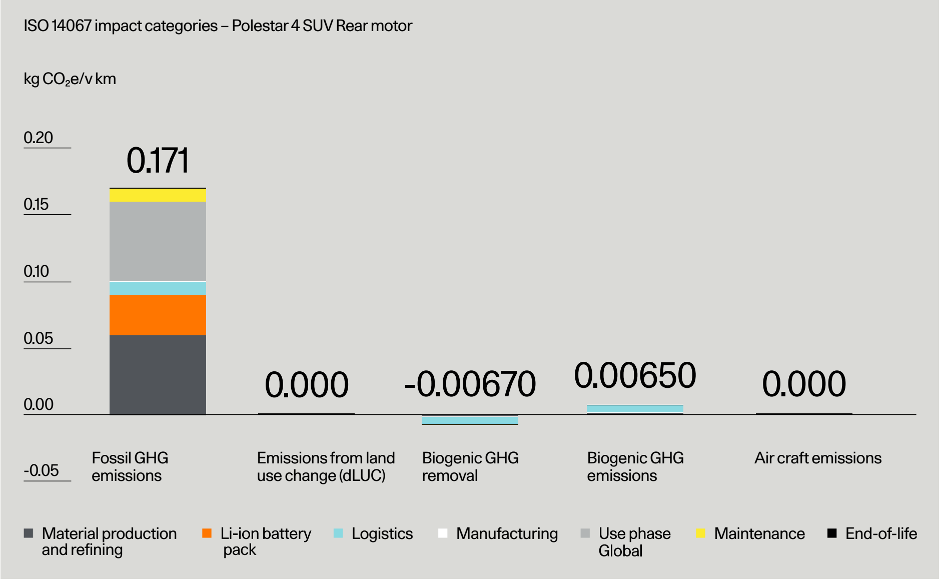
For EU electricity mix and for wind power electricity the highest climate impacts are seen in material production and refining and the Li-ion battery pack. Total climate impact over the lifetime of one vehicle accounts for 27.0 tonnes CO_2e and 23.9 tonnes CO_2e respectively, for 1 Dual motor vehicle.

Polestar 4 SUV Rear motor	Global electricity		EU electricity		Wind power electricity	
FU	tCO_2e per vehicle	gCO_2e per vkm	tCO_2e per vehicle	gCO_2e per vkm	tCO_2e per vehicle	gCO_2e per vkm
Materials production and refining	11.7	58.5	11.7	58.5	11.7	58.5
Li-ion battery pack	5.46	27.3	5.46	27.3	5.46	27.3
Logistics	2.66	13.3	2.66	13.3	2.66	13.3
Manufacturing	0.375	1.88	0.375	1.88	0.375	1.88
Use phase	11.7	58.3	3.41	17.0	0.496	2.48
Maintenance	1.50	7.50	1.50	7.50	1.50	7.50
End-of-Life	0.712	3.56	0.712	3.56	0.712	3.56
Total	34.1	170	25.8	129	22.9	115

← Table 9

Cradle-to-grave climate impact, Polestar 4 SUV Rear motor with different energy mix during use phase for the functional unit 1 vkm measured in gCO_2e, and for the entire life cycle of 1 vehicle with driving distance 200 000 km measured in tonnes CO_2e.





← Figure 16

Results cradle-to-grave for Polestar 4 SUV Dual motor according to functional unit 1 vkm for the five climate impacts categories according to ISO 14067 with global energy mix in kg CO_2e.

← Figure 17

Results cradle-to-grave for Polestar 4 SUV Rear motor according to functional unit 1 vkm for the five climate impacts categories according to ISO 14067 with global energy mix in kg CO_2e.

Climate impact categories

According to ISO 14067 this study includes the five different climate impact categories: fossil GHG emissions, emissions from land use change, biogenic GHG emissions and removal, and aircraft emissions.

The five climate change impact categories are shown in Figure 16 and 17. 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. Land use change emissions together with aircraft emissions are reported negligible in contrast to the other emissions. Biogenic carbon removal is equal in magnitude to biogenic emissions. These percentages are based on the global energy mix, due to that mix being the most conservative for GWP. In Table 10 and Table 11 all three energy mixes are represented for each climate impact category.

	Fossil GHG emissions gCO_2e	Emissions from land use change (dLUC) gCO_2e	Biogenic GHG removal gCO_2e	Biogenic GHG emissions gCO_2e	Aircraft emissions gCO_2e
Materials production and refining	63.3	0.0339	-1.70	1.43	0.000
Li-ion battery pack	27.3	0.000	0.000	0.000	0.000
Manufacturing	1.87	0.000	-0.0436	0.0540	0.000
Logistics	13.3	0.000	0.000	0.000	0.000
Use phase Global	63.2	0.0947	-5.43	5.46	0.000
Use phase EU	18.4	0.105	-11.7	11.7	0.000
Use phase Wind	2.68	0.00568	-0.168	0.178	0.000
Maintenance	7.50	0.000946	-0.0415	0.0456	0.000
End-of-Life	3.64	0.00363	-0.124	0.121	0.000

	Fossil GHG emissions gCO_2e	Emissions from land use change (dLUC) gCO_2e	Biogenic GHG removal gCO_2e	Biogenic GHG emissions gCO_2e	Aircraft emissions gCO_2e
Materials production and refining	58.7	0.0321	-1.49	1.25	0.000
Li-ion battery pack	27.3	0.000	0.000	0.000	0.000
Manufacturing	1.87	0.000	-0.0436	0.0540	0.000
Logistics	13.3	0.000	0.000	0.000	0.000
Use phase Global	58.2	0.0872	-5.00	5.03	0.000
Use phase EU	16.9	0.0969	-10.8	10.8	0.000
Use phase Wind	2.47	0.00523	-0.154	0.164	0.000
Maintenance	7.50	0.000946	-0.0415	0.0456	0.000
End-of-Life	3.56	0.00354	-0.122	0.118	0.000

← Table 10

Results, Polestar 4 SUV Dual motor according to functional unit 1 vkm for the five climate impacts categories according to ISO 14067 in gCO_2e.

← Table 11

Results, Polestar 4 SUV Rear motor according to functional unit 1 vkm for the five climate impacts categories according to ISO 14067.

Climate impact materials production and refining

The primary contributors to GHG emissions within the category materials production and refining (excluding battery) are aluminium, accounting for 37.2% (Rear motor) – 35.2% (Dual motor) of the total climate impact, followed by steel and iron at 31.0% (Rear motor) – 31.5% (Dual motor). Additionally, the climate impact from polymers at 16.3% (Rear motor) – 15.4% (Dual motor) and electronics 9.1% (Rear motor) – 11.2% (Dual motor) used in the vehicle rank as the third and fourth most significant. Other categories such as fluids, copper, other metals, and tyres also contribute but to a lesser degree. Figures 18 and 19 display the distribution of impacts per material category. Table 12 illustrates the results for GWP100 in tonnes CO_2e for the different materials used in the vehicle. Natural materials show a negative climate impact due to most of these parts being derived from wood which can carry a negative carbon footprint from cradle to gate. However, over the entire lifecycle these often become neutral or slightly positive.

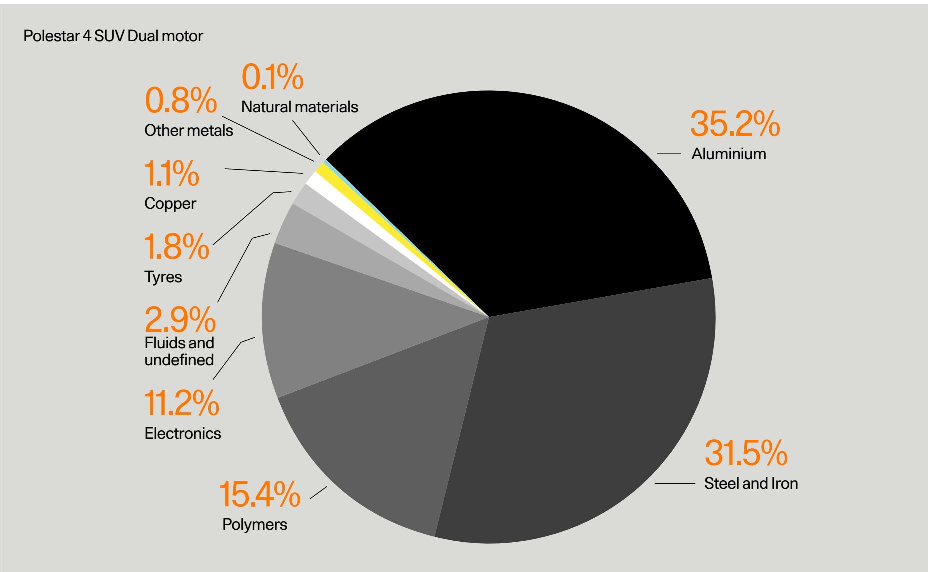
Table 12 →

GWP 100 results in tonnes CO_2e for different material categories.

