# Environmental Certificate
# Mercedes-Benz E-Class

Mercedes-Benz
The best or nothing.

# Contents

Prepared by:

Daimler AG, Untertürkheim
Department: Group Environmental Protection, RD/RSE

As of: November 2016

# Editorial

„We improve the environmental performance over the entire life cycle of a car“

Dear readers,

One of our six environmental protection and energy guidelines reads as follows: “We strive to develop products that are highly responsible to the environment in their respective market segments.” To achieve this goal we have to incorporate environmental protection into our products from the very start of vehicle design.

The earlier this “Design for Environment” approach is integrated into the development process, the greater the benefits in terms of minimized environmental impact and cost.

It is likewise crucial to reduce the environmental impact caused by emissions and consumption of resources during the entire life cycle. This comprehensive and exhaustive Life Cycle Assessment (LCA) we call ‘360° environmental check‘. It scrutinizes all environmentally relevant aspects of a car‘s life: from manufacture of the raw materials to production, vehicle operation and then recycling at the end of the vehicle‘s life – a long way off in the case of a new Mercedes-Benz.

As well as documenting every last detail of this LCA in-house throughout the entire life cycle, we have the results checked and confirmed by independent assessors from the TÜV Süd inspection authority. Only then does a car receive its Environmental Certificate.

This brochure summarises the results of the LCA for you. Incidentally, the new E-Class is a good example of why a comprehensive assessment is necessary to gauge the overall environmental impact. Because whilst the extensive lightweight construction measures do necessitate higher energy consumption in production, this is however more than compensated for by the clearly improved efficiency of the car during operation.

I hope you enjoy the informative and certainly entertaining article LifeCycle. By the way: this brochure is how all previously published LifeCycle brochures available for download from http://www.daimler.com.

Kind regards.
Yours,

**Anke Kleinschmit**
Chief Environmental Officer of the Daimler Group

# Validation

**TÜV SÜD Management Service GmbH**, supported by an external expert in the critical review, verified the Life Cycle Assessment (LCA) of the following product-related environmental information of Daimler AG, *Mercedesstraße 137, 70327 Stuttgart,* referred to as

## “Environmental Certificate Mercedes-Benz E-Class”

Verification was based on the requirements of the following standards and guidance documents in as far as applicable:

- EN ISO 14040/14044:2006 regarding the statements on the LCA of E 200, E 220 d and E 350 e saloon and E 220 d estate (Principles and general requirements, definition of objective and scope of the LCA, life cycle inventory analysis, life cycle impact assessment, interpretation, critical review)
- Technical Report DIN ISO/TR 14062 (Integration of environmental aspects into product design and development)
- ISO/TS 14071:2014 Environmental management - Life cycle assessment - Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006
- EN ISO 14020 (Environmental labels and declarations. General principles) and EN ISO 14021 (Self-declared environmental claims)

**Result:**

1. The environmental certificate includes a comprehensive and appropriate presentation or interpretation of the results based on reliable and traceable information.
2. The life-cycle assessment on which the environmental certificate is based is in compliance with ISO 14040 and ISO 14044. The methods used and the modelling of the product system correspond to the state of the art. They are suitable for fulfilling the goals stated in the LCA study. The information contained in the environmental certificate is based on reliable and traceable data and statements provided by the LCA study. The statements made in the environmental certificate, in particular the information based on the NEDC (New European Driving Cycle) certification values, were appropriately verified and discussed in sensitivity analyses in terms of their variability-dependent influence on the relevant impact categories.
3. The assessed samples of data and environmental information included in the environmental certificate were traceable and plausible. Verification did not reveal any issues within the defined scope that compromised the validation in any way.

**Verification process:**

Verification of the LCA included a critical review of the methodology applied and – where relevant for the environmental certificate – a data-oriented audit of the LCA results and their interpretation in the form of interviews, inspections of technical documents and selective checks of the data entered in the LCA database. Wherever possible, random checks were performed on LCA input data (including weights, materials, fuel and electricity consumption, emissions) and random samples of other statements included in the certificate (such as use of renewable raw materials and recyclates, non-allergenic car interiors, recycling concept etc.) were traced back where possible to documents including official type approval documents, parts lists, supplier information, measurement results etc.

TÜV SÜD Management Service GmbH

Brunk

U. Wegner

Munich, 2016-11-10
Michael Brunk

Environmental verifier

Dipl.-Ing. Ulrich Wegner
Head of Certification Body
Environmental verifier

**Independence of verifier:**
Daimler AG has not placed any contracts for consultancy concerning product-related environmental aspects with TÜV SÜD, either in the past or at present. There are no areas of financial dependence or conflicts of interest between TÜV SÜD Management Service GmbH and Daimler AG.

**Responsibilities:**
Sole liability for the content of the environmental certificate rests with Daimler AG. TÜV SÜD Management Service GmbH was commissioned to review said LCA study for compliance with the methodical requirements, and to verify and validate the correctness and credibility of the information included therein.

# 1. General environmental issues

## 1.1 Product information

With the new E-Class, substantial reductions in fuel consumption have been achieved compared to the predecessor. The E 220 d with the new nine-speed automatic transmission 9G-TRONIC shows a drop in NEDC fuel consumption in comparison to its predecessor from between 6.2 and 6.0 l/100 km (at the time of the market launch in 2009) to between 4.3 and 3.9 l/100 km – depending on the tyres fitted. This corresponds to $CO_2$-emissions of 112 – 102 gram per kilometer.

The fuel efficiency benefits of the new E-Class are ensured by an intelligent package of measures. These extend to optimization measures in the powertrain, energy management, aerodynamics, weight reduction using lightweight construction techniques and driver information to encourage an energy saving in driving style.

The following figure 1-1 shows the realized fuel economy measures for the new E-Class.

Figure 1-1: Fuel-saving measures for the new E-Class

The new four-cylinder diesel engine OM 654 is launched in the E 220 d. The new diesel engine is designed to meet future emission legislation (RDE – Real Driving Emissions). Both the cylinder head and the crankcase are made of aluminium. The Mercedes-Benz developed NANOSLIDE® surface coating efficiently reduces the friction between cylinder surface and steel piston. The close coupled exhaust system consists of an Oxi-Cat (DOC), a dispense and mixing unit for AdBlue® as well as a combined diesel particulate filter with SCR coating. The so far common structural separation of diesel particulate filter (DPF) and SCR unit is no longer required. Diesel particulate filter (DPF) and SCR function are merged in one single installation space. With lower weight, this compact construction of the exhaust system reduces not only the required space of the engine, but it also contributes to a faster heating of the diesel particulate filter and startup of the oxidation catalyst.

Further model variants are added to the range after the market launch in early 2016, including the E 350 e featuring hybrid technology. The Plug-In Hybrid enables purely electric and therefor locally emission-free driving. Plug-in hybrids are an essential part of the Mercedes-Benz strategy for sustainable mobility.

In addition to the improvements to the vehicle, the driver also has a decisive influence on fuel consumption. Three bar graphs in the instrument cluster provide drivers with feedback about the economy of their driving style. The E-Class owner’s manual also includes additional tips for an economical and environmentally friendly driving style. Furthermore, Mercedes-Benz offers its customers “Eco Driver Training”. The results of this training course have shown that adopting an efficient and energy-conscious style of driving can help to further reduce a car’s fuel consumption.

The new E-Class is also fit for the future when it comes to its fuels. The EU’s plans make provision for an increasing proportion of biofuels to be used. It goes without saying that the E-Class meets these requirements: in the case of petrol engines, a bioethanol content of 10 percent (E 10) is permitted. A 10 percent biofuel component is also permitted for diesel engines in the form of 7 percent biodiesel (B 7 FAME) and 3 percent high-quality, hydrogenated vegetable oil.

### 1.2 Production

The E-Class is built at the Mercedes plant in Sindelfingen. An environmental management system certified in accordance with EU eco-audit regulations and ISO standard 14001 has been in place at the Sindelfingen plant since 1995. The painting technology used at the Sindelfingen plant, for example, boasts a high standard not only in technological terms but also with regard to environmental protection and workplace safety. Service life and value retention are further increased through the use of a clear coat, whose state-of-the-art nanotechnology ensures much greater scratch-resistance than conventional paint. Through the use of water-based paints and fillers, solvent emissions have been drastically reduced. Continuous process optimization also helps to save energy. By cutting down the air supply during weekend operations and extending the process window, for example, an annual saving of 6.4 gigawatt hours of energy was made. This equates to $CO_2$ savings of around 2,200 tons annually.

### 1.3 After Sales

High environmental standards are also firmly established in the environmental management systems in the sales and after-sales sectors at Mercedes-Benz. At dealer level, Mercedes-Benz meets its product responsibility with the MeRSy recycling system for workshop waste, used parts and warranty parts and packaging materials. The take-back system introduced in 1993 also means that Mercedes-Benz is a model for the automotive industry where workshop waste disposal and recycling are concerned. This exemplary service by an automotive manufacturer is implemented right down to customer level. The waste materials produced in our outlets during servicing and repairs are collected, reprocessed and recycled via a network operating throughout Germany. Classic components include bumpers, side panels, electronic scrap, glass and tyres.

The reuse of used parts also has a long tradition at Mercedes-Benz. The Mercedes-Benz Used Parts Center (GTC) was established back in 1996. With its quality-tested used parts, the GTC is an integral part of the service and parts operations for the Mercedes-Benz brand and makes an important contribution to the appropriately priced repair of Mercedes-Benz vehicles.

Although the reuse of Mercedes passenger cars lies in the distant future in view of their long service life, Mercedes-Benz offers a new, innovative procedure for the rapid disposal of vehicles in an environmentally friendly manner and free of charge.

For convenient recycling, a comprehensive network of collection points and dismantling facilities is available to Mercedes customers. Owners of used cars can find out all the important details relating to the return of their vehicles via the free phone number 00800 1 777 7777.


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# 2. Life Cycle Assessment (LCA)

The environmental compatibility of a vehicle is determined by the environmental burden caused by emissions and the consumption of resources throughout the vehicle's lifecycle (cf. Figure 2-1). The standardised tool for evaluating a vehicle's environmental compatibility is the LCA. It comprises the total environmental impact of a vehicle from the cradle to the grave, in other words from raw material extraction through production and use up to recycling.

