Life cycle assessment

Carbon footprint of Polestar 4 model year 2026

Long range Dual motor
Long range Single motor

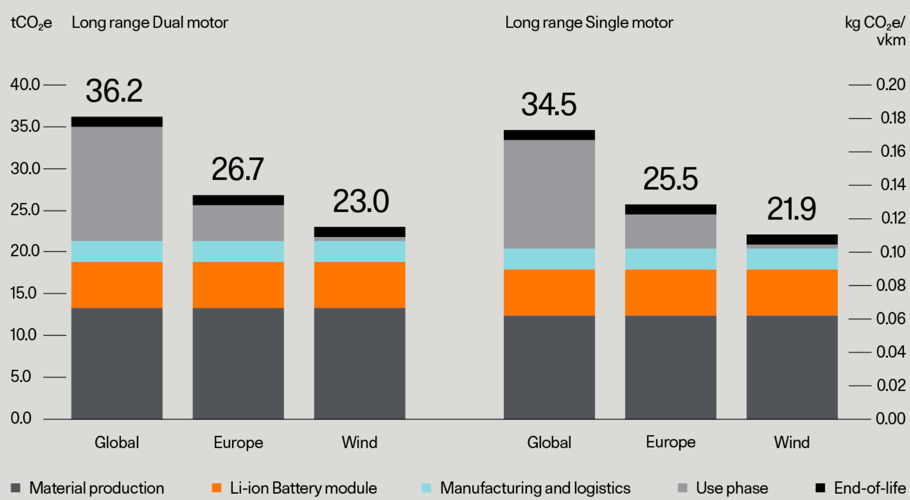
4

This report is for information only and (1) is based solely on an analysis of Polestar 4 (model year 2026) “Long range Dual motor” and “Long range Single motor” 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. Full study methodology is available in the previous Polestar 4 life cycle assessment report, available via this link: Polestar 4 LCA report. To get a full understanding of the methodology used to calculate the carbon footprints in this report, it is recommended to read the previous report in conjunction with this one.

The result of this study is dependent upon agreed and validated information from Polestar's suppliers and sub-suppliers. During the course of 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.

Content

Cradle-to-grave carbon footprint – Polestar 4 MY26



← Figure 1

Carbon footprint for Polestar 4 variants, with different electricity mixes in the use phase. The axis to the left, as well as the data labels, presents the result per functional unit (200,000 km lifetime driving distance) in tCO_2e. The axis to the right presents the result in kg CO_2e using a secondary functional unit of 1 vkm (vehicle kilometer, 200,000 km lifetime driving distance).

At the end of 2023, a carbon footprint report of Polestar 4 Long range Dual motor, Long range Single motor, and Standard range Single motor for model years 2024 and 2025 was published. The carbon footprint presented in this report is a continuation of that work. The Polestar 4 model year 2026 does not come with the Standard range Single motor as an option. Therefore, only the Long range Dual motor and Long range Single motor are assessed.

The carbon footprint presented in this report is, as the previous Polestar 4 carbon footprint, based on a Life Cycle Assessment (LCA). The LCA is performed according to ISO LCA standards[1]. In addition, the "Product Life Cycle Accounting and Reporting Standard"[2] published by the Greenhouse Gas Protocol has been used for guidance in methodological choices. Given the great number of variables and possible methodological choices in LCA studies, these standards generally provide few strict requirements to be followed. Instead, they mostly provide guidelines for the practitioner. For this reason, care should be taken when comparing our results with results from other vehicle manufacturers' carbon footprints. In general, Polestar has made some conservative assumptions in order not to underestimate the impact of unknown data. Methodological choices and data sources are described in the previous Polestar 4 LCA report. Some methodological and data changes have been made, which are described in this report. To get a full understanding of the methodology used to calculate the carbon footprints in this report, it is recommended to read the previous Polestar 4 LCA report. This previous report corresponds to Polestar 4 model years 2024 and 2025.

The carbon footprint includes emissions from upstream supplier activities, manufacturing, logistics, use phase and the end-of-life phase of the vehicle. The functional unit chosen is "The production and use of a Polestar 4 vehicle driving 200,000 km between the full years of 2025 to 2039".

Changes have been made in the Polestar 4 battery supply chain which has led to reductions in the cradle-to-gate carbon footprint of the Long range Dual motor and Long range Single motor variants of Polestar 4. The previous Polestar 4 carbon footprint report used preliminary WLTP (Worldwide Harmonised Light Vehicle Test Procedure) figures for energy consumption in the use phase. This report uses the certified WLTP figures. Methodological changes in the use phase have also been made, including the account for changes in driving patterns throughout the vehicle's lifetime. Accounting for these driving patterns leads to the cradle-to-grave carbon footprint results in this report being comparable to Polestar vehicle carbon footprint reports currently published for model year 2024 and later (as of April 2025).

As shown in Figure 1, the life cycle (cradle-to-grave) carbon footprints are 23.0-36.2 tCO_2e for Long range Dual motor and 21.9-34.5 tCO_2e for Long range Single motor. The range in results is caused by differences in electricity mix scenarios, where the highest value reflects that a global electricity mix is used in the vehicle use phase (for vehicle charging) and the lowest value reflects that wind power is used.

1 ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines" and ISO 14040:2006 "Environmental management – Life cycle assessment – Principles and framework"

2 https://ghgprotocol.org/sites/default/ files/standards/Product-Life-CycleAccounting-Reporting-Standard_041613.pdf

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Battery pack
Complete vehicle battery including battery cells, modules and battery pack structure.