Material category	Tonnes CO_2e per Polestar 4 SUV Dual motor	Tonnes CO_2e per Polestar 4 SUV Rear motor
Aluminium	4.44	4.35
Steel and Iron	3.98	3.63
Polymers	1.94	1.90
Electronics	1.42	1.07
Fluids and Undefined	0.365	0.324
Tyres	0.229	0.229
Copper	0.137	0.103
Other Metals	0.0961	0.0950
Natural Materials	0.0072	0.00936

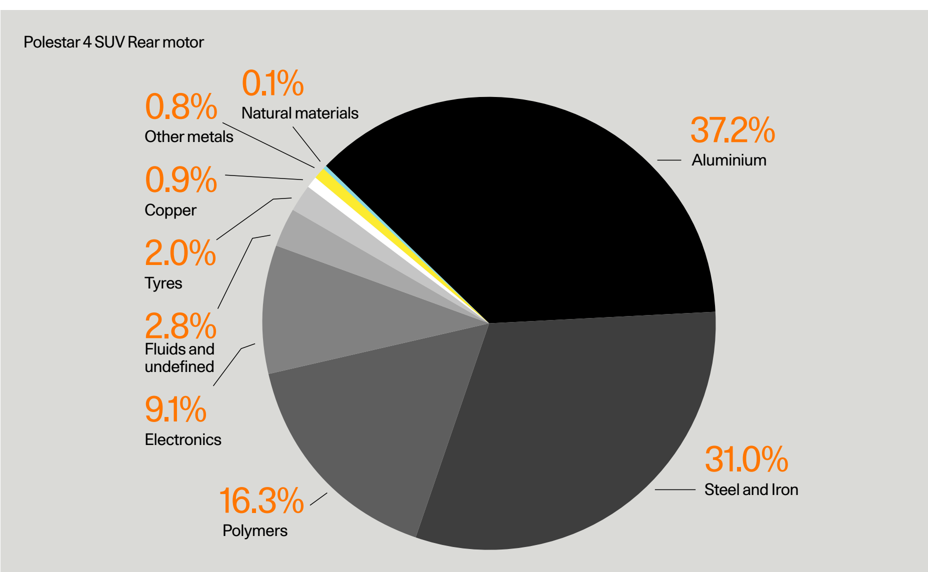
Climate impact of battery

The results for the battery climate impact were provided by the supplier in a LCA report. The scope includes analysing processes from raw material extraction to the finalised product at the battery supplier gate. The impact categories focus on GWP over 100 years. Evaluation was based on two functional units: kWh capacity of battery cells, and pack as summarised in chapter 2.8. Data from primary processes managed by the reporting company are included, while specific data sources include manufacturing plants and contracted suppliers, energy used as electricity comes mainly from hydropower from purchase agreements, and thermal power generated from natural gas. Generic data was based on attributional modelling and represent the process's geographical region and extracted from LCI databases such as ecoinvent and Sphera. The results reveal that the primary sources of greenhouse



← Figure 18

Share of GWP 100 results for different materials categories, Polestar 4 SUV Dual motor.



← Figure 19

Share of GWP 100 results for different materials categories, Polestar 4 SUV Rear motor.

gas emissions are production of the anode and cathode of the cell, along with the aluminium casing. Additionally, thermal energy from natural gas plays a significant role as a major contributor in the production process.

Climate impact of use phase

One of the stages in the vehicle's life cycle with the greatest emissions is the use phase, encompassing the vehicle's entire operational lifespan and the associated electricity usage. The climate impact within this category depends on the origin of electricity production. Notably, for the different scenarios in the use phase electricity sourced from wind power has the least environmental impact during the use phase, followed by the average EU electricity mix scenario. The impact from 100% wind-generated electricity is non-zero since the impacts resulting from the production of electricity generation infrastructure are also included within the system boundary.

Considering the anticipated changes in electricity production—specifically, the reduction in fossil fuel-based electricity and the concurrent increase in renewable electricity forecasted from 2026, it is expected that yearly emissions will decline. The distances driven are then multiplied by the emission factors corresponding to each year, reflecting the changes in global and European electricity. This process yields the graphical representation showcased in Figure 20. On average, the emissions throughout the entire lifespan amount to 0.33 kg CO_2e/kWh for the global electricity mix scenario and 0.10 kg CO_2e/kWh for the EU electricity mix scenario.

To be able to calculate the emissions in the use phase of the vehicle, the well-to-wheel emissions from electricity production, are needed. During the lifetime of the vehicle (15 years) it is expected to drive 200 000 km.

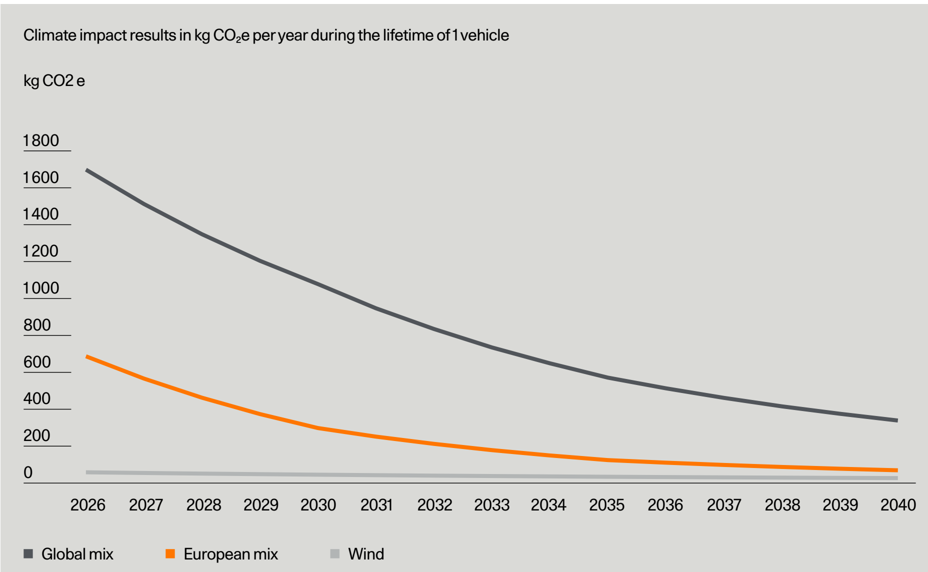
The energy-related emissions associated with the actual driving of the vehicle consist of the climate impact caused during production and distribution of the of the electricity used.

Electricity production is modelled according to three cases: regional (global and EU) grid mixes and a specific energy source (wind). Current and future global and EU electricity generation mixes are based on the World Energy Outlook 2024 Extended Dataset[20] from IEA. Amounts of electricity from different energy sources have in this study been paired with appropriate LCI datasets from Sphera Database (see Appendix 1) to determine the total climate impacts from different electricity generation mixes, both direct (at the site of electricity generation) and upstream.

Climate impact of maintenance

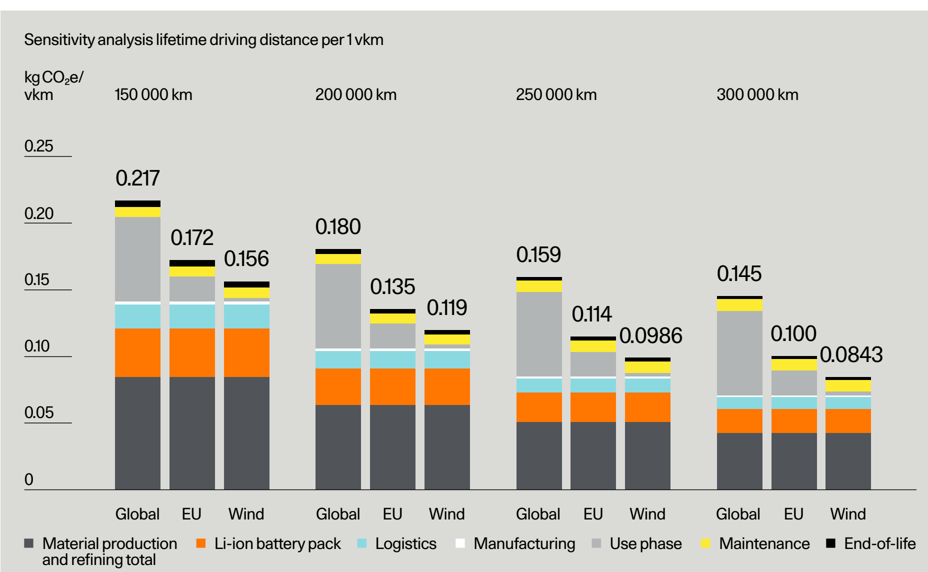
The result from the cradle-to-grave study shows that the expected maintenance of the vehicle contributes approximately 1.50 tonnes of CO_2e to the total climate impact of the Polestar 4 SUV for both variants, this amounts to 7.50 gCO_2e/vkm. The replacement of tyres is the largest contributor at 77% followed by the exchange of 12 V batteries at 9%, cabin filter and windscreen wiper exchanges contribute 3% each. The rest of the components together account for 7% of the total climate impact arising because of vehicle maintenance. In previous studies changing of brake discs have been a significant source of emissions, however the frequency of changing of brake discs have proven to be a lot lower for BEVs due to the high use of regenerative braking from the e-motors.