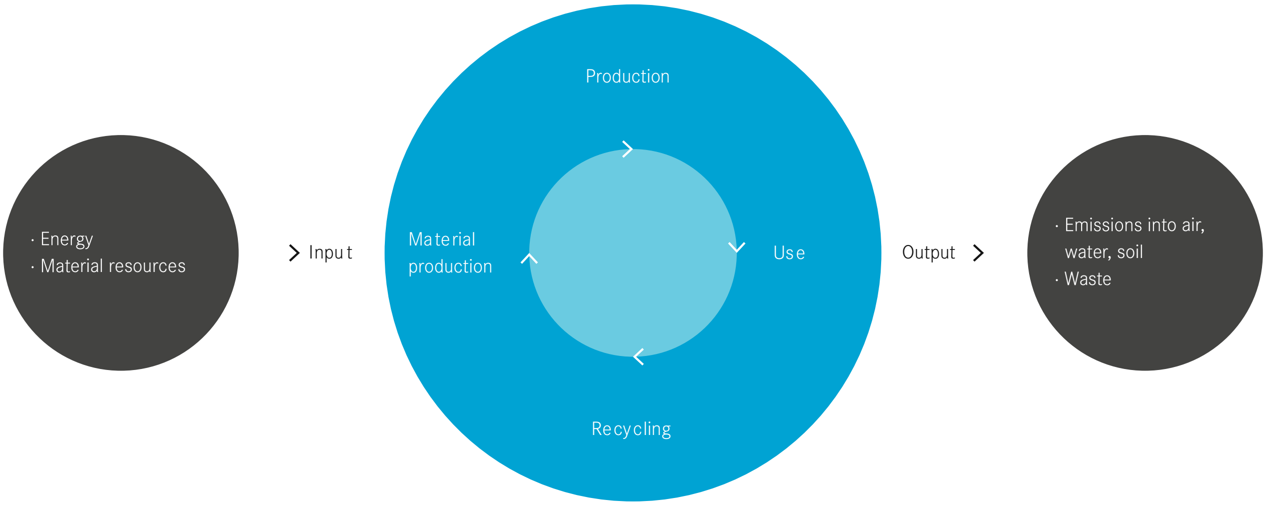
Life Cycle Assessments are used by the Mercedes-Benz passenger car development division for the evaluation and comparison of different vehicles, components, and technologies. The DIN EN ISO 14040 and DIN EN ISO 14044 standards prescribe the procedure and the required elements.

The elements of a Life Cycle Assessment are:

1. Goal and scope definition: define the objective and scope of an LCA.
2. Inventory analysis: encompasses the material and energy flows throughout all stages of a vehicle's life: how many kilograms of raw material are used, how much energy is consumed, what wastes and emissions are produced etc.
3. Impact assessment: gauges the potential effects of the product on the environment, such as global warming potential, summer smog potential, acidification potential, and eutrophication potential.
4. Interpretation: draws conclusions and makes recommendations.

The LCA results of the new E-Class are shown in the following chapters. The main parameters of the LCA are documented in the glossary. The operation phase is calculated on the basis of a mileage of 250,000 kilometres.

Figure 2-1: Overview of the Life Cycle Assessment



## 2.1 Material composition new E-Class E 220 d Saloon

The weight and material data for the new E 220 d were determined on the basis of internal documentation of the components used in the vehicle (parts list, drawings). The "kerb weight according to DIN" (without driver and luggage, fuel tank 90 percent full) served as a basis for the recycling rate and LCA. Figure 2-2 shows the material composition of the new E-Class in accordance with VDA 231-106.

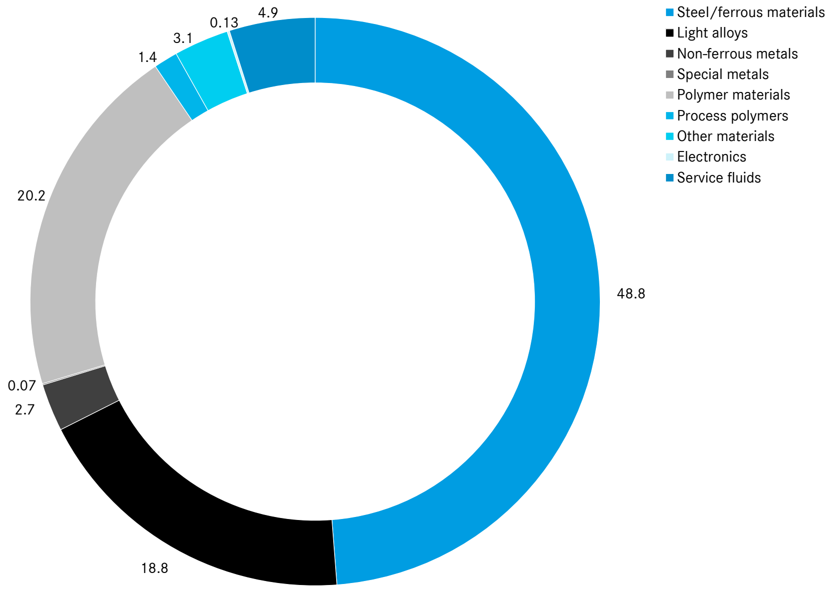
Steel/ferrous materials account for slightly the half of the vehicle weight (48.8 percent) in the new E-Class. These are followed by polymer materials at 20.2 percent and light alloys as third-largest group (18.8 percent). Service fluids comprise around 4.9 percent. The proportions of other materials (e. g. glass) and non-ferrous metals are somewhat lower, at about 3.1 and 2.7 percent respectively. The remaining materials – process polymers, electronics, and special metals – contribute about 1.6 percent to the weight of the vehicle. In this study, the material class of process polymers largely comprises materials for the paint finish.

The polymers are divided into thermoplastics, elastomers, duromers and non-specific plastics, with the thermoplastics accounting for the largest proportion at 12.5 percent. Elastomers (predominantly tyres) are the second-largest group of polymers with 5.6 percent.

The service fluids include oils, fuels, coolants, refrigerants, brake fluid, and washer fluid. The electronics group only comprises circuit boards and their components. Cables and batteries have been allocated according to their material composition in each particular case.

In comparison with the predecessor E 220 CDI the new E 220 d reveals several differences in the material mix. Due to lightweight construction measures in the areas of body shell and chassis, the new E 220 d has an approximately 7 percent lower steel content, while the proportion of light alloys increases by the same amount.

Figure 2-2: Material composition of the new E 220 d Saloon



## 2.2 LCA results for the new E-Class E 220 d Saloon

Over the entire lifecycle of the new E-Class 220 d, the lifecycle inventory analysis yields according to the method of electricity generation e. g. a primary energy consumption of 581 gigajoules (corresponding to the energy content of around 16,000 litres of petrol), an environmental input of approx. 36 tonnes of carbon dioxide ($CO_2$), around 15 kilograms of non-methane volatile organic compounds (NMVOC), around 45 kilograms of nitrogen oxides (NOx) and 35 kilograms of sulphur dioxide ($SO_2$). In addition to the analysis of the overall results, the distribution of individual environmental impacts over the various phases of the lifecycle is investigated. The relevance of the respective lifecycle phases depends on the particular environmental impact under consideration. For $CO_2$-emissions, and likewise for primary energy requirements, the operating phase dominates with a share of 76 and 73 percent respectively (see Figure 2-3).

However, it is not the use of the vehicle alone which determines its environmental compatibility. Some environmentally relevant emissions are caused principally by manufacturing, for example $SO_2$ and NOx emissions (see Figure 2-5). The production phase must therefore be included in the analysis of ecological compatibility.

During the use phase of the vehicle, many of the emissions these days are dominated less by the actual operation of the vehicle and far more by the production of fuel, as for example in the case of the NMVOC and $SO_2$ emissions and the inherently associated environmental impacts such as the summer smog (POCP) and acidification potential (AP).

Figure 2-3: Overall carbon dioxide emissions ($CO_2$) in tons

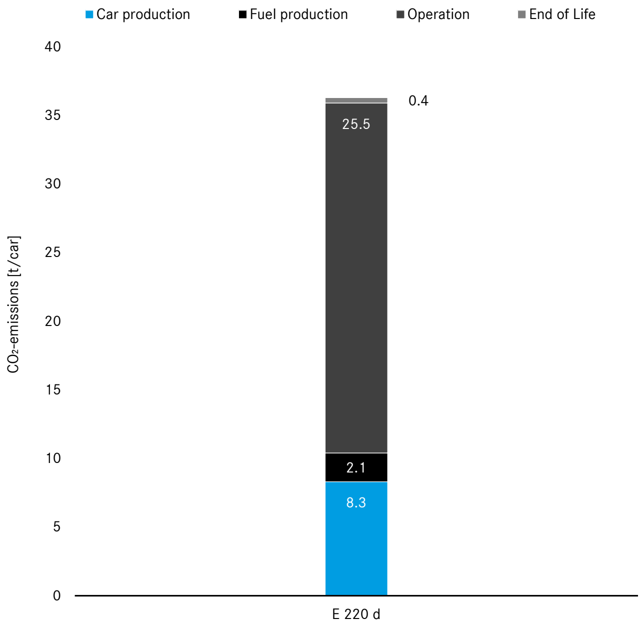
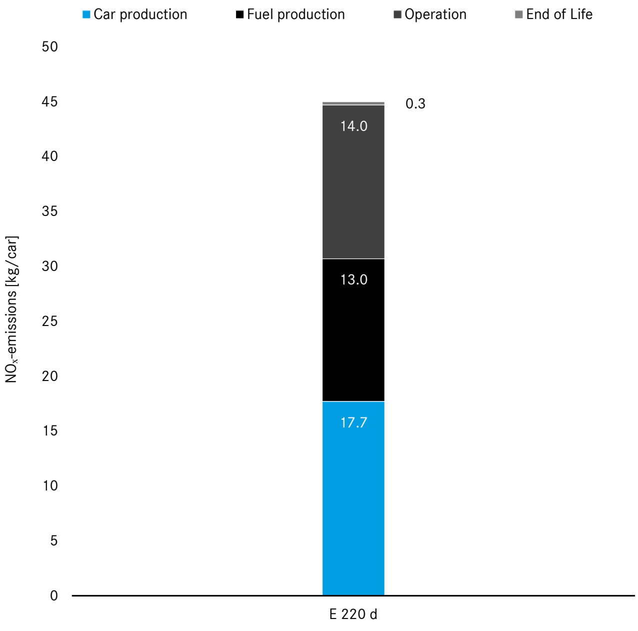