Cradle-to-gate
A cradle-to-gate assessment considers impacts at parts of the product's life cycle; in Polestars studies it starts from the time natural resources are extracted from the ground and processed through each subsequent stage of manufacturing and ends after the vehicle has been transported to sales market.

Cradle-to-grave
A cradle-to-grave assessment considers impacts at each stage of the product's life cycle, from the time natural resources are extracted from the ground and processed through each subsequent stage of manufacturing, logistics, product use, recycling, and ultimately, end-of-life treatment.

Dataset (LCI or LCIA dataset)
A dataset containing life cycle information of a specified product or other reference (e.g. site, process), covering descriptive metadata and quantitative life cycle inventory and/or life cycle impact assessment data, respectively.

End-of-life
End-of-life means the end of a product's life cycle. Traditionally it includes waste collection and waste treatment, e.g. re-use, recycling, incineration, landfill, etc.

Functional unit
Quantified performance of a product system for use as a reference unit.

GHG
Greenhouse gases. These are gases that contribute to global warming, e.g. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), as well as freons/CFCs. Greenhouse gases are often quantified as a mass unit of CO_2e, where "e" is short for equivalents.

Life cycle
Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.

Life Cycle Assessment (LCA)
Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life.

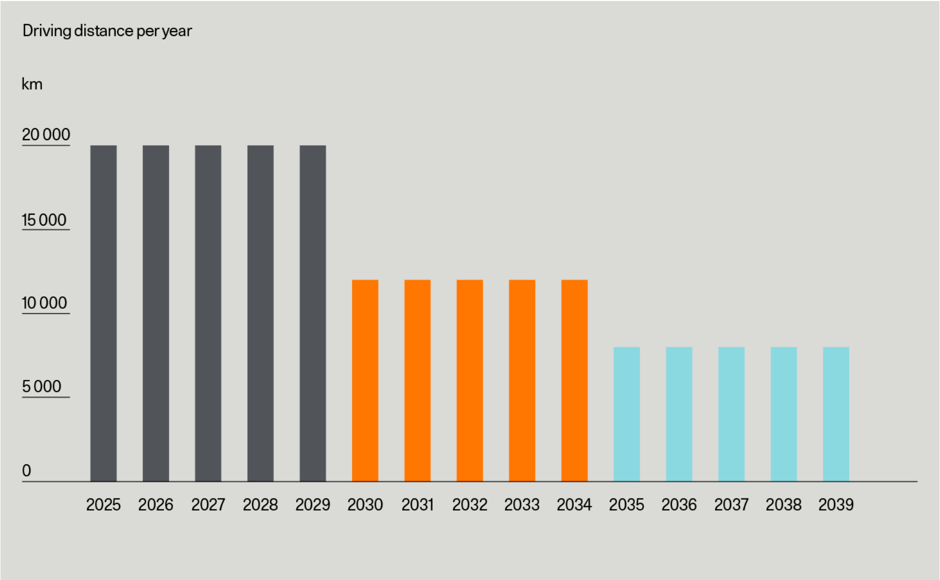
LR / SR / DM / SM
Long range / standard range / dual motor / single motor

MY
Model year

Raw material
Primary or secondary material that is used to produce a product.

tCO_2e
Metric tonne carbon dioxide equivalents.

WLTP
Worldwide Harmonised Light Vehicle Test Procedure, used for certification of vehicles in the EU



← Figure 2

Assumed driving distances in kilometers per year during the lifetime of the vehicle.

Changes in methodology and data since previous Polestar 4 LCA

The previously published Polestar 4 LCA report describes and motivates the way of working to obtain data, data sources, LCA databases and software, relation to standards, system boundaries, allocation methods, assumptions, and limitations. The original report also describes material categories, manufacturing methods, logistics, use phase, and end-of-life treatment. Polestar aims to make continuous improvements to the LCA methodology. Methodological changes can lead to either a higher or a lower carbon footprint of the vehicle.

This chapter only describes the changes made in either methodology or data, from the previous Polestar 4 LCA. All other methodology is the same as in the previous Polestar 4 LCA and are described in the Polestar 4 LCA report. The updated use phase methodology provides a more accurate estimation of the carbon footprint and increases the overall cradle-to-grave comparability across Polestar's current three-car line-up (see Polestar 2 and Polestar 3 LCA reports).

Updated use phase assumptions

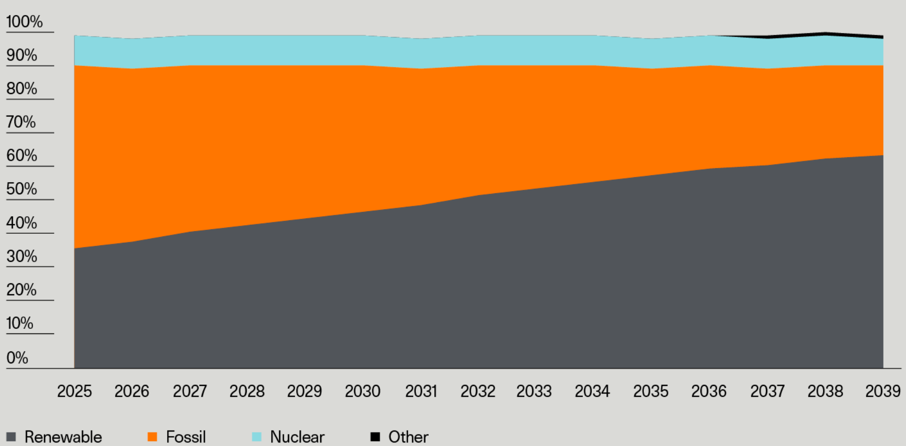
The previous use phase assumption can be found in the previous report, section 2.10. To be able to calculate the emissions in the use phase of the vehicle, the distance driven is needed together with the energy use, as well as emissions from electricity generation. The vehicle lifetime driving distance for Polestar vehicles has been set to 200,000 km, and the energy use of the vehicle corresponds to driving according to the WLTP driving cycle, according to the lower consumption figures in Table 1. WLTP does not take all driving conditions into account, for example, WLTP 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.