20 World Energy Outlook 2024 Extended Dataset - Data product - IEA



← Figure 20

Climate impact results in kg CO_2e per year during the lifetime of 1 Polestar 4 SUV Dual motor vehicle and 200 000 km driving distance with different electricity mixes during use phase.



← Figure 21

Sensitivity analysis of Polestar 4 SUV Dual motor using lifetime driving distance per 1 vkm (functional unit) for driving distance 150 000 km, 200 000 km, 250 000 km and 300 000 km with different electricity mix scenarios.

Sensitivity analysis

Given the fact that the results from this study are dependent on data which may differ during real world usage of the vehicle, exploring the climate impact of the vehicle when varying certain key parameters is interesting. A sensitivity analysis was carried out to examine the climate impact of lifetime driving distance, the electricity source during the use phase as well as use phase electricity consumption.

Lifetime driving distance

The current study assumes a lifetime distance driven of 200 000 km, as that is a common distance to use in personal vehicle LCA studies. Larger personal vehicles, such as SUVs, can be argued to have a longer lifetime distance driven[21]. For that reason, a sensitivity analysis with 250 000 km and 300 000km lifetime distances driven was carried out. To explore the effects of a shorter lifetime distance driven, a sensitivity analysis of 150 000 km was also carried out. Figure 21 presents the results of the cradle-to-grave life cycle for the different driving distances together with different electricity scenarios. The sensitivity analysis is presented in Figure 21 and only considers the Polestar 4 SUV Dual motor, the Rear motor variant would present very similar results in terms of the general trends.

Maintenance scenario

Lifetime affects maintenance of the vehicle and Table 13 describes the maintenance for lifetimes included in the sensitivity analysis for lifetime driving distance. The 12V lead battery is not assumed to be replaced more due to increased milage since the main factor is not milage but aging of the battery. Since the same 15-year lifetime is assumed, no additional 12V batteries added.

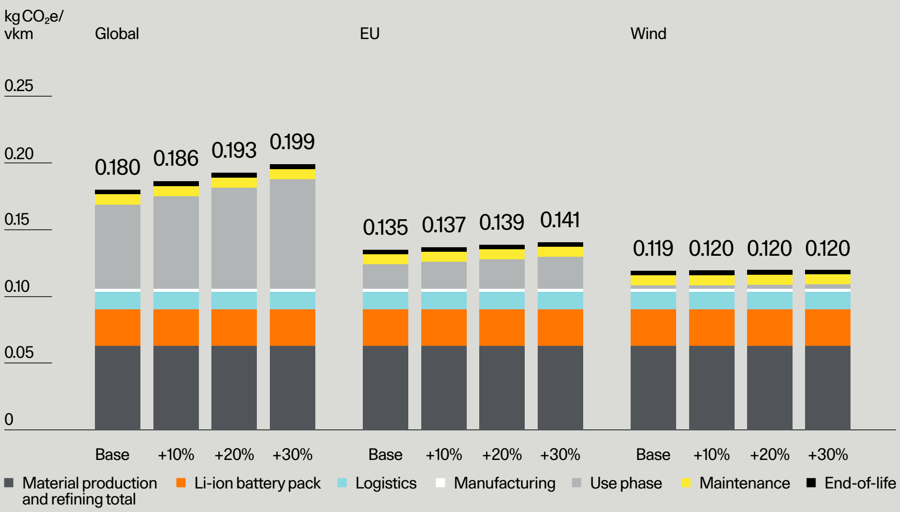
Table 13 →

Parts changed during maintenance for different driving distances of the vehicle.

Vehicle part	150 000km	200 000km	250 000km	300 000km
Wiper blades	30	39	48	60
Tyres	12	16	24	28
Brake fluid (l)	3	4	5	6
Brake pads	4	4	8	8
Brake discs	0	0	0	2
Lead, battery 12 V	3	3	3	3
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

21 Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA - Publications Office of the EU

Sensitivity analysis lifetime driving distance per 1 vkm



← Figure 22

Sensitivity analysis of electricity consumption in use phase per vkm (functional unit) for driving distance 200 000 km with different electricity mix scenarios and increases in baseline WLTP electricity consumption.

Use phase electricity consumption

Electricity consumption is calculated based on the WLTP standard. However, this method does not account for factors such as individual driving behavior, traffic conditions, weather conditions, road gradient, or vehicle load—each of which can significantly influence actual electricity use. To account for potential underestimations in certain markets, an evaluation of the impact of 10%, 20% and 30% increases in electricity consumption is included in this sensitivity analysis. These effects are reflected in the results given in Figure 22 and Table 14. The analysis only considers the Polestar 4 SUV Dual motor, the Rear motor variant would present very similar results in terms of the general trends.

Electricity consumption scenario	Tonnes CO_2e per vehicle	kg CO_2e per vehicle km
Global base	36.0	0.180
Global +10%	37.3	0.186
Global +20%	38.5	0.193
Global +30%	39.8	0.199
EU base	27.0	0.135
EU +10%	27.4	0.137
EU +20%	27.8	0.139
EU +30%	28.2	0.141
Wind base	23.9	0.199
Wind +10%	23.9	0.120
Wind +20%	24.0	0.120
Wind +30%	24.0	0.120

Table 14 →

ensitivity analysis of electricity consumption in use phase per 1 vehicle (functional unit) and per vkm (functional unit) for driving distance 200 000 km with different electricity mix scenarios and increases in baseline WLTP electricity consumption.

4

In conclusion the climate impact of the cradle-to-gate study of the Polestar 4 SUV Dual motor variant reveals that 59.7% is caused by material production and refining of which aluminium represents 35.2% of these emissions, iron and steel contributing with 31.5% and polymers 15.4%. Following is the production of battery pack which emerge as a significant factor, constituting 25.9% of the cradle-to-gate impact. Logistics contribute 12.6% and manufacturing contributes 1.78%. The Rear motor variant present similar results, however, the share of emissions from material production and refining is slightly lower at 57.9% due to the fact that the vehicle has one less motor.

The cradle-to-grave study reveals a total carbon footprint for the complete life cycle of the Polestar 4 SUV Dual motor variant of 36.0 tonnes CO_2e over the complete lifetime with global electricity mix in the use phase, in terms of the functional unit per vkm the same result amounts to 0.180 kg CO_2e/vkm. 35.0% of the total climate impact is caused by the material production and refining (excluding battery pack). Following is the use phase (global electricity mix) contributing 35.2% of the vehicle's total climate impact, and then the battery pack, constituting 15.2% of the overall climate impact. The Rear motor variant again present similar results.

The study categorises the environmental impact into five climate change impact categories, as depicted in Figures 16 and 17. Fossil GHG emissions emerge as the predominant contributor, accounting for 0.180 kg CO_2e/vkm (Dual motor variant). Biogenic carbon emission contributes the second most with 0.00711 kg CO_2e/vkm (Dual motor variant), which is low in comparison to the fossil emission.

Due to the use phase contributing a large share of the emissions for the lifetime of the vehicle the emissions connected to the electricity production during this phase is of importance. One can see in Figure 15 that renewable electricity production such as wind power reduces the overall lifetime climate impact. The same goes for EU electricity mix and solar power (available in Appendix 7), however not contributing to the same extent. This is due to the larger share of electricity production stemming from renewable sources in the EU electricity mix, as seen in Figure 10.

When considering emissions linked to battery manufacturing as per the battery pack supplier LCA, the emissions might appear relatively low to the industry. Although electricity use in production is one of the major contributors to emissions in battery pack production, 100% renewable electricity is used. Another action taken by the battery pack supplier to reduce GHG emissions is the use of aluminium from smelters running on renewable electricity for the battery pack structure as well as the incorporation of recycled aluminium in these components.

The results of the sensitivity analysis on the Dual motor variant for three different driven lifetime km scenarios, 150 000 km, 250 000 km and 300 000 km, demonstrate that the longer distance driven by the vehicle over the lifetime the lower the emissions per vehicle km. This suggests that whilst total emissions per vehicle over its lifetime will be higher, on a per-kilometre basis, the climate impact of the vehicle is lower when covering a longer lifetime distance (i.e. fewer vehicles are required to provide the same utility in terms of km driven). As transportation solutions with a lower climate impact are a necessity to reach globally set targets for climate neutrality, these results emphasise the potential benefits of optimising vehicle usage over its entire lifespan for reduced climate impact.