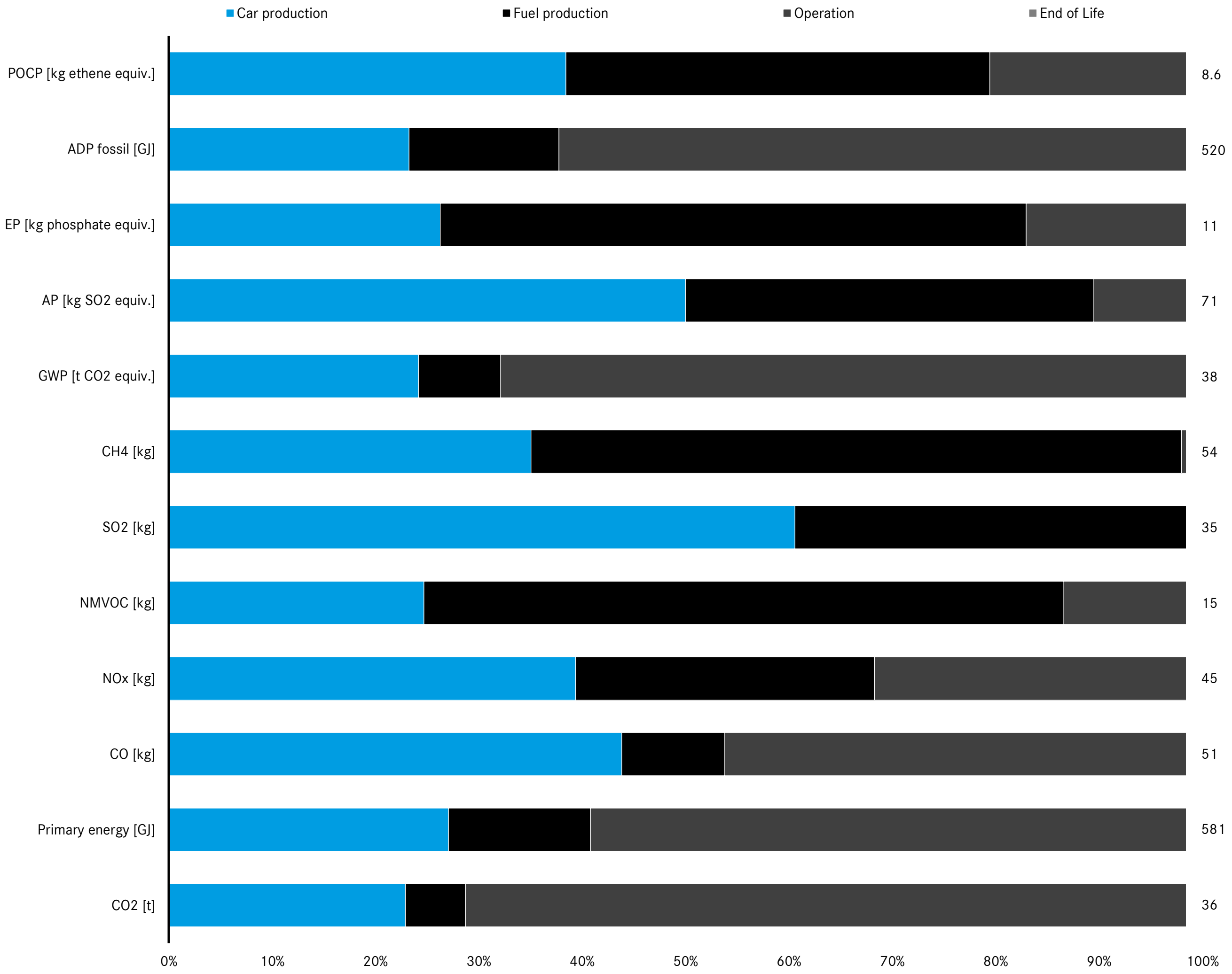
Figure 2-4: Overall nitric oxides emissions (NOx) in kilograms



For comprehensive and thus sustainable improvement of the environmental impacts associated with a vehicle, it is essential that the end-of-life phase is also considered. In terms of energy, the use or initiation of recycling cycles is worthwhile. For a complete assessment, all environmental inputs within each lifecycle phase are taken into consideration.

Environmental burdens in the form of emissions into water result from vehicle manufacturing, in particular owing to the output of inorganic substances (heavy metals, $NO_3^-$ and $SO_4^{2-}$ ions) as well as organic substances, measured according to the factors AOX, BOD and COD.

Figure 2-5: Share of lifecycle phases for selected parameters



## 2.3 Comparing the new E-Class E 220 d Saloon with the predecessor

In parallel with the analysis of the new E 220 d, an assessment of the ECE base version of the predecessor E 220 CDI was made (1,660 kilograms DIN weight). The parameters on which this was based are comparable to the modelling of the new E 220 d. The production process was represented on the basis of extracts from the current list of parts. The operation phase was calculated using the valid certification values. The same state-of-the-art model was used for recovery and recycling.

As Figure 2-6 shows, the production of the new E-Class E 220 d results in a higher quantity of carbon dioxide emissions than in the case of the predecessor. This is mainly due to the lightweight construction and the subsequent higher use of aluminum. Thanks to its higher efficiency in the use phase the new E-Class shows however significant advantages over the whole lifecycle compared to the previous model E 220 CDI.

At the beginning of the lifecycle, production of the new E 220 d gives rise to a higher quantity of $CO_2$-emissions (8.3 tons of $CO_2$) than it was the case with the predecessor E 220 CDI. In the subsequent operating phase, the new E 220 d emits around 27.6 tons of $CO_2$; the total emissions during production, use, and recycling thus amount to 36.3 tons of $CO_2$.

Production of the predecessor gives rise to 7.8 tons of $CO_2$. During the operation phase it emits 42.7 tons of $CO_2$, the contribution of the recycling is 0.4 tons of $CO_2$. The overall amount is 51 tons of $CO_2$-emissions respectively.
Taking the entire lifecycle into consideration, namely production, operation over 250,000 kilometres and recycling/disposal, the new E-Class E 220 d produces $CO_2$-emissions that are 29 percent lower than those of its predecessor.

Figure 2-6: Comparison of $CO_2$-emissions [t/car]

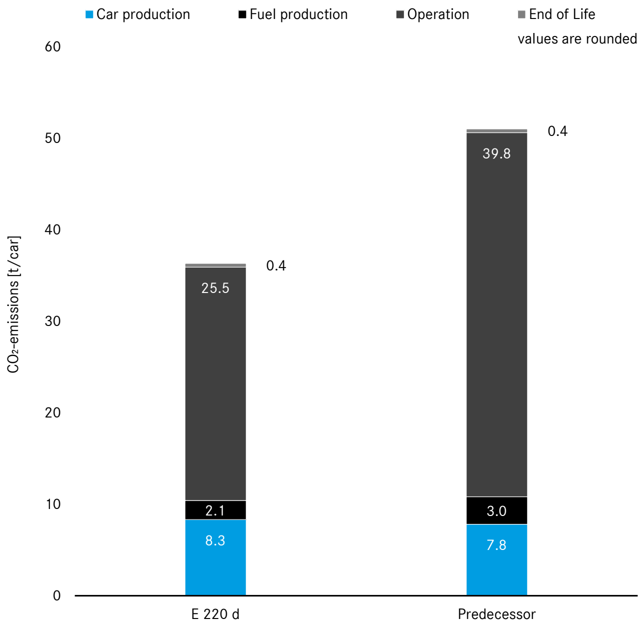


Figure 2-7: Comparison of NOx-emissions [t/car]

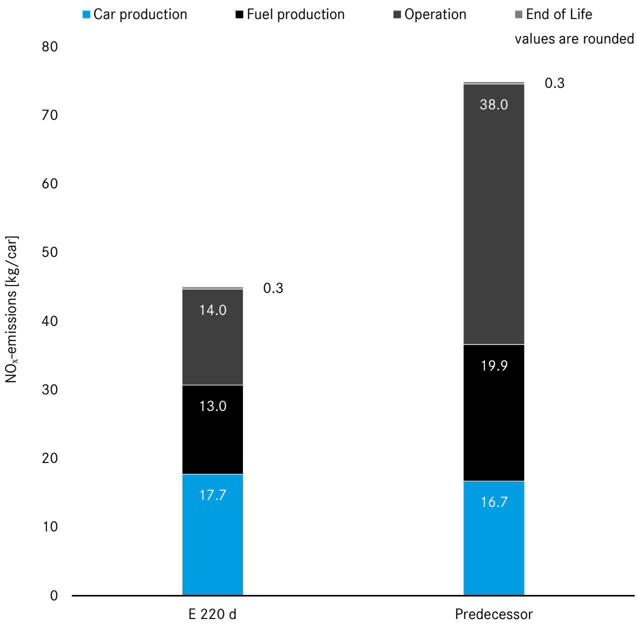


Figure 2-8 shows further emissions into the atmosphere and the corresponding impact categories in comparison over the various lifecycle phases. Over the entire lifecycle, the new E-Class shows clear advantages towards the previous model in terms of global warming potentials (GWP100), summer smog (POCP), acidification potential (AP) and eutrophication (EP).

Regarding the energy resources there are also changes compared to the previous model E 220 CDI (cf. Figure 2-9).

The consumption of crude oil could be reduced notably by 33 percent. Other energetic resources hard coal and uranium which are mainly used for car production do rise slightly. Overall the fossil abiotic depletion potential (ADP fossil) could be reduced clearly by 28 percent.

Figure 2-8: Selected result parameters for the E 220 d Saloon compared with the predecessor [unit/car]