The analysis assumes that 50% of a vehicle's total lifetime mileage is covered in the initial five years, equivalent to 20,000 kilometres per year, while 30% is driven in the subsequent five years, amounting to 12,000 kilometres annually. During the last five years of the vehicle's life, it is assumed that the yearly distance driven is 8,000 km, illustrated in Figure 2.

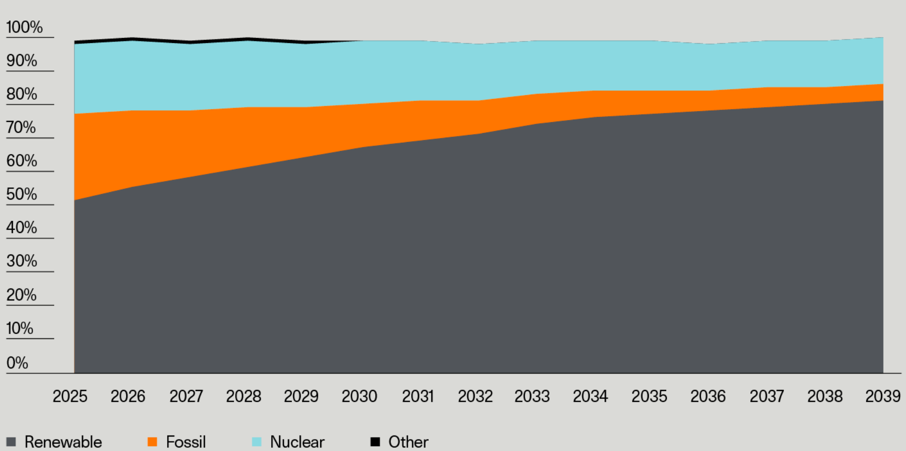
Electricity generation is modelled according to three cases: Global and EU (European Union) grid mix and a specific source of electricity, wind power. Current and future global and EU electricity generation mixes are based on the World Energy Outlook 2024 Extended Dataset[3].) from IEA between 2025 and 2039. The previous LCA study utilised data from the World Energy Outlook 2022 Extended Dataset which predicted slightly lower shares of renewables in the grid mixes compared to the 2024 dataset. IEA uses the Global Energy and Climate (GEC) Model to explore possible future energy-related scenarios based on different assumptions. For this study, STEPS (Stated Policies Scenario) 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.

3 World Energy Outlook 2024 Extended Dataset - IEA

Global electricity mix – IEA STEPS Scenario



European electricity mix – IEA STEPS Scenario



← Figure 3

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

← Figure 4

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

Figure 3 and Figure 4 visually represent the development of electricity sources. 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.

Amounts of electricity from different energy sources have in this study been paired with appropriate LCI datasets from the Sphera professional 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. On average, the emissions throughout the entire use phase amount to 0.360 kg CO_2e/kWh for the global electricity mix scenario and 0.112 kg CO_2e/kWh for the European electricity mix scenario.

Considering the anticipated changes in electricity generation, specifically, the reduction in fossil fuel-based electricity and the concurrent increase in renewable electricity forecasted from 2025, it is expected that yearly emissions from electric vehicle usage will decline. The distances driven, described in Figure 2, are multiplied by the emission factors corresponding to each year, reflecting the changes in the global and EU electricity mix.

Battery pack carbon footprint updates

In the previous Polestar 4 LCA report the battery pack was wrongfully referred to as "battery modules". The term "battery modules" is often referred to as a subcomponent of the complete "battery pack", thereby the battery pack is a larger component that holds battery cells, battery modules and the carrier and protective structure which is the battery pack. This is an important distinction since Polestar uses separate battery carbon footprint studies, made by the battery supplier in collaboration with Polestar, to account for the carbon footprint of vehicle batteries and in the case of Polestar 4, these LCAs account for the complete battery pack. The supplier LCA was updated during 2024 and is included in the carbon footprint calculation of the long range Polestar 4 variants of the model year 2026, however, the updated LCA is also applicable to most of the model year 2025. The major change in the updated supplier LCA is improved data quality concerning the aluminium in the battery.

Increased recycled content of aluminium in the battery pack and battery module structure as well as aluminium from smelters utilizing renewable electricity in the battery pack structure has been identified, which has led to a reduction of the battery pack carbon footprint of 2.1 tCO_2e. The recycled content includes both post-consumer material and post-industrial material by the definition of recycled content in ISO 14021 "Environmental Labels and Declarations". Polestar aims to increase the recycled content of post-consumer materials in the future, as this material is more in line with the principles of circular economy.