The sensitivity analysis of increased electricity consumption in the use phase on the Dual motor variant suggests that increased consumption has an impact on the per vehicle km climate impact, but not to a very high extent. The largest increase of climate impact per vehicle km is observed in the +30% global electricity mix scenario where the impact increased from 0.180 kg CO_2e / vkm in the baseline scenario to 0.199 kg CO_2e / vkm. On per vehicle km basis this may not seem as much but in absolute numbers, per vehicle over its lifetime, this increase amounts to 3.8 tonnes CO_2e over the 200 000km lifetime. The absolute figure of the increase for the +30% EU electricity and wind power electricity scenarios is 1.1 and 0.2 tonnes CO_2e, respectively. Thereby it can be concluded that driving behaviour, weather conditions and other factors which influence vehicle electricity consumption has an impact on the use phase climate impact.

The EU regulation[22] regarding batteries and waste batteries from 2023 outlines the importance for future end-of-life handling of lithium-ion batteries. The framework emphasises various crucial elements such as recycled content, collection rates, and end-of-life considerations.

The regulation places a strong emphasis on harmonising product and marketing requirements across the life cycle of batteries. To enhance future reports, environmental implications associated with the disposal and recycling of batteries utilised in vehicles would be beneficial. This would give a more comprehensive picture of the impacts and challenges linked to the end-of-life management of batteries in the context of electric vehicles.

Environmental sustainability involves a multifaceted perspective. While the focus of the study has been on carbon emissions following ISO 14067, future assessments should also aim to broaden the scope by incorporating other significant environmental impact categories such as water consumption, resource depletion, and impact on biodiversity. Expanding the analysis will yield a more holistic evaluation of the vehicle's environmental performance, allowing the possibility to make more informed decisions about its overall sustainability. A limitation to the study is the prediction on future electricity grid GHG intensity, as these based on scenarios from the IEA it could be of interest to assess alternative future energy scenarios in addition to IEA STEPS scenarios as these scenarios have a history of changing to a high degree in between years. Additionally, a key limitation is the reliance on generic data from ecoinvent and Sphera for most materials and parts in the vehicle. For future reports supplier specific data for more materials and parts can increase the accuracy of carbon footprint reporting.

Material extraction and refining and Li-ion battery pack production as well as electricity usage in the use phase, depending on electricity mix are identified as three hot spots, just as in previous Polestar carbon footprint reports. Further efforts in reducing the climate impact from these categories is needed to reduce the carbon footprint of battery electric vehicles and reach globally set targets for climate neutrality. As this is the part of the vehicle life cycle of which Polestar holds the most influence, these parts of the life cycle should remain the focus of decarbonisation efforts.

22 REGULATION (EU) 2023/1542 OF THE EUROPEAN PARLIAMENTAND OF THE COUNCIL of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC

← Table 15

Chosen datasets for materials.

In the LCA a large number of generic datasets from databases are used. In this appendix the datasets used are listed, see Table 15. Some materials are listed multiple times with different datasets. The reason is that the material carbon footprint is modelled based on a mix of the different datasets corresponding to the material composition. Datasets from Sphera Professional are all from version 10.9.5.2.

Material	Location	Dataset name	Type	Source
ABS	GLO	market for acrylonitrile-butadiene-styrene copolymer	agg	ecoinvent 3.12
Aluminium	CN	aluminium ingot mix IAI 2019	agg	IAI via Sphera professional database
Aluminium, recycled	RNA	Aluminum, secondary, ingot, at plant USLCI – open energy inputs	p-agg	USLCI via Sphera professional database
Aramid	DE	aramide fiber (para-aramid)	agg	Sphera professional database
Brake fluid	RoW	market for diethylene glycol	agg	ecoinvent 3.12
Cast iron	DE	cast iron part (automotive) - open energy inputs	p-agg	Sphera professional database
Catalytic coating	ZA	market for platinum group metal concentrate	agg	ecoinvent 3.12
Copper	EU-28	copper Wire Mix (Europe 2015)	agg	DKI/ECI via Sphera professional database
Copper alloys	GLO	copper mix (99.999% from electrolysis) (65%)	agg	Sphera professional database
Copper alloys	GLO	market for zinc (35%)	agg	ecoinvent 3.12
Cotton	GLO	market for textile, woven cotton	agg	ecoinvent 3.12
Damper	RoW	market for polymethyl methacrylate (60%)	agg	ecoinvent 3.12
Damper	RoW	market for lime (40%)	agg	ecoinvent 3.10.1
E/P	GLO	polyethylene production, low density, granulate	agg	ecoinvent 3.12
Electronics	GLO	market for printed wiring board, surface mounted, unspecified, Pb containing	agg	ecoinvent 3.12
EPDM	DE	ethylene Propylene Diene Elastomer (EPDM)	agg	Sphera professional database
Epoxy	GLO	market for epoxy resin, liquid	agg	ecoinvent 3.12
EVAC	GLO	market for ethylene vinyl acetate copolymer	agg	ecoinvent 3.12
Ferrite magnet	GLO	market for ferrite	agg	ecoinvent 3.12
Filler for Polymer	RER	Talcum Powder (filler) (64%)	agg	Sphera professional database
Filler for Polymer	GLO	Market for glass fibre (36%)	agg	ecoinvent 3.12
Float glass	RoW	market for flat glass, coated	agg	ecoinvent 3.10.1
Friction	DE	cast iron part (automotive) - open energy inputs (48%)	agg	Sphera professional database

Material	Location	Dataset name	Type	Source
Friction	GLO	market for zirconium oxide (12%)	agg	ecoinvent 3.12
Friction	GLO	market for graphite (11%)	agg	ecoinvent 3.12
Friction	GLO	market for barium sulfide (10%)	agg	ecoinvent 3.12
Friction	GLO	market for barite (7%)	agg	ecoinvent 3.12
Friction	GLO	market for aluminium hydroxide (5%)	agg	ecoinvent 3.12
Friction	GLO	market for magnesium oxide (4%)	agg	ecoinvent 3.12
Friction	GLO	market for expanded vermiculite (2%)	agg	ecoinvent 3.12
Friction	EU-28	calcined petroleum (2%)	agg	Sphera professional database
GF-fibre	GLO	market for glass fibre	agg	ecoinvent 3.12
Glycol	RoW	market for ethylene glycol	agg	ecoinvent 3.12
Lead, battery	DE	lead (99.995%)	agg	Sphera professional database
Lubricants	EU-28	lubricants at refinery	agg	Sphera professional database
Magnesium	CN	magnesium	agg	Sphera professional database
NdFeB	GLO	market for permanent magnet, electric passenger car motor	agg	ecoinvent 3.12
NR	GLO	market for seal, natural rubber based	agg	ecoinvent 3.12
PA	DE	Polyamide 6 granulate (PA 6) mix	agg	Sphera professional database
PBT	DE	polybutylene Terephthalate Granulate (PBT) Mix	agg	Sphera professional database
PC	GLO	market for polycarbonate	agg	ecoinvent 3.12
PE	RoW	polyethylene production, low density, granulate	agg	ecoinvent 3.12
PET	GLO	market for polyethylene terephthalate, granulate, amorphous	agg	ecoinvent 3.12
PMMA	RoW	Polymethyl methacrylate	agg	ecoinvent 3.12
Polymer, recycled	EU-28	Plastic granulate secondary (low metal contamination)	agg	Sphera professional database
Polyester	GLO	market for fibre, polyester	agg	ecoinvent 3.12
Polyurethane	RoW	market for polyurethane, rigid foam	agg	ecoinvent 3.12

Material	Location	Dataset name	Type	Source
POM	DE	polyoxymethylene (POM)	agg	Sphera professional database
PP	CN	market for polypropylene, granulate	agg	ecoinvent 3.12
PS	GLO	market for polystyrene, general purpose	agg	ecoinvent 3.12
PVB	DE	polyvinyl butyral granulate (PVB) by-product ethyl acetate	agg	Sphera professional database
PVC	GLO	polyvinylchloride production, suspension polymerisation	agg	ecoinvent 3.12
R-1234yf	DE	R-1234yf production (approximation)	agg	Sphera professional database
SBR	DE	styrene-butadiene rubber (S-SBR) mix	agg	Sphera professional database
Silicone rubber	DE	silicone rubber (RTV-2, condensation)	agg	Sphera professional database
Steel, Sintered	Asia	steel hot dip galvanised (1%)	agg	Worldsteel via Sphera professional database
Steel, Stainless, Austenitic	RER	stainless steel cold rolled coil (304)	p-agg	Eurofer via Sphera professional database
Steel, Stainless, Ferritic	EU-28	stainless steel cold rolled coil (430)	p-agg	Eurofer via Sphera professional database
Steel, Unalloyed	Asia	steel hot dip galvanised (89%)	agg	Worldsteel via Sphera professional database
Steel, Unalloyed	RoW	market for waste steel (11%)	agg	ecoinvent 3.12
Sulphuric acid	EU-28	sulphuric acid (96%)	agg	Sphera professional database
Thermoplastic elastomers	DE	polypropylene / Ethylene Propylene Diene Elastomer Granulate (PP/EPDM, TPE-O) Mix	agg	Sphera professional database
Thermoplastics	GLO	market for nylon 6	agg	ecoinvent 3.12
Tyre	KR	Supplier specific carbon footprint report	agg	Tire supplier
Undefined	GLO	market for nylon 6	agg	ecoinvent 3.12
Washer fluid	DE	Ethanol (96%) (hydrogenation with nitric acid)	agg	Sphera professional database
Wood (paper, cellulose ...)	EU-28	Laminated veneer lumber (EN15804 A1-A3)	agg	Sphera professional database
Zinc	GLO	Special high-grade zinc	p-agg	IZA via Sphera professional database

↓ Table 16

Chosen datasets for material manufacturing processes.