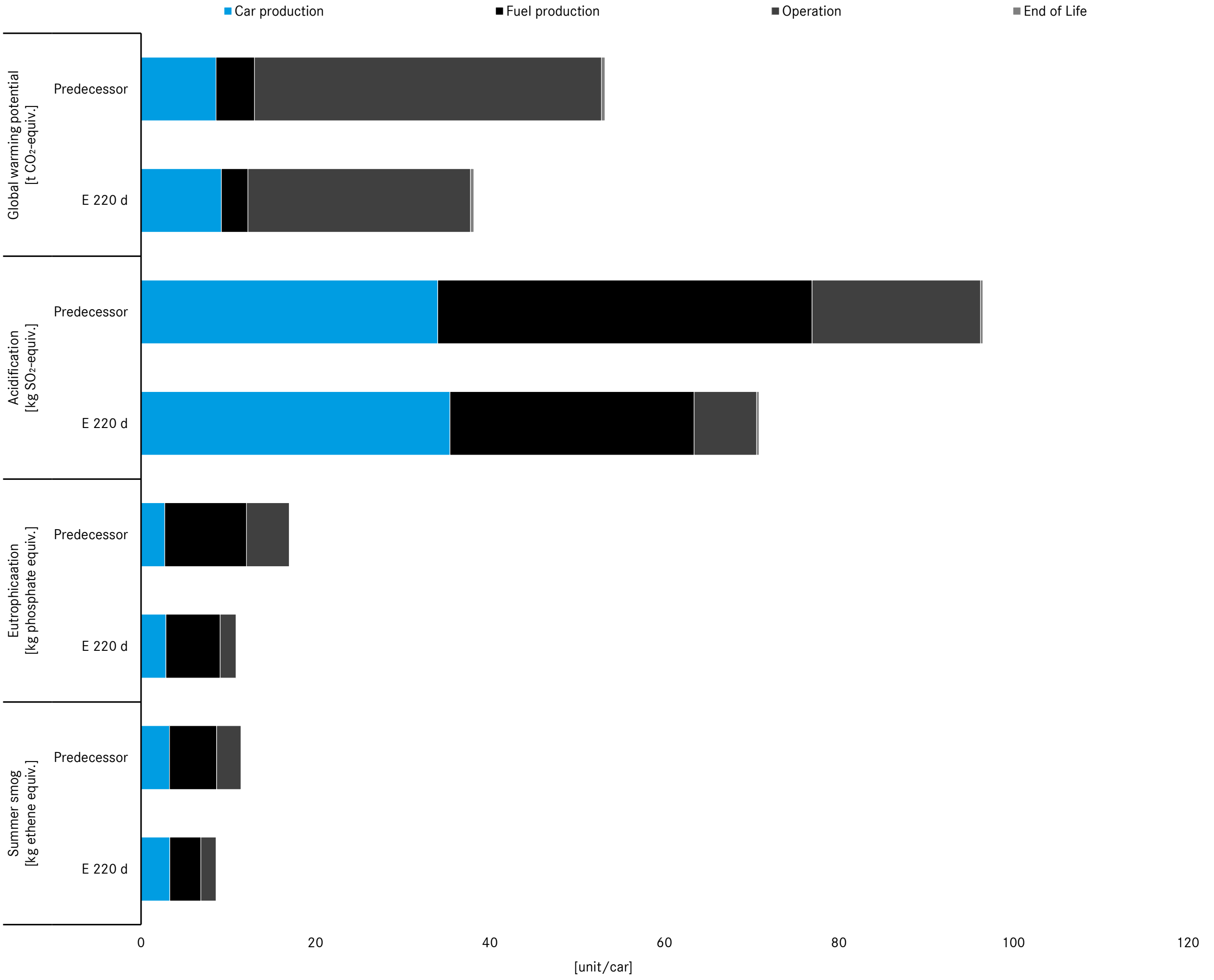
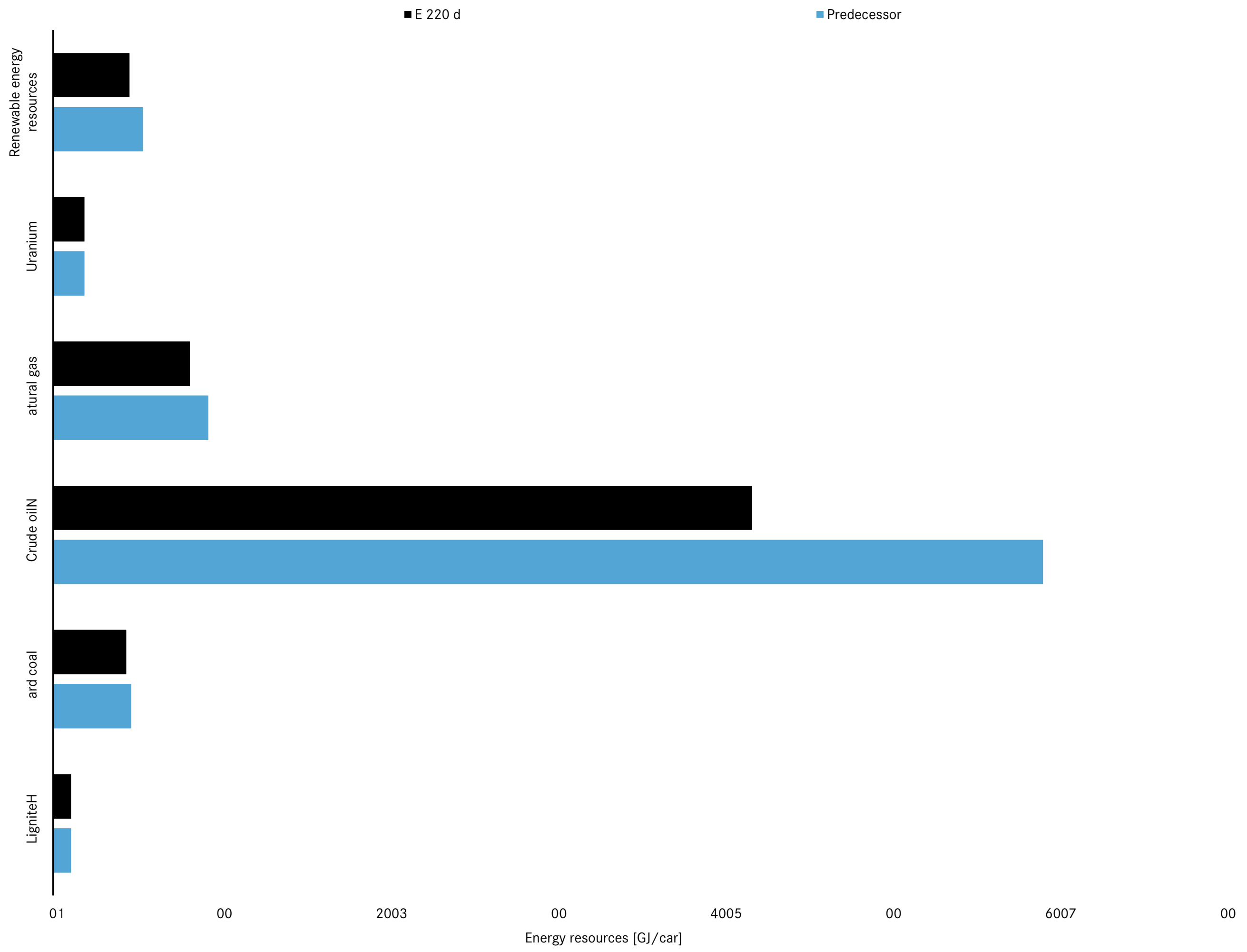


Figure 2-9: Consumption of selected energy resources E 220 d Saloon compared with the predecessor [GJ/car]



Tables 2-1 and 2-2 show further LCA result parameters as an overview. The goal of bringing about improved environmental performance in the new model over its predecessor was achieved overall. Over the entire lifecycle, the new E-Class shows notable advantages in the impact categories global warming potential (GWP100), eutrophication (EP), acidification (AP), fossil abiotic depletion potential (ADP fossil) and summer smog (POCP) compared to the predecessor E 220 CDI.

Table 2-1: Overview of LCA parameters (I)

| **Input parameters** | **E 220 d** | **Predecessor** | **Delta E 220 d to predecessor** | **Comments** |
|---|---|---|---|---|
| **Material resources** | | | | |
| Bauxite [kg] | 1,541 | 1,130 | **36 %** | Aluminium production, higher primary content (mainly body shell, motor, and axles). |
| Dolomite [kg] | 172 | 135 | **27 %** | Magnesium production, higher mass of magnesium. |
| Iron [kg]* | 975 | 1,046 | **-7 %** | Steel production, smaler mass of steel (delta mainly in body shell or engine). |
| Non-ferrous metals (Cu, Pb, Zn) [kg]* | 177 | 183 | **-3 %** | |
| * as elementary resources | | | | |
| | | | | |
| **Energy resources** | | | | |
| ADP fossil** [GJ] | 520 | 725 | **-28 %** | Mainly fuel consumption: 62 % for the E 220 d, 70 % for the predecessor. |
| Primary energy [GJ] | 581 | 796 | **-27 %** | Consumption of energy resources much lower compared with the predecessor, due to fuel reduction of new E 220 d. |
| Proportionately | | | | |
| Lignite [GJ] | 10 | 11 | **-7 %** | E 220 d approx. 85 %, predecessor approx 82 % from car production. |
| Natural gas [GJ] | 79 | 91 | **-14 %** | E 220 d approx. 56 %, predecessor approx. 46 % from car production.<br>E 220 d approx. 44 %, predecessor approx. 54 % from use. |
| Crude oil [GJ] | 389 | 582 | **-33 %** | E 220 d approx. 93 %, predecessor approx 93 % from car production. |
| Hard coal [GJ] | 42 | 41 | **2 %** | E 220 d approx. 95 %, predecessor approx 93 % from car production. |
| Uranium [GJ] | 19 | 18 | **3 %** | E 220 d approx. 86 %, predecessor approx 80 % from car production. |
| Renewable energy resources [GJ] | 43 | 53 | **-18 %** | E 220 d approx. 47 %, predecessor approx. 34 % from car production.<br>E 220 d approx. 47 %, predecessor approx. 65 % from use. |
| ** CML 2001, as of April 2015 | | | | |

Table 2-2: Overview of LCA parameters (II)

| **Output parameters** | **E 220 d** | **Predecessor** | **Delta E 220 d to predecessor** | **Comments** |
|---|---|---|---|---|
| **Emissions in air** | | | | |
| GWP** [t CO$_2$-equiv.] | 38 | 53 | **-28 %** | Mainly due to CO$_2$-emissions. |
| AP** [kg SO$_2$-equiv.] | 71 | 97 | **-27 %** | Mainly due to SO$_2$-emissions. |
| EP** [kg phosphate-equiv.] | 11 | 17 | **-36 %** | Mainly due to NOx-emissions. |
| POCP** [kg ethene-equiv.] | 9 | 11 | **-25 %** | Mainly due to NMVOC and CO-emissions. |
| CO$_2$ [t] | 36 | 51 | **-29 %** | Mainly from driving operation. CO$_2$-reduction is a direct result of the lower fuel consumption. |
| CO [kg] | 51 | 65 | **-21 %** | E 220 d approx. 44 %, predecessor approx. 36 % from car production.<br>E 220 d approx. 56 %, predecessor approx. 63 % from use. |
| NMVOC [kg] | 15 | 20 | **-25 %** | E 220 d approx. 75 %, predecessor approx. 82 % from use. |
| CH$_4$ [kg] | 54 | 71 | **-23 %** | E 220 d approx. 35 %, predecessor approx. 25 % from car production.<br>E 220 d approx. 65 %, predecessor approx. 75 % from use. |
| NOx [kg] | 45 | 75 | **-40 %** | E 220 d approx. 39 %, predecessor approx. 22 % from car production.<br>E 220 d approx. 60 %, predecessor approx. 77 % from use. |
| SO$_2$ [kg] | 35 | 42 | **-16 %** | E 220 d approx. 61 %, predecessor approx. 49 % from car production.<br>E 220 d approx. 39 %, predecessor approx. 51 % from use. |
| | | | | |
| **Emissions in water** | | | | |
| BOD [kg] | 0.14 | 0.17 | **-17 %** | E 220 d approx. 62 %, predecessor approx. 53 % from car production.<br>E 220 d approx. 38 %, predecessor approx. 47 % from use. |
| Hydrocarbons [kg] | 2.7 | 3.5 | **-24 %** | E 220 d approx. 24 %, predecessor approx. 16 % from car production.<br>E 220 d approx. 76 %, predecessor approx. 84 % from use. |
| NO$_3^-$ [kg] | 13.3 | 20.3 | **-34 %** | E 220 d approx. 96 %, predecessor approx. 98 % from use. |
| PO$_4^{3-}$ [g] | 640 | 956 | **-33 %** | E 220 d approx. 91 %, predecessor approx. 94 % from use. |
| SO$_4^{2-}$ [kg] | 19.1 | 23.1 | **-17 %** | E 220 d approx. 58 %, predecessor approx. 47 % from car production.<br>E 220 d approx. 41 %, predecessor approx. 52 % from use. |