Logistics data updates

In the previous LCA study of Polestar 4, GHG emissions from both inbound and outbound logistics were estimated based on assumptions on transport patterns as data on actual transport patterns were unavailable. These previous logistics assumptions can be found in the previous report, section 2.9. Instead of estimations, this study incorporates a three-year average (2022-2024) of outbound logistics GHG emissions per manufactured Polestar vehicle, calculated according to ISO 14083:2023 "Quantification and reporting of greenhouse gas emissions arising from transport chain operations". For the inbound logistics of Polestar 4, the 2024 average GHG emissions per manufactured Polestar 4 vehicle are calculated according to the same ISO standard. This update has led to an increase of approximately 2 tCO_2e in the life cycle stage "manufacturing and logistics".

The products

The study assesses two Polestar 4 model year 2026 variants: the Long range Dual motor, and the Long range Single motor. Both variants have been developed in collaboration with Zhejiang Geely Holding Group and are produced in Hangzhou Bay, China. Later in 2025 the Polestar 4 will also be produced in Busan, South Korea. The variants are produced with different specifications. This study encompasses the specifications expected to have the largest sales volumes. Descriptions of the studied vehicles are presented in Tables 1 and 2, and the material composition of both variants is available in Appendix 5. The previous Polestar 4 carbon footprint report used preliminary WLTP figures for energy consumption in the use phase while this report uses the certified WLTP figures, depicted in Table 2.

Table 1 →

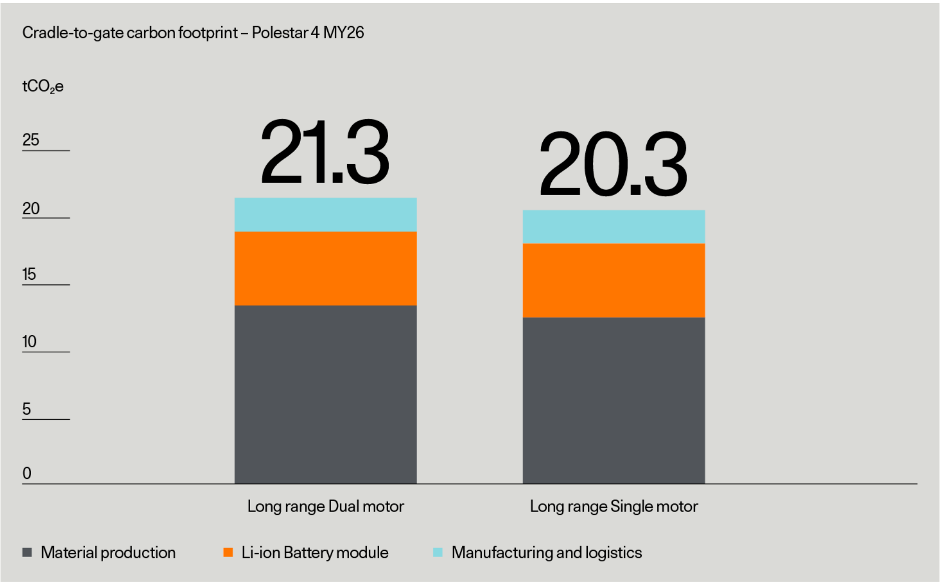
Studied vehicles and corresponding weights in kg.

Polestar 4 MY26	Long range Dual motor	Long range Single motor
Total weight (kg)	2,351	2,229
Li-ion battery pack weight (kg)	581	581

Table 2 →

Descriptions of the Polestar 4 MY26 variants.

Polestar 4 MY26	Long range Dual motor	Long range Single motor
Battery capacity	100 kWh	100 kWh
Output	400 kW 544 hp 686 Nm	200 kW 272 hp 343 Nm
Energy consumption (WLTP)	19.0-21.7 kWh/100 km	18.1-18.4 kWh/100 km
Preliminary range (WLTP)	590 km	620 km



← Figure 5

Cradle-to-gate carbon footprint for the Polestar 4 MY26 variants, including Materials production, Li-ion battery pack and Manufacturing and Logistics. Results are shown in tCO_2e per functional unit.

Figure 5 and Table 3 present the cradle-to-gate carbon footprint of both variants of the Polestar 4. The Long range Single motor variant has the lower cradle-to-gate carbon footprint at 20.3 tCO_2e compared to the Long range Dual motor variant at 21.3 tCO_2e, thereby the Polestar 4 Long range Single motor has the lowest cradle-to-gate carbon footprint of any Polestar car on sale today (April 2025). Figure 6-7 and Table 4-5 present the cradle-to-grave carbon footprint of the two Polestar 4 variants, as well as the carbon footprint distributed into life cycle phases.

Depending on the variant and electricity mix scenario, the life cycle carbon footprint varies between 21.9 and 36.2 tCO_2e. The largest variability in the results is due to the choice of electricity mix in the use phase. In the case of the global electricity mix, the use phase accounts for almost 40% of the life cycle carbon footprint, while in the case of wind power, the use phase accounts for only 2%. This displays the importance of the choice of electricity mix scenario when studying the life cycle carbon footprint of an electric vehicle as well as the influence drivers of EVs can have over their usage carbon footprint by e.g., choosing renewable electricity contracts for home charging.

The Single motor variant has a lower carbon footprint than the Dual motor variant. This is due to the fact that it 1) has one less motor and thereby requires fewer materials, resulting in less impact from material extraction and manufacturing. The lower material mass also leads to 2) a lower total vehicle weight, which increases energy efficiency and lowers the use phase carbon footprint.