Process	Location	Name	Type[23]	Source
Aluminium manufacturing	DE	aluminium die-cast part	u-so	Sphera professional database
Aluminium manufacturing	EU-28	aluminium sheet – open input aluminium rolling ingot	p-agg	Sphera professional database
Aluminium manufacturing	DE	aluminium sheet deep drawing	u-so	Sphera professional database
Aluminium manufacturing	RNA	Extrusion of aluminium billet, AEC	p-agg	Sphera professional database
Polymers (all categories) manufacturing	DE	Plastic injection moulding part (unspecific)	u-so	Sphera professional database
Stainless (all categories) manufacturing	DE	Steel sheet deep drawing (multi-level)	u-so	Sphera professional database

Electricity	Location	Name	Year	Type	Source
Chinese electricity grid mix	CN	Electricity grid mix 1kV-60kV	2026	agg	Sphera professional database
Thermal energy from natural gas	CN	CN Thermal energy from natural gas	2026	agg	Sphera professional database
Natural gas	CN	CN Natural gas mix	2026	agg	Sphera professional database

↑ Table 17

Chosen datasets for energy and electricity for material manufacturing processes.

23 U-so datasets have been adapted to use the “Chinese electricity grid mix”, “Thermal energy from natural gas” and “Natural gas” from Table 17.

↓ Table 18

Chosen datasets for electricity used in vehicle manufacturing at Renault Korea Busan plant.

Electricity	Location	Name of LCI dataset	Year	Type	Share	Source
Grid electricity South Korea	KR	Electricity grid mix 1kV-60kV	2026	agg	49%	Sphera professional database
Electricity from photovoltaic	KR	Electricity from photovoltaic	2026	agg	51%	Sphera professional database

Material category	Location	Name of LCI dataset	Year	Type	LCI database
Use phase					
Electricity from solar power	RER	Electricity from photovoltaic	2026	agg	Sphera professional database
Electricity from wind power	RER	Electricity from wind power	2026	agg	Sphera professional database
Electricity from geothermal	RER	Electricity from geothermal	2026	agg	Sphera professional database
Electricity from hydro power	RER	Electricity from hydro power	2026	agg	Sphera professional database
Electricity from bioenergy	RER	Electricity from biomass (solid)	2026	agg	Sphera professional database
Electricity from nuclear power	RER	Electricity from nuclear	2026	agg	Sphera professional database
Electricity from unabated coal	RER	Electricity from hard coal	2026	agg	Sphera professional database
Electricity from unabated gas	RER	Electricity from natural gas	2026	agg	Sphera professional database
Electricity from oil	RER	Electricity from heavy fuel oil (HFO)	2026	agg	Sphera professional database
Transmission and distribution losses	RER	Electricity grid mix 1kV-60kV (loss figure is licensed data and cannot be disclosed)	2026	N/A	Sphera professional database

↑ Table 19

Chosen data sets for electricity for use phase.

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Table 20 →

IMDS Material Library material categories.

Material name	Material group
Steel, sintered	Steel and iron
Steel, unalloyed	Steel and iron
Steel, stainless, austenitic	Steel and iron
Steel, stainless, ferritic	Steel and iron
Cast iron	Steel and iron
Aluminium	Aluminium
Low carbon aluminium	Aluminium
Recycled aluminium	Aluminium
Recycled aluminium produced with renewable electricity	Aluminium
Copper alloys	Copper
Magnesium	Other Metals
Zinc	Other Metals
NdFeB	Other Metals
ABS (filled)	Polymers
ASA (filled)	Polymers
E/P (filled)	Polymers
EVAC (filled)	Polymers
PA (filled)	Polymers
PBT (filled)	Polymers
PC (filled)	Polymers
PC+ABS (filled)	Polymers
PE (filled)	Polymers
PET (filled)	Polymers
PMMA (filled)	Polymers
POM (filled)	Polymers
PP (filled)	Polymers
PVB (filled)	Polymers
PVC (filled)	Polymers
ABS (unfilled)	Polymers

Material name	Material group
ASA (unfilled)	Polymers
E/P (unfilled)	Polymers
EVAC (unfilled)	Polymers
PA (unfilled)	Polymers
PBT (unfilled)	Polymers
PC (unfilled)	Polymers
PC+ABS (unfilled)	Polymers
PE (unfilled)	Polymers
PET (unfilled)	Polymers
PMMA (unfilled)	Polymers
POM (unfilled)	Polymers
PP (unfilled)	Polymers
PVB (unfilled)	Polymers
PVC (unfilled)	Polymers
Thermoplastics	Polymers
Thermoplastic elastomers	Polymers
Elastomer	Polymers
EPDM	Polymers
NR	Polymers
SBR	Polymers
Silicone rubber	Polymers
Epoxy	Polymers
Polyurethane	Polymers
Damper	Polymers
Polyester	Polymers
Aramid	Polymers
Tyre	Tyres
Lubricants (matcat)	Fluids & Undefined
Brake fluid	Fluids & Undefined

Material name	Material group
Catalytic coating	Fluids & Undefined
Ceramic	Fluids & Undefined
Damper	Fluids & Undefined
Ferrite magnet	Fluids & Undefined
Float glass	Fluids & Undefined
Friction	Fluids & Undefined
GF-Fibre	Fluids & Undefined
Glycol	Fluids & Undefined
Lead, battery	Fluids & Undefined
Sulphuric acid	Fluids & Undefined
Cotton	Natural Materials
Wood (paper, cellulose ...)	Natural Materials
Washer fluid	Fluids & Undefined
Undefined	Fluids & Undefined
R-1234yf	Fluids & Undefined
NR	Natural Materials
Leather	Natural Materials

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Life cycle assessment

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Appendix 3 – Summary of data choices and assumptions for component manufacturing

Table 21 →

Summary of data choices and assumptions for component manufacturing.

Material	Assumption on component manufacturing	Comment	Material utilisation rate in additional component manufacturing
Cast iron	No extra manufacturing processes	The chosen dataset already includes the production of a finished part to be used in automotive applications.	
Fluids	No extra manufacturing processes	Assumed that fluids do not need further refining after production of the raw material (the fluid itself).	
Tyres	No extra manufacturing processes	Assumed that the processes after vulcanisation only has minor GHG-emissions	
Copper (wire)	No extra manufacturing processes	Assumed that processing after manufacturing into copper wire has negligible emissions and waste.	
NdFeB magnets	No extra manufacturing processes	The chosen dataset already includes the production of a finished magnet to be used in electric motors for automotive applications	
Electronics (PCBs)	No extra manufacturing processes	The chosen dataset already includes the production of a finished printed circuit board.	
Cast Aluminium	Die-casting process	Assumed to represent different types of casting processes. MUD according to dataset	96%
Pressing Aluminium	Rolling and Aluminium sheet deep drawing	Assumed to represent different types of pressing processes. MUD according to dataset	62%
Extrusion Aluminium	Extrusion process	Assumed to represent different types of extrusion processes. MUD according to article "Reducing the environmental impacts of aluminum extrusion[24]	82%
Steel (in parts, processed at suppliers)	Steel sheet deep drawing	Sheet is assumed to adhere to the conservative approach as most parts are likely not made from sheets as an input material MUD according to dataset	63%
Steel (stamped in Busan plant)	Steel scrap generated at Busan plant	The steel scrap generated at stamping in the Busan plant, that is the steel in workstream "vehicle structures"	Confidential
Stainless steel	Steel sheet deep drawing	Sheet is assumed to adhere to the conservative approach as most parts are likely not made from sheets as an input material MUD according to dataset	63%
Polymers	Injection moulding process	Assumed to represent different types of processes	98%
Other materials	Raw material weight x2	Emissions from raw material production has been multiplied by two, to compensate for further refining and processing.	50%

24 Reducing the environmental impacts of aluminum extrusion - ScienceDirect

Disassembly stage	Pre-processing stage	Final disposal
Batteries	Separated handling. Lead recovery from lead acid and designated Li-ion battery dismantling	According to material category*
Tyres	Pre-treatment for tyre recycling	None (sent to material recycling)
Liquids (coolants, brake fluid etc)		Incineration
Airbags and seat belt pretensioners	Disarming of explosives. Shredding	According to material category*
Rest of vehicle	Shredding	According to material category*

*Metals sent to material recycling, combustible materials to incineration (mainly plastics) and residue to landfill

← Table 22

Data collection activities.