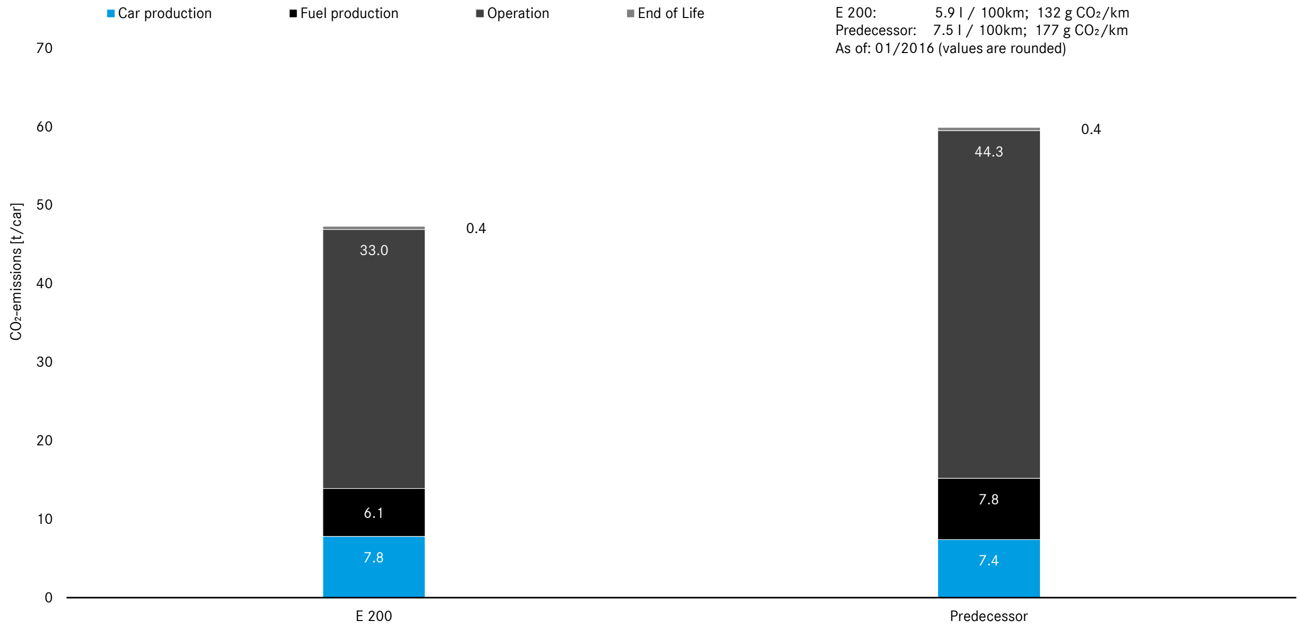
** CML 2001,as of April 2015

## 2.4 LCA results for the new E-Class E 200 Saloon in comparison with the predecessor

In parallel with the analysis of the diesel models E 220 d and previous model E 220 CDI, an assessment of the new E-Class E 200 and the ECE base version of the predecessor E 200 was made (1,540 kilograms DIN weight). The parameters on which this was based are comparable to the modelling of the new E 200. The production process was represented on the basis of extracts from the current list of parts. The operation phase was calculated using the valid certification values. The same state-of-the-art model was used for recovery and recycling.

Figure 2-10 compares the carbon dioxide emissions of the new E-Class E 200 with those of the comparable predecessor E 200. In the production phase the new E 200 gives rise to a visibly higher quantity of carbon dioxide emissions especially caused by lightweight construction measures. Thanks to its higher efficiency in the use phase the new E 200 shows however significant advantages over the whole lifecycle. The $CO_2$-emissions could be reduced towards the predecessor E 200 by approximately 21 percent (12.5 tons).

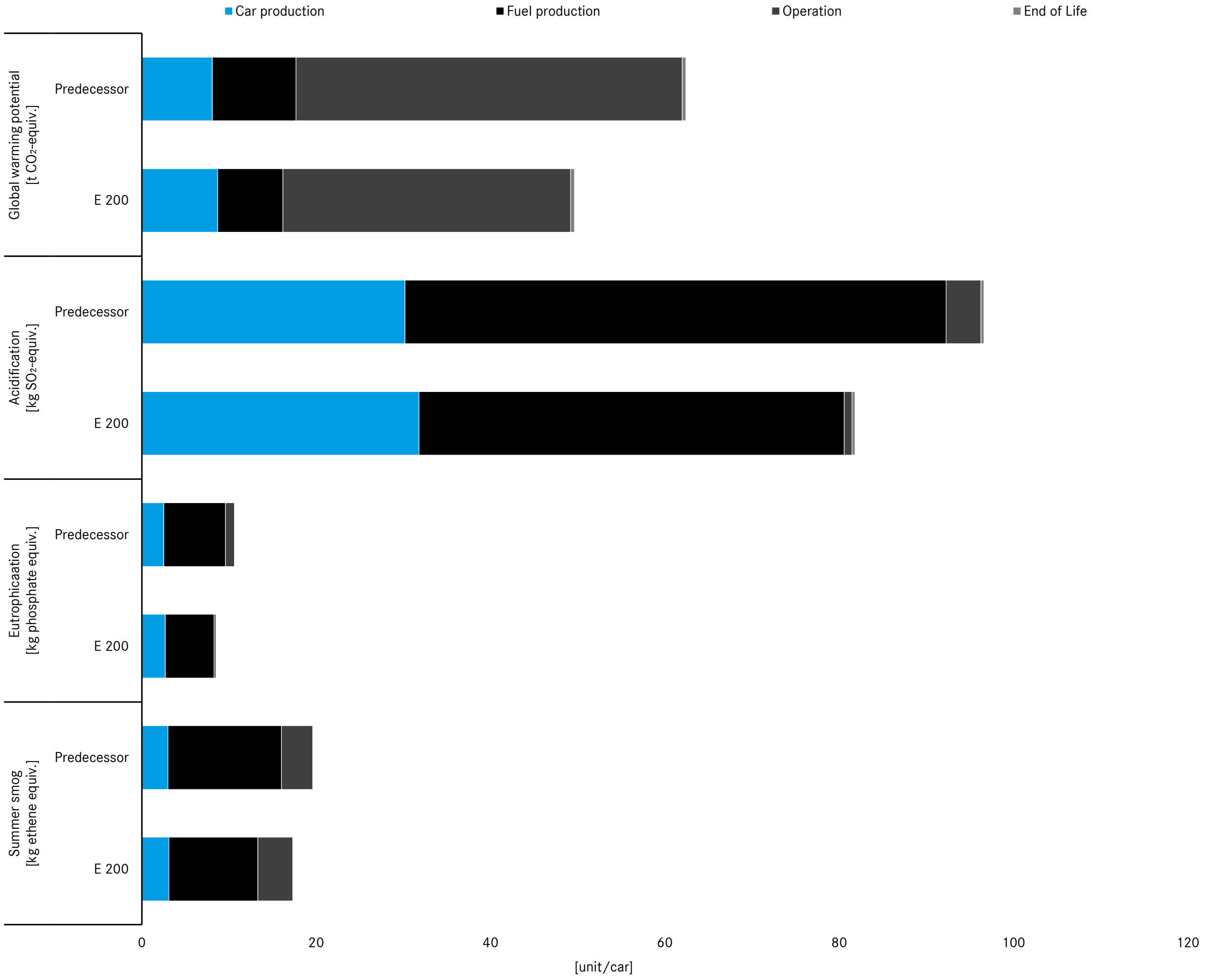
Figure 2-10: Comparison of $CO_2$-emissions over the entire lifecycle [t/car]



E 200: 5.9 l / 100km; 132 g $CO_2$/km
Predecessor: 7.5 l / 100km; 177 g $CO_2$/km
As of: 01/2016 (values are rounded)

Fig. 2-11 shows a comparison of the examined environmental impacts over the individual lifecycle phases. Over the entire lifecycle, the E 200 has clear advantages in terms of all result parameters shown, compared to the predecessor E 200.

Figure 2-11: Selected result parameters E 200 Saloon compared with the predecessor [unit / car]



Regarding the energetic resources there is also improvement compared to the previous model E 200 (cf. Figure 2-12). The consumption of crude oil could be reduced notably by 20 percent. Energy resources, mainly used for car production, like hard coal and uranium, do rise slightly. Over the entire lifecycle, primary energy savings of 17 percent are possible in comparison to the predecessor E 200.

The decrease in required primary energy by 152 gigajoule corresponds to the energy content of approx. 4,700 litres of petrol respectively (cf. Table 2-3).

Tables 2-3 and 2-4 show further result parameters for the new E-Class E 200 and the predecessor E 200 as an overview.

Figure 2-12: Consumption of selected energy resources E 200 Saloon compared to the predecessor [GJ/car]

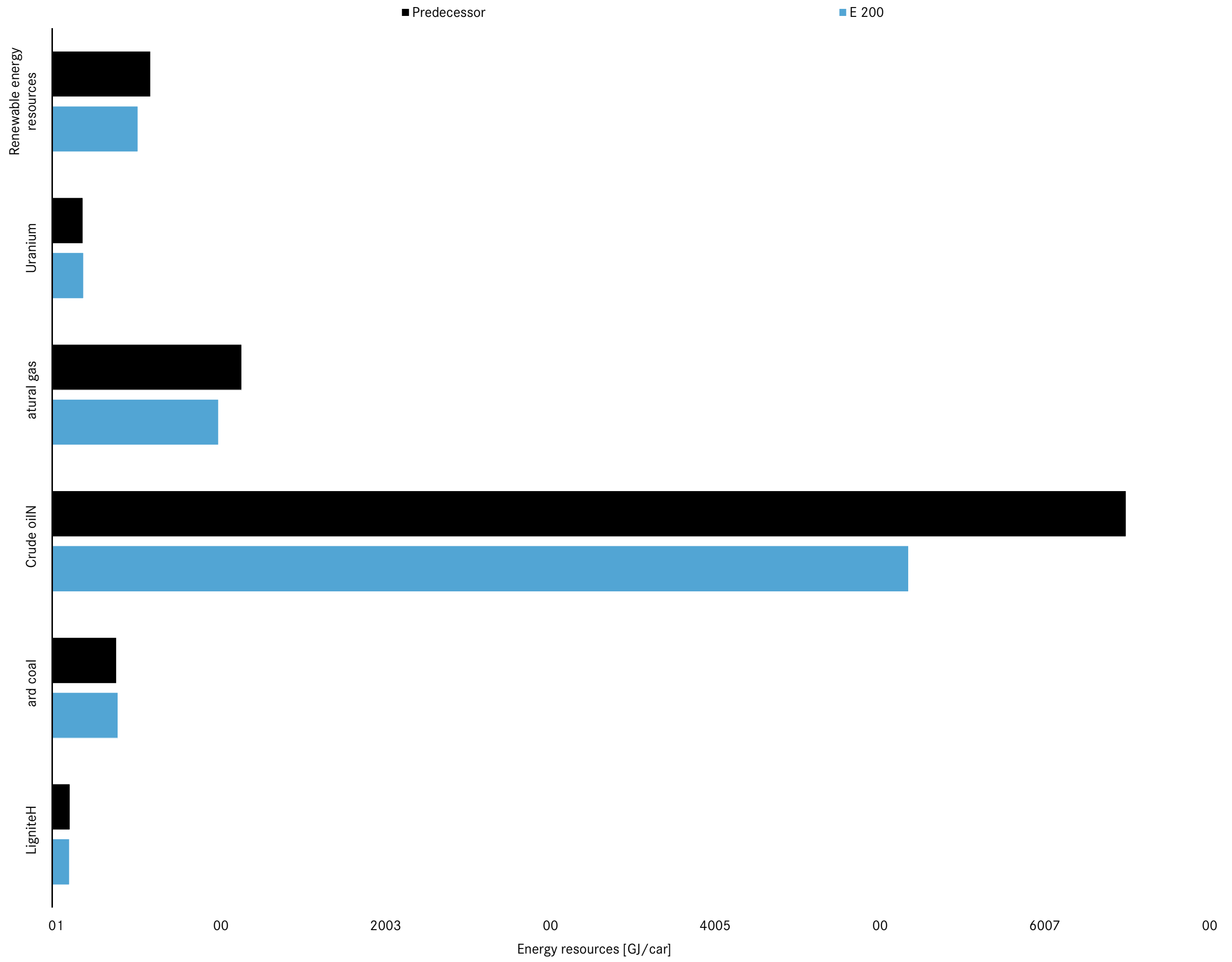



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Table 2-3: Overview of LCA result parameters (I)