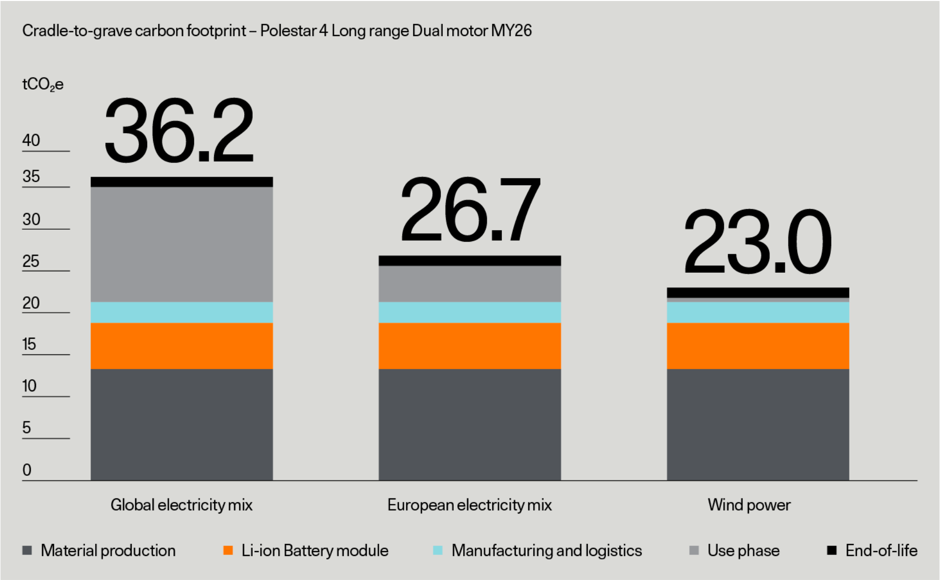
Figure 8-9 in Appendix 3 presents a breakdown of material contribution to the carbon footprint of the two Polestar 4 variants. The battery pack represents the highest share of the carbon footprint of materials production and refining, with 29-31%. Aluminium represents 27% while steel and iron represent 22%. Compared to the original Polestar 4 MY24 and MY25 carbon footprint reports, the battery pack in MY26 represents a smaller share of the carbon footprint, from 32% for the Long range Dual motor variant down to 29%.

As seen in Table 3, the impact from manufacturing and logistics is 2.5 tCO_2e for both variants. This is significantly higher than the 0.5 tCO_2e in the first Polestar 4 carbon footprint report. This is due to the incorporation of previously unavailable actual data on logistics as described in Section 1.3. Another important difference between the present report and the previous report is that the carbon footprint from the battery pack has decreased significantly, from 7.6 tCO_2e for both variants to 5.5 tCO_2e for both variants due to improved data quality as described in Section 1.2. In Appendix 4, a comparison between the first and present model year of Polestar 4 Long range Dual motor is presented.

Table 3 →

Cradle-to-gate carbon footprint for the Polestar 4 MY26 variants, including Materials production, Li-ion battery pack, Manufacturing and Logistics. Results are shown in tCO_2e.

Polestar 4 MY26	Long range Dual motor	Long range Single motor
Material production	13.3	12.4
Li-ion battery pack	5.5	5.5
Manufacturing and logistics	2.5	2.5
Total cradle-to-gate	21.3	20.3



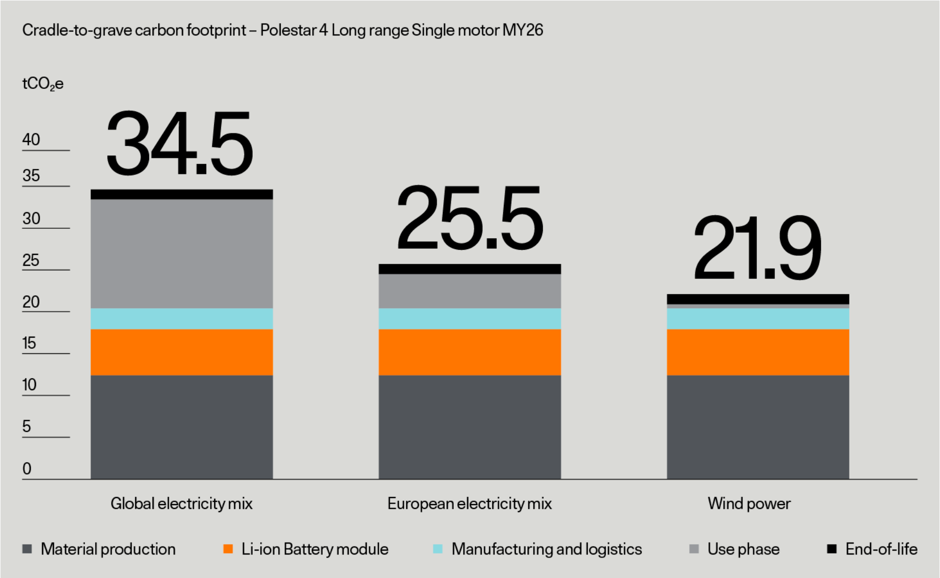
← Figure 6

Cradle-to-grave carbon footprint for Polestar 4 Long range Dual motor, with different electricity mixes in the use phase. Results are shown in tCO_2e per functional unit (200,000 km lifetime range).

Table 4 →

Cradle-to-grave carbon footprint for Polestar 4 Long range Dual motor, with different electricity mixes used in the use phase. Results are shown in tCO_2e per functional unit.