Transport

Transportation of materials sent to material recycling is included and is conservatively assumed to be transported 100 km by truck.

Disassembly

The disassembly stage is, globally, still a mostly manual process. The energy usage of this stage was therefore disregarded.

Pre-treatment

Pre-treatment and 500km of transport were included for the following disassembled components:

- Lead acid battery
- Tyres
- Li-ion batteries
- Fluids

For the lead acid batteries and tyres, ecoinvent datasets were used for the pre-treatment stage. The Li-ion battery is assumed to be of high value and were assumed to be shredded into black mass and then recycled, no specific recycling process of the black mass is assumed however, both hydrometallurgical and pyrometallurgical Li-ion battery recycling can use black mass as input material. For the remaining disassembled parts, no inventory was made since their disassembly is mainly done as a safety precaution. After this stage, they will be handled similarly to the rest of the vehicle. The fluids that are incinerated likewise do not go through any pre-treatment.

Shredding

In the shredding process, the vehicles are milled to smaller fractions. This process uses electricity. To estimate the amount of energy needed, the energy usage per kg in the dataset "treatment of used glider, passenger car, shredding" from ecoinvent 3.12 was used. The electricity used for this process was modelled as a 2040 global electricity mix, based on the IEA STEPS scenario and Sphera professional database data. Emissions of metals to water and air have been omitted due to the focus on climate change. The entire vehicle, except the parts sent for specific pre-treatment, is sent through the shredding process. No additional transport is included, as shredding is modelled as occurring at the same site as dismantling.

Material recycling

This is the fate of the flows of metals from the shredding, as well as for the materials in the pretreated components. Based on the choice of the cut-off allocation approach for end-of-life modelling, this stage is outside the boundaries of the life cycle and is not included in the inventory, except for the transportation to material recycling, as mentioned above.

Final disposal – incineration and landfill

The disassembled fluids as well as the combustible part of the shredder light fraction, are modelled to be incinerated without energy recovery. The choice to not include energy recovery relates to the global scope of the study.

To model the emissions from the combustion of material from the shredder, a dataset for incineration of mixed plastics was used, based on the main content of the flow going to this stage. The main part of the weight will be from the plastics in the vehicle. The dataset chosen was a Sphera dataset of EU-28 waste incineration of plastics (unspecified) fraction in municipal solid waste (MSW). The EU-28 dataset was chosen due to the lack of datasets representing the global average situation. 50% of plastics is assumed to be incinerated while the other 50% is assumed to be sent to landfill. This to make a rough estimation of the global average situation.

Non-combustible materials, such as ceramics and glass, are a small part of the vehicle but make up the part of the shredder light fraction that cannot be combusted. This flow is either landfilled or recycled as filler material, in both cases modelled with a dataset for landfilling of glass/inert matter, from Sphera.

Transportation of materials which are separated in the shredding processes, and which are assumed to be recycled is conservatively estimated to be 100 km by truck.

Data collection

This section provides an overview of the data collection activities relating to each life cycle stage, see Table 22. According to the cut-off EoL allocation approach, the processes presented below are included in the data collection effort.

Aspect	1	2	3	4	5
Temporal correlation (time related coverage)	Less than three years of difference to year of study	Less than six years of difference	Less than 10 years of difference	Less than 15 years of difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area of process origin	Average data from larger area in which area of process origin is included	Data from area with similar production conditions	Data from specified area used for process in unknown area	Data from area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprise or group of enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different or unknown technology
Represent-ative	Representative data from sufficient sample over an adequate period to even out normal fluctuations (this includes future projection if necessary)	Representative data from a small sample but for adequate periods	Representative data from sufficient sample but from shorter periods	Representative data but from a small sample and shorter periods or incomplete data from sufficient sample and periods	Representative-ness unknown or incomplete data from a small sam-ple and/or shorter periods
Precision	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

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← Table 23

Data quality indicator matrix used to assess the data used in the study.

Table 23 lists the data quality indicators used to assess the data used in this study. Each datapoint has received a score from 1 (best) to 5 (worst) according to five different correlation aspects. Table 24 lists the scores for the data used for materials production and refining in the study. Table 25 summarises the findings.

For the temporal and geographical correlation, the scores vary widely. The datasets from ecoinvent are often more than 10 years old, while Sphera professional database datasets tend to be less than three years old. The most important reason why the geographical correlation varies widely is that the origin of many materials is unknown. The origin of the materials that are used in the largest quantity and with the largest overall climate impact, however, score 1-2 on geographical coverage: aluminium, steel and battery pack. Another material group with high climate impact is electronics. Electronics scores poorly on both geographical and technological correlation, which should be considered when interpreting the results. Overall, technological correlation also has a large variation in scores, however, most of the data has 2 as a score. Representativeness and precision have good scores, as the data is from databases or supplier specific.

Car manufacturing and logistics receive overall good scores as the data is collected from partner production facilities and controlled or overseed processes. The use phase also scores well, as electricity usage data is based on vehicle specific measurements, and climate impact calculations are based on new emission factors from the Sphera professional database (2026) and current and forecasted electricity mix data from IEA (2024). The End-of-Life treatment receives fewer good scores as data from the current state is used, and it is highly uncertain how well it correlates to the conditions in 15 years. It is also highly uncertain how the waste handling will be (and in some cases currently is) performed in different markets.

Regarding completeness aspect of the study, the criteria has been met through the use of credible data sources such as ecoinvent, Sphera and the IEA and by collecting carbon footprint data from the battery pack supplier. The consistency requirement has been ensured by applying the same functional unit, system boundaries, allocation rules, cut-off criteria, GWP100 method, database versions, and modelling assumptions across all life-cycle stages. All methodological choices are aligned, documented, and any deviations are transparently justified. The study is reproducible as methods, assumptions, and data sources are clearly described and referenced, enabling an independent practitioner to replicate the results. Data are sourced from credible and recognised databases, literature, and reports, with full references provided to ensure transparency. Uncertainty is addressed by using high-quality data, documenting assumptions, and acknowledging limitations related to data, models, and methodological choices.

Based on the comprehensive assessment of data quality, it is indicated that the data quality requirements outlined in section 1.7 are met.

← Table 24

Quality assessment of data used for materials and processes in the study.

					Correlation score				
Material/process	Location	Dataset name	Year	Source	Temporal	Geographical	Technological	Representative	Precision
ABS	GLO	market for acrylonitrile-butadiene-styrene copolymer	2024	ecoinvent 3.12	1	4	2	1	1
Aluminium	CN	aluminium ingot mix IAI 2019	2019	IAI/Sphera professional database	3	1	2	1	1
Aluminium from hydropower	CN	Low carbon aluminium	2022	Polestar's own investigations	2	1	1	1	2
Aluminium, recycled	RNA	RNA: Aluminum, secondary, ingot, at plant USLCI – open energy inputs	2003	Sphera professional database / USLC	5	5	2	1	1
Aramid	DE	aramide fiber (para aramid)	2021	Sphera professional database	2	5	2	1	1
Battery pack	CN	Polestar 4 battery pack	2024	Battery pack supplier	1	1	1	1	2
Brake fluid	GLO	market for diethylene glycol	2011	Ecoinvent 3.12	5	4	2	1	1
Cast iron	DE	cast iron part (automotive) - open energy inputs	2023	Sphera professional database	2	5	2	1	1
Catalytic coating	ZA	market for platinum group metal concentrate	2018	ecoinvent 3.12	3	5	2	1	1
Copper	EU-28	copper Wire Mix (Europe 2015)	2015	DKI/ECI via Sphera professional database	4	5	3	1	1
Copper alloys	GLO	copper mix (99.999% from electrolysis)	2023	Sphera professional database	1	4	2	1	1
Copper alloys	GLO	market for zinc	2014	ecoinvent 3.12	4	4	2	1	1
Cotton	GLO	market for textile, woven cotton	2011	ecoinvent 3.12	5	4	2	1	1
Damper	RoW	market for polymethyl methacrylate	2024	ecoinvent 3.12	1	4	2	1	1
Damper	RoW	market for lime	2014	ecoinvent 3.10.1	4	4	2	1	1
E/P	GLO	polyethylene production, low density, granulate	2025	ecoinvent 3.12	1	4	3	1	1
Electronics	GLO	market for printed wiring board, surface mounted, unspecified, Pb containing	2014	Ecoinvent 3.12	4	4	3	1	1
EPDM	DE	ethylene Propylene Diene Elastomer (EPDM)	2025	Sphera professional database	1	5	2	1	1
Epoxy	GLO	market for epoxy resin, liquid	2014	ecoinvent 3.12	4	4	2	1	1
EVAC	GLO	market for ethylene vinyl acetate copolymer	2014	ecoinvent 3.12	4	4	2	1	1
Ferrite magnet	GLO	market for ferrite	2014	ecoinvent 3.12	4	4	3	1	1
Float glass	RoW	market for flat glass, coated	2011	ecoinvent 3.12	5	4	2	1	1
Friction	DE	cast iron part (automotive) - open energy inputs	2023	Sphera professional database	1	5	4	1	1
Friction	GLO	market for zirconium oxide	2011	ecoinvent 3.12	5	4	4	1	1
Friction	GLO	market for graphite	2011	ecoinvent 3.12	5	4	4	1	1
Friction	GLO	market for barium sulfide	2018	ecoinvent 3.12	3	4	4	1	1
Friction	GLO	market for barite	2011	ecoinvent 3.12	5	4	4	1	1
Friction	GLO	market for aluminium hydroxide	2018	ecoinvent 3.12	3	4	4	1	1
Friction	GLO	market for magnesium oxide	2011	Ecoinvent 3.12	5	4	4	1	1
Friction	GLO	market for expanded vermiculite	2011	ecoinvent 3.12	5	4	4	1	1
Friction	EU-28	calcined petroleum	2025	Sphera professional database	2	5	4	1	1
GF-fibre	GLO	market for glass fibre	2011	ecoinvent 3.12	5	4	2	1	1