| Input parameters | E 200 | Predecessor | Delta E 200 to predecessor | Comments |
|---|---|---|---|---|
| **Material resources** | | | | |
| Bauxite [kg] | 1,449 | 1,138 | **27 %** | Aluminium production, higher primary content. |
| Dolomite [kg] | 170 | 134 | **27 %** | Magnesium production, higher mass of magnesium. |
| Iron [kg]* | 936 | 1,000 | **-6 %** | Steel production, smaler mass of steel (delta mainly in body shell and axles). |
| Non-ferrous metals (Cu, Pb, Zn) [kg]* | 173 | 173 | **0 %** | |
| * as elementary resources | | | | |
| | | | | |
| **Energy resources** | | | | |
| ADP fossil** [GJ] | 671 | 816 | **-18 %** | Mainly due to car production. |
| Primary energy [GJ] | 742 | 894 | **-17 %** | New E 200 approx. 80 % from operation (fuel), predecessor 84 %. |
| Proportionately | | | | |
| Lignite [GJ] | 10.4 | 10.7 | **-3 %** | New E 200 approx. 79 % from car production, approx. 15 % from fuel production. |
| Natural gas [GJ] | 101 | 115 | **-12 %** | New E 200 approx. 59 % from use, precedessor 66 %. |
| Crude oil [GJ] | 520 | 652 | **-20 %** | E 200 approx. 95 % from use, predecessor 96 %. |
| Hard coal [GJ] | 40 | 39 | **2 %** | E 200 ca. 93 % from car production, predecessor approx. 91 %. |
| Uranium [GJ] | 19.0 | 18.6 | **2 %** | E 200 approx. 79 % from car production, predecessor 74 %. |
| Renewable energy resources [GJ] | 52 | 59 | **-11 %** | E 200 approx. 62 % from use and 37 % from car production. |
| ** CML 2001, as of April 2015 | | | | |

Table 2-4: Overview of LCA result parameters (II)

| **Output parameters** | **E 200** | **Predecessor** | **Delta E 200 to predecessor** | **Comments** |
|---|---|---|---|---|
| **Emissions in air** | | | | |
| GWP** [t $CO_2$-equiv.] | 50 | 62 | **-20 %** | Mainly due to $CO_2$-emissions. |
| AP** [kg $SO_2$-equiv.] | 82 | 97 | **-15 %** | Mainly due to $SO_2$-emissions. |
| EP** [kg phosphate-equiv.] | 8 | 11 | **-20 %** | Mainly due to NOx-emissions. |
| POCP** [kg ethene-equiv.] | 17 | 20 | **-12 %** | Mainly due to NMVOC and CO-emissions. |
| $CO_2$ [t] | 47 | 60 | **-21 %** | E 200 approx. 83 % from use (mainly driving operation). Predecessor approx. 87 %. |
| CO [kg] | 90 | 100 | **-11 %** | E 200 approx. 76 % from use (mainly driving operation). Predecessor approx. 78 %. |
| NMVOC [kg] | 34 | 38 | **-11 %** | E 200 approx. 89 % from use (mainly fuel production). Predecessor approx. 91 %. |
| $CH_4$ [kg] | 66 | 78 | **-16 %** | E 200 approx. 73 % from use (mainly fuel production). Predecessor approx. 79 %. |
| NOx [kg] | 39 | 50 | **-22 %** | E 200 approx. 57 % from use (mainly fuel production). Predecessor approx. 68 %. |
| $SO_2$ [kg] | 50 | 57 | **-13 %** | E 200 approx. 61 % from use (mainly fuel production). Predecessor approx. 69 %. |
| | | | | |
| **Emissions in water** | | | | |
| BOD [kg] | 0.17 | 0.20 | **-15 %** | New E 200 approx. 52 % from fuel production and 37 % from car production. |
| Hydrocarbons [kg] | 2.0 | 2.3 | **-14 %** | New E 200 approx. 69 % from fuel production, rest from car production. |
| $NO_3^-$ [kg] | 6.5 | 8.2 | **-21 %** | New E 200 approx. 94 % from fuel production. Predecessor approx. 95 %. |
| $PO_4^{3-}$ [g] | 539 | 669 | **-19 %** | New E 200 approx. 90 % from fuel production. Predecessor approx. 93 %. |
| $SO_4^{2-}$ [kg] | 23.7 | 27.0 | **-12 %** | New E 200 approx. 55 % from fuel production. Predecessor approx. 61 %. |

** CML 2001, as of April 2015

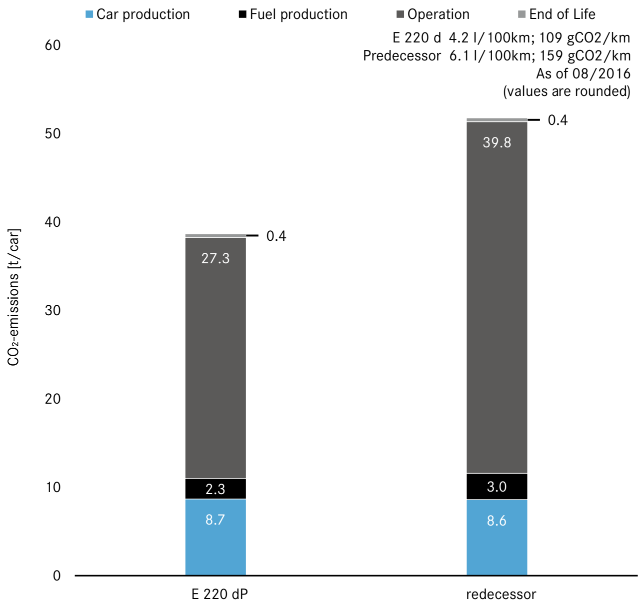
## 2.5 LCA results for the new E-Class E 220 d Estate in comparison with the predecessor

In addition to the analysis of the E-Class E 220 d Saloon and E 200 Saloon, the new E-Class Estate model E 220 d was evaluated and compared to the predecessor E-Class E 220 CDI Estate as ECE base version (1,770 kilograms DIN weight). The parameters on which this was based are comparable to the modelling of the new E 220 d Estate. The production process was represented on the basis of extracts from the current list of parts. The operation phase was calculated using the valid certification values. The same state-of-the-art model was used for recovery and recycling.

Figure 2-13 compares the carbon dioxide emissions of the new E-Class E 220 d Estate with those of the predecessor E 220 CDI Estate. In the production phase the new E 220 d Estate gives rise to a slightly higher quantity of carbon dioxide emissions especially caused by lightweight construction measures. Thanks to its higher efficiency in the use phase the new E 220 d Estate shows however significant advantages over the entire lifecycle compared to the predecessor E 220 CDI Estate. The $CO_2$-emissions could be reduced towards the predecessor E 220 CDI Estate by approximately 26 percent (approx. 13 tons).

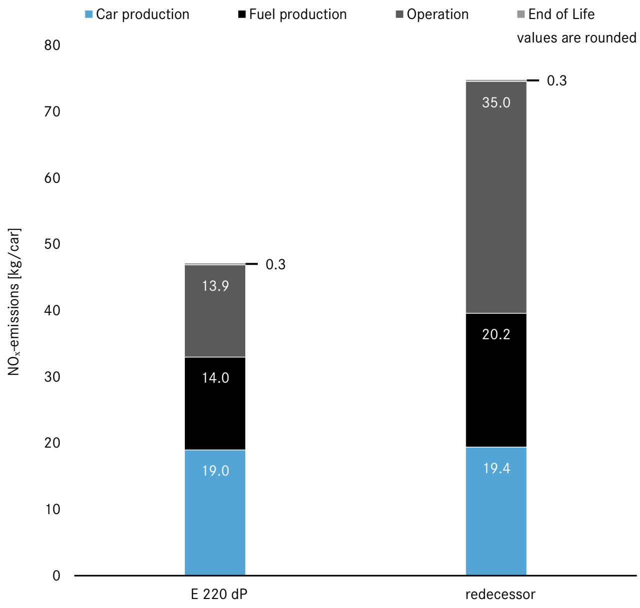
Figure 2-14 compares the nitric oxide emissions of the new E-Class E 220 d Estate with those of the predecessor. Car production results for both vehicles in an almost identical amount of nitric oxide emissions. However, in the use phase the new E 220 d Estate shows clear advantages compared to its predecessor. Over the entire lifecycle about 37 % can be saved in total. In addition to the standard scenario with certified nitric oxide emissions values a scenario using real driving emissions instead of the certified values was examined. In that scenario, the new E 220 d Estate also shows clear advantages for nitric oxide emissions and all the other examined result parameters compared to its EU5 certified predecessor.