Polestar 4 Long range Dual motor MY26	Global electricity mix	European electricity mix	Wind power
Material production	13.3	13.3	13.3
Li-on battery pack	5.5	5.5	5.5
Manufacturing and logistics	2.5	2.5	2.5
Use phase	13.7	4.3	0.5
End-of-life	1.2	1.2	1.2
Cradle-to-grave	36.2	26.7	23.0



← Figure 7

Cradle-to-grave carbon footprint for Polestar 4 Long range Single motor, with different electricity mixes in the use phase. Results are shown in tCO_2e per functional unit (200,000 km lifetime range).

Table 5 →

Cradle-to-grave carbon footprint for Polestar 4 Long range Single motor, with different electricity mixes used in the use phase. Results are shown in tCO_2e per functional unit.

Polestar 4 Long range Single motor MY26	Global electricity mix	European electricity mix	Wind power
Material production	12.4	12.4	12.4
Li-on battery pack	5.5	5.5	5.5
Manufacturing and logistics	2.5	2.5	2.5
Use phase	13.0	4.1	0.5
End-of-life	1.2	1.2	1.2
Cradle-to-grave	34.5	25.5	21.9

3

LCA is continuously used for assessing the carbon footprint of Polestar's cars. Major work has been put into building the methodology, and it is continuously being developed. One such development in this study is incorporating Polestar's actual carbon footprint from outbound logistics into this study. Another is the incorporation of the latest data from the International Energy Agency STEPS scenario for electricity in the use phase.

In this study, the carbon footprints of the two Polestar 4 variants Long range Dual motor and Long range Single motor model year 2026 were calculated, including all life cycle phases, i.e. materials production and refining, manufacturing, use phase and end-of-life.

According to the methodology described in this report and the previous Polestar 4 LCA report, the cradle-to-grave carbon footprints are 23.0-36.2 tCO_2e for Long range Dual motor, 21.9-34.5 tCO_2e for Long range Single motor. The range in results is caused by differences in electricity mix scenarios, where the highest value reflects that a global electricity mix is used in the vehicle use phase while the lowest value reflects that wind power is used.

Polestar will continue to improve its LCA methodology to create an even more robust methodology. To follow up more closely on how different sourcing decisions and material choices impact the results, Polestar also aims to increase the supplier-specific data used in the LCAs.

Electricity	Location	Name of LCI dataset	Year	Type	Source
Electricity from solar power	RER	Electricity from photovoltaic Sphera	2019	agg	Sphera professional database
Electricity from wind power	RER	Electricity from wind power Sphera	2019	agg	Sphera professional database
Electricity from geothermal	RER	Electricity from geothermal	2019	agg	Sphera professional database
Electricity from hydro power	RER	Electricity from hydro power Sphera	2019	agg	Sphera professional database
Electricity from bioenergy	RER	Electricity from biomass (solid)	2019	agg	Sphera professional database
Electricity from nuclear power	RER	Electricity from nuclear	2019	agg	Sphera professional database
Electricity from unabated coal	RER	Electricity from hard coal	2019	agg	Sphera professional database
Electricity from unabated gas	RER	Electricity from natural gas	2019	agg	Sphera professional database
Electricity from oil	RER	Electricity from heavy fuel oil (HFO)	2019	agg	Sphera professional database

A1

← Table 6

Chosen datasets for electricity sources in use phase.

In the LCA a large number of generic datasets from databases are used. In this appendix, the datasets used are listed in Table 6. Appendix 1 only presents changes to the datasets used from the previous LCA study on Polestar 4. The original Polestar 4 LCA contains all other datasets used.