Material/process	Location	Dataset name	Year	Source	Correlation score: Temporal	Geographical	Technological	Representative	Precision
Glycol	RER	Market for ethylene glycol	2011	ecoinvent 3.12	5	5	2	1	1
Lead, battery	DE	lead (99.995%)	2025	Sphera professional database	1	5	2	1	1
Lubricants	EU-28	lubricants at refinery	2022	Sphera Professional database	2	5	2	1	1
Magnesium	CN	magnesium	2025	Sphera Professional database	1	1	2	1	1
NdFeB	GLO	market for permanent magnet, electric passenger car motor	2012	Ecoinvent 3.12	4	4	2	1	1
NR	GLO	market for seal, natural rubber based	2014	Ecoinvent 3.12	4	4	2	1	1
PA	DE	Polyamide 6 granulate (PA 6) mix	2025	Sphera professional database	1	5	2	1	1
PBT	DE	Polybutylene Terephthalate Granulate (PBT) Mix	2025	Sphera professional database	1	5	2	1	1
PC	RoW	Market for polycarbonate	2014	ecoinvent 3.12	4	4	2	1	1
PE	RoW	Polyethylene production, low density, granulate	2025	ecoinvent 3.12	1	4	2	1	1
PET	GLO	Market for polyethylene terephthalate, granulate, amorphous	2014	Ecoinvent 3.12	4	4	2	1	1
PMMA	RoW	market for polymethyl methacrylate	2024	Ecoinvent 3.12	1	4	2	1	1
Polymer, recycled	EU-28	Plastic granulate secondary (low metal contamination)	2025	Sphera Professional database	1	5	3	1	1
Polyester	GLO	market for fibre, polyester	2018	Ecoinvent 3.12	3	4	2	1	1
Polyurethane	RoW	market for polyurethane, rigid foam	2014	Ecoinvent 3.12	4	4	2	1	1
POM	DE	polyoxymethylene (POM)	2025	Sphera Professional database	1	5	2	1	1
PP	CN	Market for polypropylene, granulate	2025	Ecoinvent 3.12	1	1	2	1	1
PS	GLO	market for polystyrene, general purpose	2014	Ecoinvent 3.12	4	4	2	1	1
PVB	DE	polyvinyl butyral granulate (PVB) by-product ethyl acetate	2025	Sphera Professional database	1	5	2	1	1
PVC	CN	polyvinylchloride production, suspension polymerisation	2025	Ecoinvent 3.12	1	1	2	1	1
R-1234yf	DE	R-1234yf production (approximation)	2021	Sphera Professional database	2	5	3	1	1
SBR	DE	styrene-butadiene rubber (S-SBR) mix	2025	Sphera Professional database	1	5	2	1	1
Silicone rubber	DE	silicone rubber (RTV-2, condensation)	2025	Sphera Professional database	1	5	2	1	1
Steel, Sintered	Asia	steel hot dip galvanised	2022	Worldsteel via Sphera professional database	2	2	3	1	1
Steel, Stainless, Austenitic	RER	stainless steel cold rolled coil (304)	2021	Eurofer via Sphera professional database	3	5	2	1	1
Steel, Stainless, Ferritic	RER	stainless steel cold rolled coil (430)	2021	Eurofer via Sphera professional database	3	5	2	1	1
Steel, Unalloyed	Asia	steel hot dip galvanised	2022	Worldsteel via Sphera professional database	2	2	2	1	1
Sulphuric acid	RER	sulphuric acid (96%)	2025	Sphera professional database	1	5	2	1	1
Thermoplastic elastomers	DE	polypropylene / Ethylene Propylene Diene Elastomer Granulate (PP/EPDM, TPE-O) Mix	2025	Sphera Professional database	1	5	3	1	1
Thermoplastics	RoW	market for nylon 6	2014	Ecoinvent 3.12	4	4	3	1	1
Tyre	DE	styrene-butadiene rubber (S-SBR) mix	2025	Sphera professional database	1	5	2	1	1
Tyre	RER	water (deionised)	2025	Sphera professional database	1	5	2	1	1

Material/process	Location	Dataset name	Year	Source	Correlation score: Temporal	Geographical	Technological	Representative	Precision
Tyre	GLO	vulcanisation of synthetic rubber (without additives)	2025	Sphera professional database	1	4	2	1	1
Undefined	RoW	market for nylon 6	2014	Ecoinvent 3.12	4	4	5	1	1
Washer fluid	DE	Ethanol (96%) (hydrogenation with nitric acid)	2025	Sphera professional database	1	5	3	1	1
Wood (paper, cellulose ...)	EU-28	Laminated veneer lumber (EN15804 A1-A3)	2025	Sphera Professional database	1	5	3	1	1
Zinc	GLO	Special high grade zinc	2021	IZA via Sphera professional database	2	4	3	1	1
Aluminium manufacturing	DE	aluminium die-cast part	2025	Sphera professional database	1	5	3	1	1
Aluminium manufacturing	EU-28	aluminium sheet – open input aluminium rolling ingot	2025	Sphera professional database	1	5	3	1	1
Aluminium manufacturing	DE	aluminium sheet deep drawing	2021	Sphera professional database	2	5	3	1	1
Aluminium manufacturing	RNA	Extrusion of aluminum billet, AEC	2015	Sphera professional database	4	5	3	1	1
Polymers (all categories) manufacturing	DE	Plastic injection moulding part (unspecific)	2021	Sphera professional database	2	5	2	1	1
Steel (all categories) manufacturing	DE	Steel sheet deep drawing (multi-level)	2021	Sphera Professional database	2	5	3	1	1

Data points	Material production and refining	Car manufacturing, inbound and outbound logistics	Use of vehicle	End-of-life treatment
Temporal correlation (time related coverage)	1-5	1	1	3
Geographical correlation	1-5	1	2	3
Technological correlation	1-5	1	1	3
Representative	1	1-2	1-2	5
Precision	1-2	2	2	4

↑ Table 25

Summarised quality assessment of data used in the study (based on matrix in table).

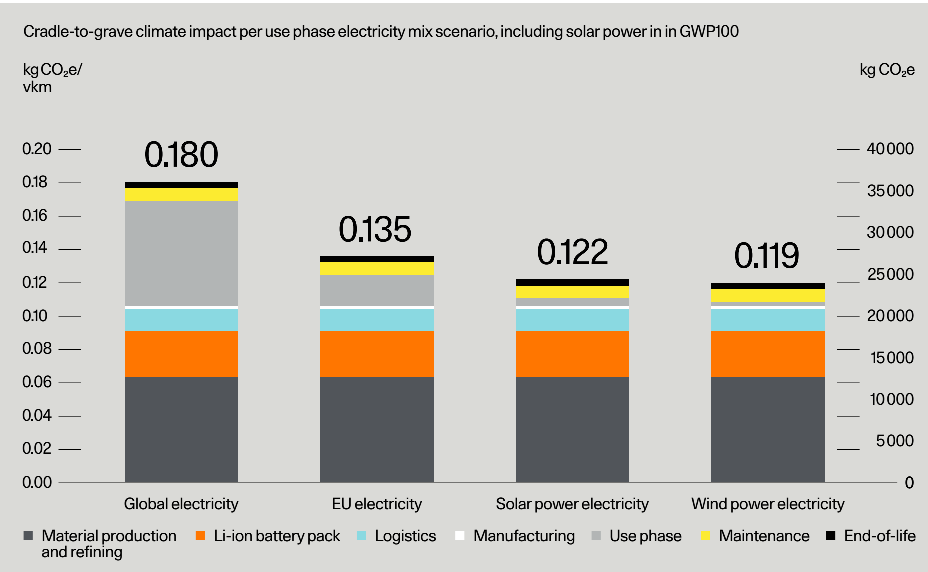
Species	GWP-100	Unit
Carbon dioxide	1	CO_2-eq
Nitrous oxide (laughing gas)	273	CO_2-eq
R 116 (hexafluoroethane)	12400	CO_2-eq
Tetrafluoromethane	7380	CO_2-eq
Sulphur hexafluoride	24300	CO_2-eq
Methane	27.9	CO_2-eq
Carbon dioxide, fossil	1	CO_2-eq
R 23 (trifluoromethane)	14600	CO_2-eq
R 113 (trichlorotrifluoroethane)	6520	CO_2-eq
Carbon tetrachloride (tetrachloromethane)	2200	CO_2-eq
R 22 (chlorodifluoromethane)	1960	CO_2-eq
R 12 (dichlorodifluoromethane)	10200	CO_2-eq
R 134a (tetrafluoroethane)	1530	CO_2-eq
Ethane	0.437	CO_2-eq
Halon (1301)	7200	CO_2-eq
R 152a (difluoroethane)	164	CO_2-eq
R 124 (chlorotetrafluoroethane)	597	CO_2-eq
Trichloromethane (chloroform)	20.6	CO_2-eq
Dichloromethane (methylene chloride)	11.2	CO_2-eq
R 11 (trichlorofluoromethane)	5560	CO_2-eq
Propane	0.02	CO_2-eq
Methyl bromide	2.43	CO_2-eq
Dichloroethane (ethylene dichloride)	1.3	CO_2-eq
R 245fa (1,1,1,3,3-Pentafluoropropane)	962	CO_2-eq