Figure 2-13: Comparision of $CO_2$-emissions over the entire lifecycle [t/car]



E 220 d 4.2 l/100km; 109 gCO2/km
Predecessor 6.1 l/100km; 159 gCO2/km
As of 08/2016
(values are rounded)

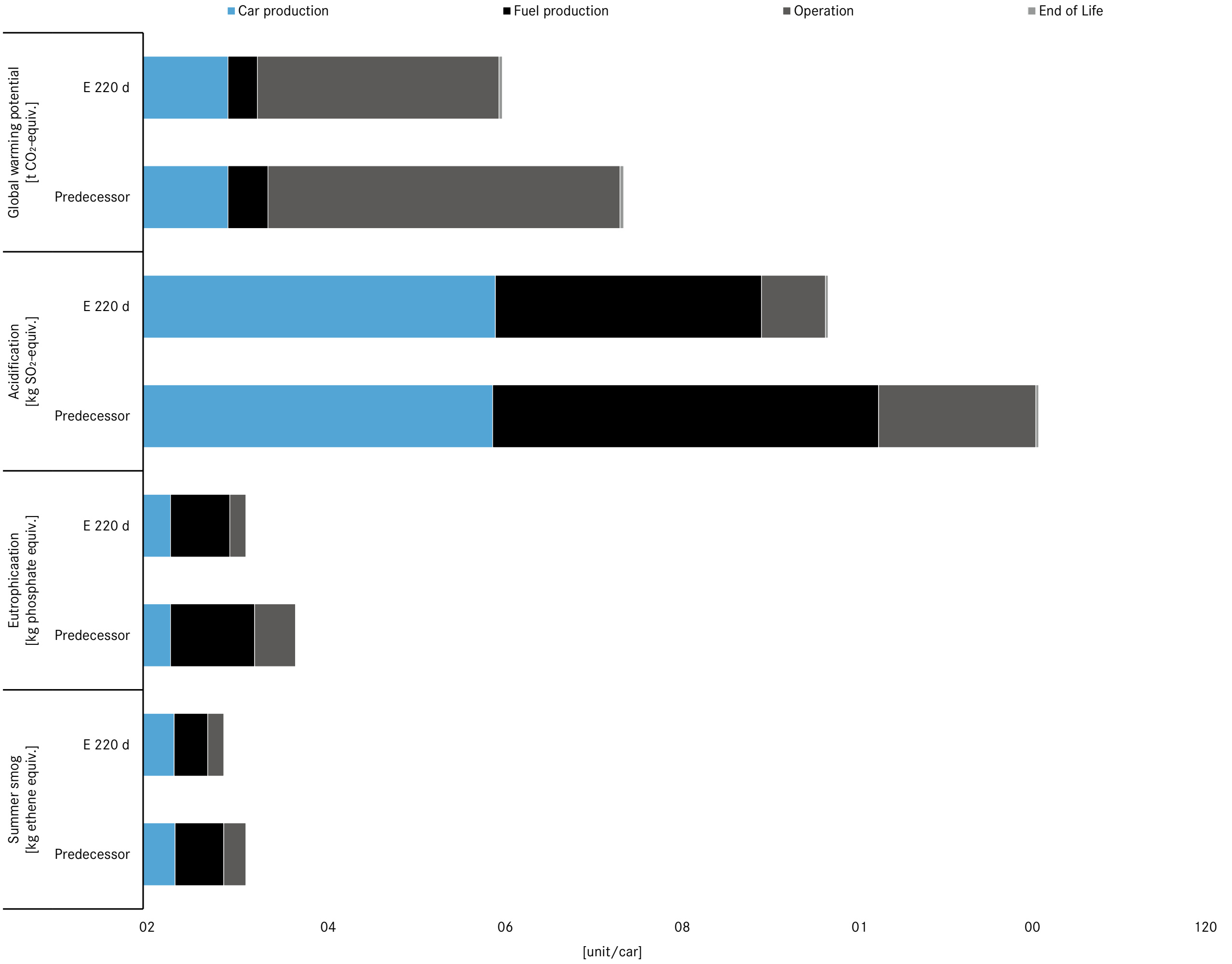
Figure 2-14: Comparision of NOx-emissions over the entire lifecycle [kg/car]



values are rounded

Fig. 2-15 shows a comparison of the examined environmental impacts over the individual lifecycle phases. Over the entire lifecycle, the new E 220 d Estate has clear advantages in terms of all result parameters shown, compared to the predecessor E 220 CDI Estate.

Figure 2-15: Selected result parameters E 220 d Estate compared with the predecessor [unit/car]



Regarding the energy resources there is also improvement compared to the previous model E 220 CDI Estate (cf. Figure 2-16). The consumption of crude oil could be reduced notably by 29 percent. Energy resource uranium, mainly used for car production, does rise slightly. Over the entire lifecycle, primary energy savings of 24 percent are possible in comparison to the predecessor E 220 CDI Estate. The decrease in required primary energy by 196 gigajoule corresponds to the energy content of approx. 5,400 litres of diesel respectively (cf. Table 2-5).

Tables 2-5 and 2-6 show further result parameters for the new E-Class E 220 d Estate and the predecessor E 220 CDI Estate as an overview.

Figure 2-16: Consumption of selected energy resources E 220 d Estate compared with the predecessor [GJ/car]

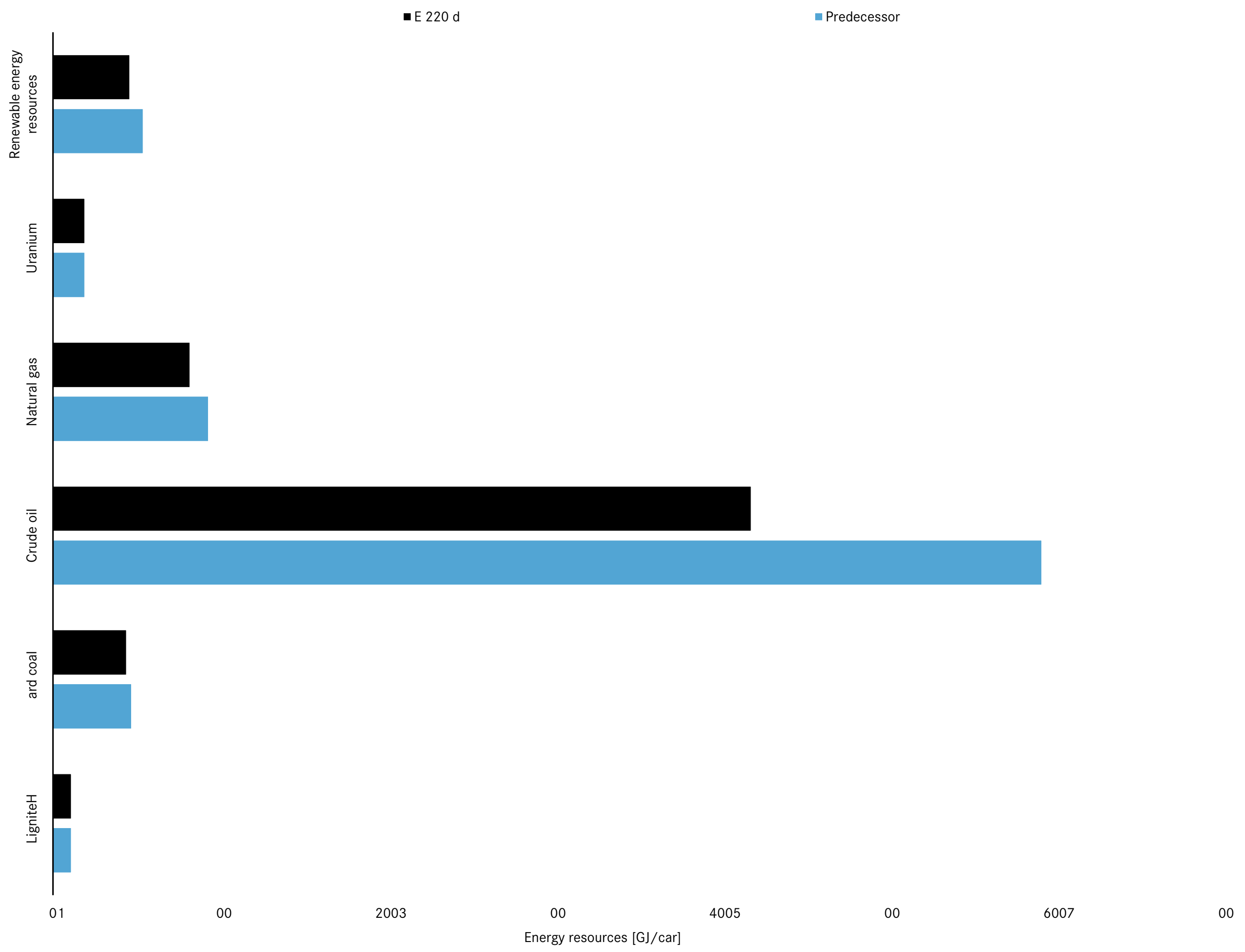



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Table 2-5: Overview of LCA result parameters E 220 d Estate compared with the predecessor (I)

| **Input parameters** | **E 220 d Estate** | **Predecessor** | **Delta E 220 d Estate to predecessor** | **Comments** |
|---|---|---|---|---|
| **Material resources** | | | | |
| Bauxite [kg] | 1,595 | 1,151 | **39%** | Aluminium production, higher primary content (mainly body shell, engine and axles). |
| Dolomite [kg] | 156 | 238 | **-35%** | Magnesium production, lower mass of magnesium (mainly body shell). |
| Iron [kg]* | 975 | 1,121 | **-13%** | Steel production, lower mass of steel (delta mainly body shell and engine). |
| Non-ferrous metals (Cu, Pb, Zn) [kg]* | 167 | 165 | **1%** | Mainly electrics/electronics. |
| * as elementary resources | | | | |
| **Energy recources** | | | | |
| **ADP fossil** ** **[GJ]** | 555 | 743 | **-25%** | Mainly fuel consumption: E 220 d 64 % and predecessor 69 %. |
| Primary energy [GJ] | 620 | 816 | **-24%** | Consumption of energy resources much lower compared with the predecessor, due to reduced fuel reduction of the new E 220 d. |
| Proportionately | | | | |
| Lignite [GJ] | 10,6 | 11,4 | **-7%** | E 220 d 85 %, predecessor 82 % from production. |
| Natural gas [GJ] | 82 | 93 | **-12%** | E 220 d 55 %, predecessor 46 % from production. E 220 d 45 %, predecessor 54 % from use. |
| Crude oil [GJ] | 418 | 592 | **-29%** | E 220 d 93 %, predecessor 95 % from use. |
| Hard coal [GJ] | 44 | 47 | **-5%** | E 220 d 95 %, predecessor 93 % from production. |
| Uranium [GJ] | 19,4 | 18,8 | **3%** | E 220 d 86 %, predecessor 80 % from production. |
| Renewable energy resources [GJ] | 46 | 54 | **-15%** | E 220 d 46 %, predecessor 34 % from production. E 220 d 53 %, predecessor 65 % from use. |
| ** CML 2001, as of April 2015 | | | | |