A2

Appendix 2: Complete list of Material Library material categories

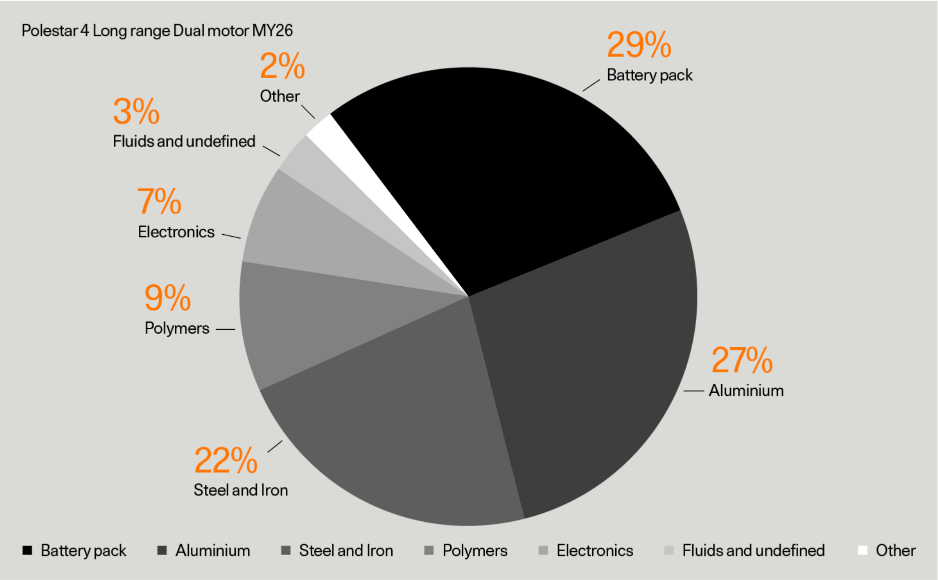
Table 7 →

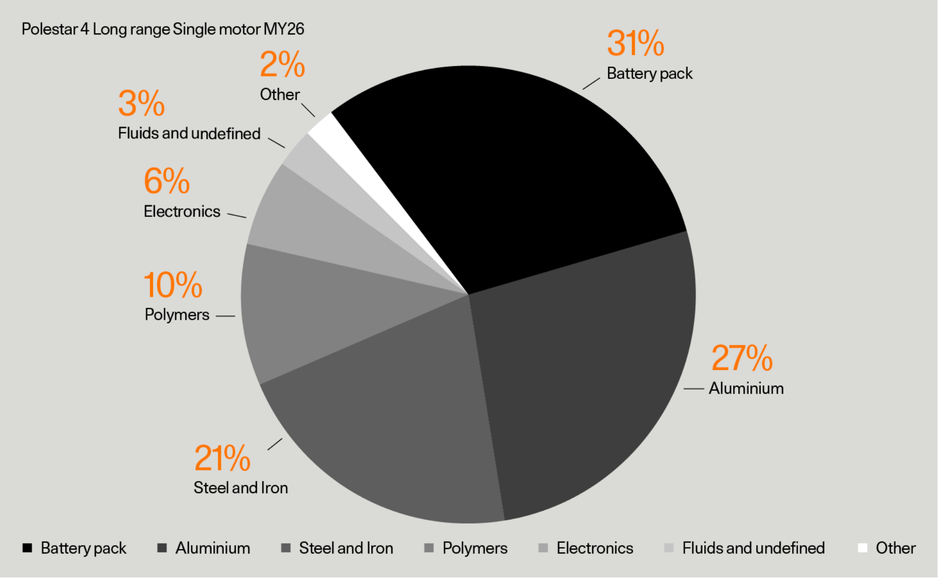
Material library material categories.

Material name	Material group
ABS (filled)	Polymers
ABS (unfilled)	Polymers
Aluminum	Aluminum
Aramid	Polymers
Brake fluid	Fluids and undefined
Carbon Fibre	Fluids and undefined
Cast iron	Steel and Iron
Catalytic coating	Fluids and undefined
Cathode	Fluids and undefined
Ceramic	Fluids and undefined
Copper	Copper
Copper alloys	Copper
Cotton	Natural materials
Damper	Fluids and undefined
E/P (filled)	Polymers
E/P (unfilled)	Polymers
Elastomer	Polymers
Electronics	Electronics
EPDM	Polymers
EVAC (filled)	Polymers
EVAC (unfilled)	Polymers
Ferrite magnet	Fluids and undefined
Float glass	Fluids and undefined
Friction	Fluids and undefined
GF-Fibre	Fluids and undefined
Glycol	Fluids and undefined
Lead (12V battery)	Fluids and undefined
Leather	Natural materials
Lubricants	Fluids and undefined

Material name	Material group
Magnesium	Other metals
Mineral	Natural materials
NdFeB	Other metals
Natural rubber	Natural materials
PA (filled)	Polymers
PA (unfilled)	Polymers
PBT (filled)	Polymers
PBT (unfilled)	Polymers
PC (filled)	Polymers
PC (unfilled)	Polymers
PC+ABS (filled)	Polymers
PC+ABS (unfilled)	Polymers
PE (filled)	Polymers
PE (unfilled)	Polymers
PET (filled)	Polymers
PET (unfilled)	Polymers
PMMA (filled)	Polymers
PMMA (unfilled)	Polymers
Polyester	Polymers
Polyurethane	Polymers
POM (filled)	Polymers
POM (unfilled)	Polymers
PP (filled)	Polymers
PP (unfilled)	Polymers
PVB (unfilled)	Polymers
PVC (filled)	Polymers
PVC (unfilled)	Polymers
R-1234yf	Fluids and undefined
Recycled Aluminum	Aluminum

Material name	Material group
Recycled Polymer	Polymers
SBR	Polymers
Silicone rubber	Polymers
Steel, Sintered	Steel and Iron
Steel, Stainless, Austenitic	Steel and Iron
Steel, Stainless, Ferritic	Steel and Iron
Steel, Unalloyed	Steel and Iron
Sulphuric acid	Fluids and undefined
Talc	Fluids and undefined
Thermoplastic elastomers	Polymers
Thermoplastics	Polymers
Undefined	Fluids and undefined
Washer fluid	Fluids and undefined
Wood (paper, cellulose, etc.)	Natural materials
Zinc	Other metals





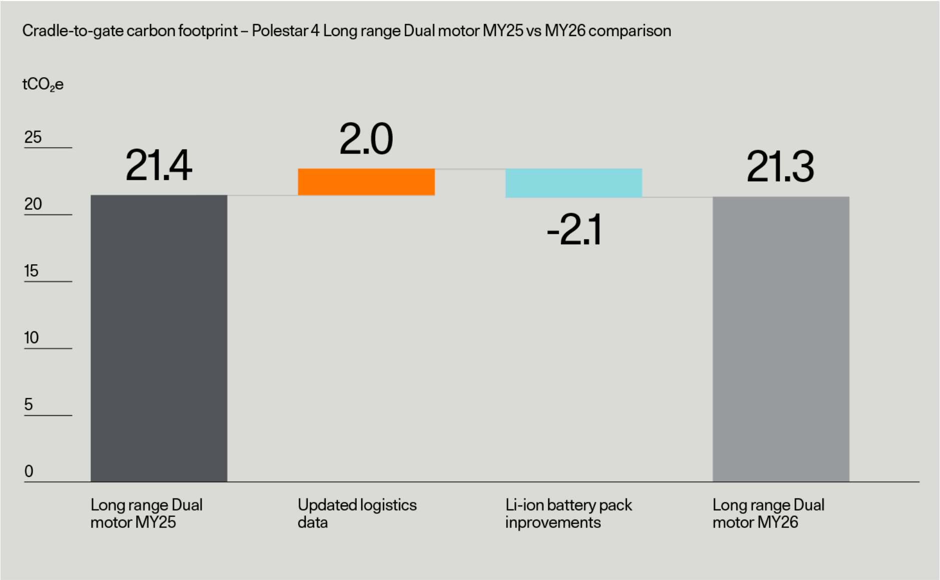
← Figure 8

Contribution from different material groups, including battery pack, to the carbon footprint from materials production and refining for Polestar 4 Long range Dual motor.