← Table 26

Characterisation factors according to IPCC Intergovernmental Panel on Climate Change by the United Nations[25].

Halon (1211)	1930	CO_2-eq
1,1,1-Trichloroethane	161	CO_2-eq
R 125 (pentafluoroethane)	3740	CO_2-eq
Butane (n-butane)	0.006	CO_2-eq
Nitrogentriflouride	17400	CO_2-eq
R 21 (Dichlorofluoromethane)	160	CO_2-eq
R 141b (dichloro-1-fluoroethane)	860	CO_2-eq
R 143 (trifluoroethane)	364	CO_2-eq
Ethyl chloride	0.481	CO_2-eq
R 32 (difluoromethane)	771	CO_2-eq
R E245fa2 (2-(Difluoromethoxy)-1,1,1-trifluoroethane)	878	CO_2-eq
Trichloroethene (isomers)	0.044	CO_2-eq
R 142b (chlorodifluoroethane)	2300	CO_2-eq
Tetrachloroethene (perchloroethylene)	6.34	CO_2-eq
Chloromethane (methyl chloride)	5.54	CO_2-eq
Perfluoropentane	9220	CO_2-eq
Bromoform	0.25	CO_2-eq
1,2-Dibromoethane	1.02	CO_2-eq
R 143a (trifluoroethane)	5810	CO_2-eq

25 https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf



← Figure 23

Cradle-to-grave climate impact per use phase electricity mix scenario, including solar power in in GWP100 for Polestar 4 SUV Dual motor.

The increasing adoption of solar power around the world justifies an additional specific electricity source to be examined. However, just as wind power, the climate impact per produced kWh of electricity from solar systems depend on weather conditions. A solar panel installed in a region with many annual hours of sunlight will generate more electricity over its lifetime than one installed in a region with fewer hours of sunlight. Thus, the climate impact associated with the production and installation of the system will be distributed across a higher electricity output (kWh) in regions with greater solar exposure compared to regions with lower solar exposure. Several other factors can also influence the average climate impact per kWh. In this study, the dataset 'RER: Electricity from photovoltaic' from the Sphera professional database has been used, which represents the average climate impact of producing and delivering 1 kWh of solar power in Europe. Consequently, it does not aim to represent a typical rooftop solar installation but rather the European average of solar power installations.

Figure 23 and Table 27 display that the carbon footprint per vehicle kilometre are comparable. However, in absolute numbers (over the 200 000km lifetime driving distance) the solar power electricity scenario in the use phase is 0.4 tonnes CO_2e higher than the wind power electricity scenario. Even though there is a slight increase, solar power proves to be a good alternative to the EU and global average electricity mix to reduce the climate impact from the use phase of the Polestar 4 SUV. The analysis has been carried out only for the Polestar 4 SUV Dual motor, for the Rear motor variant the results would be very similar.

Table 27 →

Cradle-to-grave climate impact per use phase electricity mix scenario, including solar power in GWP100 for Polestar 4 SUV Dual motor.

Electricity mix	Tonnes CO_2e per vehicle	Kg CO_2e per vehicle km
Global	36.0	0.180
EU	27.0	0.135
Solar Power	24.3	0.122
Wind power	23.9	0.119

Independent Critical Review Statement

This relates to the review of the carbon footprint (CFP) study of the Polestar 4 SUV electric vehicle. The details of this review are provided below.

Aspect	Details
Commissioner of the CFP study	Polestar
Practitioner of the CFP study	Polestar
Reviewers	Two independent external experts: Fei Zhang (WSP UK Limited); Marco Raugei (WSP UK Limited)
Date of completion of critical review	3rd July 2026
References	ISO 14067:2018 – Greenhouse gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification ISO 14044:2006 – Environmental Management – Life Cycle Assessment – Requirements and Guidelines ISO 14071:2024 – Environmental Management – Life Cycle Assessment – Critical Review Processes and Reviewer Competencies
Title of study report reviewed	Carbon footprint report of Polestar 4 SUV - Produced in Busan, South Korea - dated 29.06.2026

1.1 Scope of the Critical Review

The two external experts, independent of the CFP study, were commissioned to review a cradle-to-grave CFP report of the Polestar 4 SUV - Produced in Busan, South Korea. Input was also provided on key points by a third expert, Nikolas Hill, also at WSP UK Limited. A "Statement of Independence and Personal Competence" has been signed by both reviewers, as required by par. 4.2.1 and Annex B of ISO 14071:2024 and is attached to the Critical Review Report provided to Polestar.

In accordance with ISO 14044:2006, section 6.1, the goal of the critical review was to assess whether:

- the methods used to carry out the CFP are consistent with the standards ISO 14040 and ISO 14044.
- the methods used to carry out the CFP are scientifically and technically valid.
- the data used are appropriate and reasonable in relation to the goal of the study.
- the interpretations reflect the limitations identified and the goal of the study, and the study report is transparent and consistent.

The review statement is only valid for the specific report titled "Carbon footprint report of Polestar 4 SUV - Produced in Busan, South Korea" dated 29.06.2026, thus it does not apply to any other report versions, derivative reports, excerpts, press releases, and similar documents. The review was performed exclusively on the CFP study report. It excluded an assessment of the LCI and LCIA model. An analysis of individual datasets was not in scope.

1.2 Critical Review Process

The independent critical review process was carried out concurrently with the CFP study, in accordance with the requirements of ISO 14071:2024 (ref. par. 4.3.4,) with the first two reviews taking place on submission of the goal and scope section, and the second two reviews on submission of the full report. The reviews were conducted by exchanging comments and responses using an Excel spreadsheet based on Annex A of ISO 14071:2024.

The critical review was carried out between April 2026 and July 2026 and consisted of four rounds of comments in total. A copy of the review spreadsheet containing all written comments and responses has been provided to Polestar within the Critical Review Report.

The review was conducted in a constructive manner. All comments were addressed and all significant open issues were resolved. There were no dissenting opinions held by the involved parties upon finalisation of the review.

1.3 General Evaluation and Conclusion

The study was found to be well-scoped and the analysis capable of supporting the goals of the study. The report shows a high level of technical knowledge and methodological proficiency.

Based on the final CFP report, it can be concluded that the methods used to carry out the CFP are consistent with the ISO 14067:2018 standard, that they are scientifically and technically valid, that the data described as used are appropriate and reasonable in relation to the goals of the study, and that the interpretations reflect the limitations identified and goal of the study. The CFP report, which is also the third-party report, is considered sufficiently transparent and consistent. Key recommendations for future studies relate to continuing to seek more timely contractual evidence of electricity type and mix for the vehicle manufacturing site. Another is to push for third party verification/review of supplied CFPs of supplier parts such as the battery pack, the results of which are fed into Polestar's own CFP and were demonstrated to be hotspot. This will increase the overall robustness of Polestar's study.

The reviewers sign this review statement as independent experts. Their signatures do not constitute an endorsement of the study's scope and results.

Fei Zhang	Marco Raugei

Valid as of 3rd July 2026.

1.4 Disclaimer

Polestar retains sole liability for the content of the CFP study. WSP UK Limited was commissioned to provide a critical review of the CFP report for compliance with the methodological requirements, and to assess the adequacy, correctness and consistency of information included in the study report. WSP UK Limited makes no warranties or guarantees, actual or implied, in relation to this report, or the ultimate commercial, technical, economic, or financial effect on the project to which it relates, and bears no responsibility or liability related to its use other than as set out in the contract under which it was supplied.