Figure 8-9 presents how the different material groups, including the battery pack, contribute to the carbon footprint from materials production and refining for the two Polestar 4 variants. The group "Others" consists of all the material groups that have an individual contribution of 1% or less, which are other metals, copper and natural materials. Appendix 2 displays a more detailed view of which materials are assigned to which material group.

← Figure 9

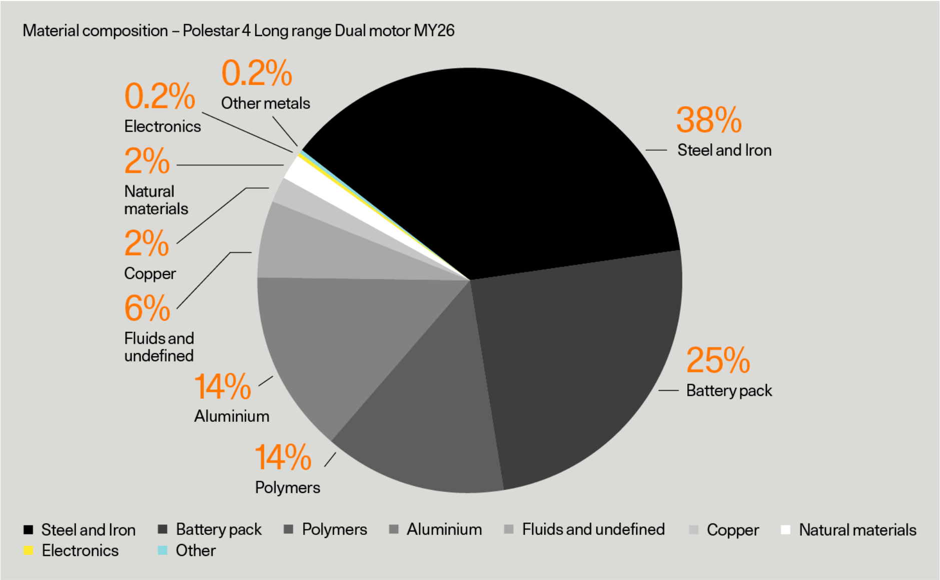
Contribution from different material groups, including battery pack, to the carbon footprint from materials production and refining for Polestar 4 Long range Single motor.

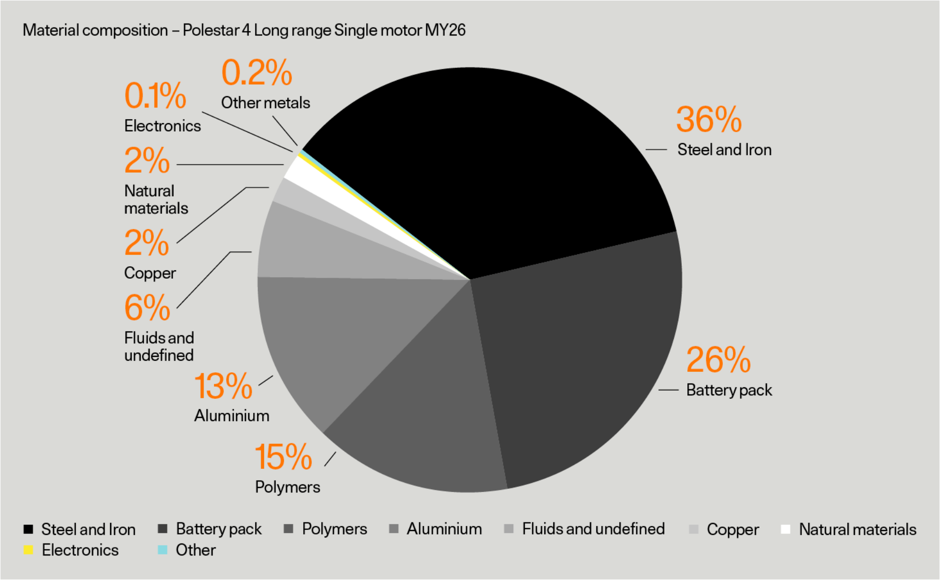


← Figure 10

Cradle-to-gate carbon footprint for the Polestar 4 Long range Dual motor, developments between model year 2024/2025 and 2026, results shown in tCO_2e per functional unit.

Figure 10 presents the changes in cradle-to-gate results between model year 2024/2025 and 2026. The increased carbon footprint from logistics is due to increased data quality on logistical services, both inbound and outbound logistics. The decrease in carbon footprint from the battery pack is attributed to the increased recycled content of aluminium in the battery pack and battery module structure as well as the implementation of aluminium from smelters utilising renewable electricity in the battery pack structure as discussed in Section 1.2.





← Figure 11

Weight shares per material category, Polestar 4 Long range Dual motor.

Figure 11-12 presents the material composition of the Polestar 4 Long range Dual motor and Long range Single motor, based on material mass.

← Figure 12

Weight shares per material category, Polestar 4 Long range Single motor.