Table 2-6: Overview of LCA result parameters E 220 d Estate compared with the predecessor (II)

| **Output parameters** | **E 220 d Estate** | **Predecessor** | **Delta E 220 d Estate to predecessor** | **Comments** |
|---|---|---|---|---|
| **Emissions in air** | | | | |
| GWP** [t CO$_2$-equiv.] | 41 | 54 | **-25%** | Mainly due to CO$_2$-emissions. |
| AP** [kg SO$_2$-equiv.] | 77 | 101 | **-24%** | Mainly due to SO$_2$-emissions. |
| EP** [kg phosphate-equiv.] | 12 | 17 | **-32%** | Mainly due to NOx-emissions. |
| POCP** [kg ethene-equiv.] | 9 | 12 | **-22%** | Mainly due to NMVOC and CO-emissions. |
| CO$_2$ [t] | 39 | 52 | **-26%** | Mainly from driving operation. CO$_2$ reduction is a direct result of the lower fuel consumption. |
| CO [kg] | 52 | 55 | **-6%** | E 220 d 44 %, predecessor 46 % from production. E 220 d 56 %, predecessor 54 % from use. |
| NMVOC [kg] | 16 | 20 | **-24%** | E 220 d 76 %, predecessor 82 % from use. |
| CH$_4$ [kg] | 58 | 73 | **-20%** | E 220 d 35 %, predecessor 26 % from production. E 220 d 64 %, predecessor 74 % from use. |
| NOx [kg] | 47 | 75 | **-37%** | E 220 d 40 %, predecessor 26 % from production. E 220 d 59 %, predecessor 74 % from use. |
| SO2 [kg] | 39 | 46 | **-15%** | E 220 d 62 %, predecessor 53 % from production. E 220 d 38 %, predecessor 47 % from use. |
| | | | | |
| **Emissions in water** | | | | |
| BOD [kg] | 0.14 | 0.17 | **-16%** | E 220 d 61 %, predecessor 54 % from production. E 220 d 39 %, predecessor 46 % from use. |
| Hydrocarbons [kg] | 2.8 | 3.6 | **-21%** | E 220 d 23 %, predecessor 16 % from production. E 220 d 77 %, predecessor 84 % from use. |
| NO$^{3}$- [g] | 14,355 | 20,454 | **-30%** | E 220 d 96 %, predecessor 98 % from use. |
| PO$_4^{3}$- [g] | 697 | 979 | **-29%** | E 220 d 90 %, predecessor 94 % from use. |
| SO$_4^{2}$- [kg] | 19.7 | 23.4 | **-16%** | E 220 d 56 %, predecessor 47 % from production. E 220 d 43 %, predecessor 52 % from use. |

** CML 2001, as of April 2015

## 2.6 LCA results for the new E-Class E 350 e Saloon in comparison with the predecessor

The plug-in hybrid model E 350 e combines a 65 kW (88 hp) electric motor with a four-cylinder petrol engine displacing just under two liters with 155 kW (211 hp).

The high-voltage lithium-ion battery of the E 350 e provides an energy content of 6.4 kWh. It can be externally charged from a charging socket and at puplic charging stations. With the power of the synchronous electric motor, the E-Class thus has an all-electric range up to 33 kilometres. The quantities of electricity and petrol consumed during the use of the vehicle were calculated with the certified consumption values based on the certification rule ECE R101. The electric energy consumption (NEDC) stands at 11.5 kWh/100 km, the corresponding fuel consumption is at 2.1 l/100 km. With regard to generation of the externally charged electric power, the two variants "EU electricity grid mix" and electricity from "hydro power" were examined.

Fig. 2-17 compares the carbon dioxide emissions of the E 350 e with those of the predecessor E 350 CGI, equipped with only a combustion engine.

In the production phase the E 350 e gives rise to a higher quantity of $CO_2$-emissions caused by the additional hybrid-specific components. Over the entire lifecycle comprising manufacture, operation over 250,000 kilometres and recycling, however, the plug-in hybrid shows clear advantages. External charging with the European electricity grid mix can cut $CO_2$-emissions by around 44 percent (approx. 29 tonnes) compared to the E 350 CGI. A 63 percent reduction (approx. 42 tonnes) is possible through the use of renewably generated electricity from hydro power.

Figure 2-18 shows the nitric oxide emissions over the entire lifecycle. With the European grid mix the E 350 e is on the same level as the predecessor E 350 CGI. With renewably generated electricity from hydro power NOx-emissions will be reduced by 42 % (23 kg) in comparison to the predecessor.

Figure 2-17: $CO_2$-emissions over the entire lifecycle [t/car]

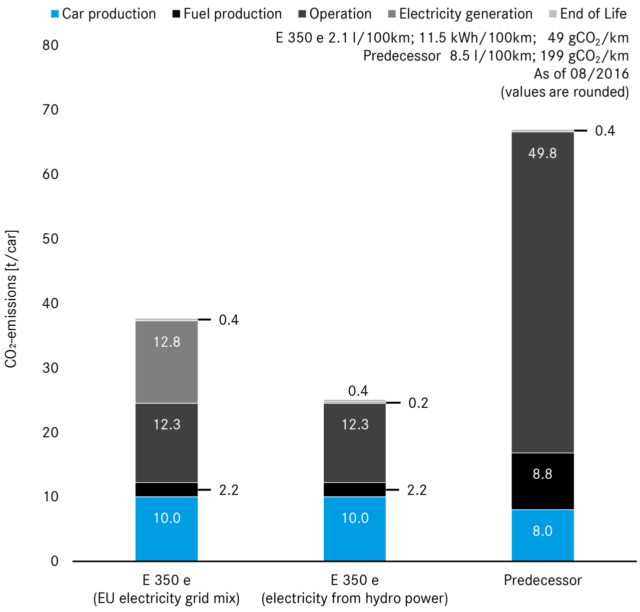


Figure 2-18: NOx-emissions over the entire lifecycle [kg/car]

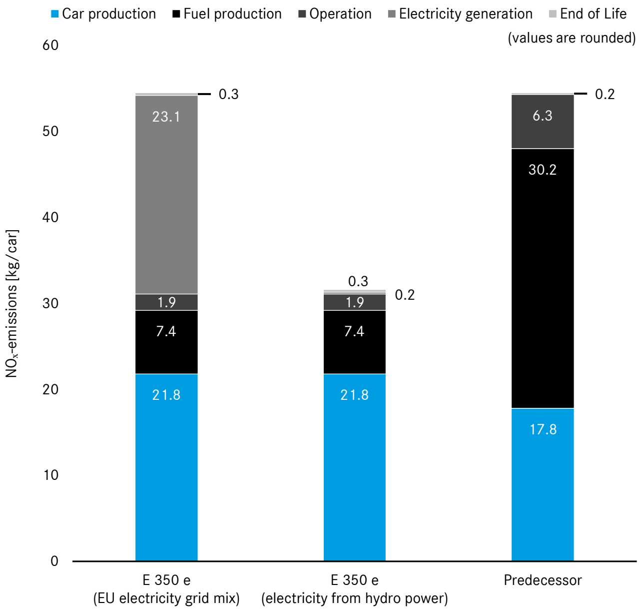
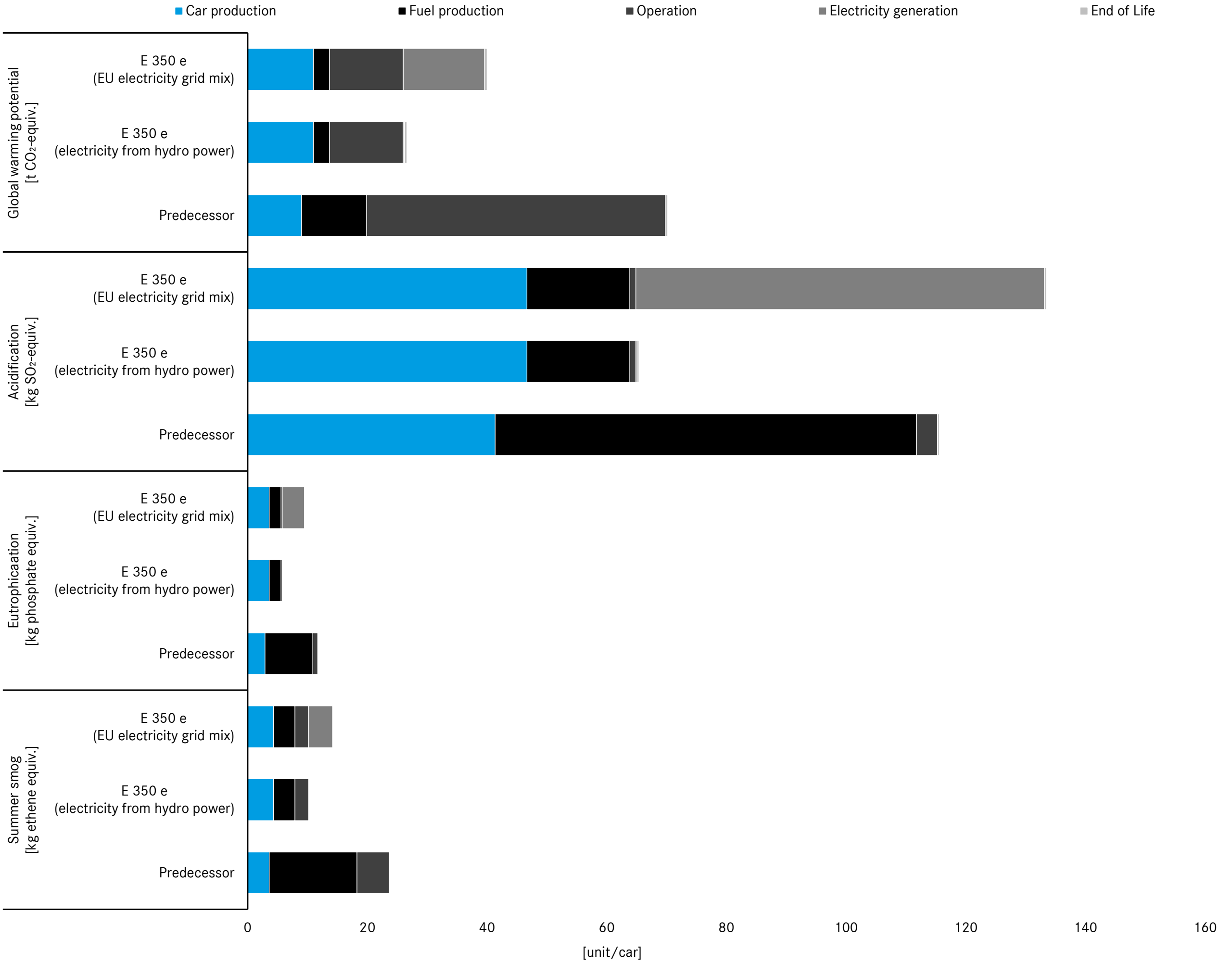


Fig. 2-19 shows a comparison of the examined environmental impacts over the individual lifecycle phases. Over the entire lifecycle, the E 350 e charged using electricity from hydro power has clear advantages in terms of all result parameters shown.

If the European electricity grid mix is used for charging, there are clear advantages with respect to global warming potential, summer smog and eutrophication. For acidification the E 350 e remains around 17 percent above the E 350 CGI.

Figure 2-19: Selected result parameters E 350 e Saloon compared with the predecessor [unit/car]



Figures 2-20 and 2-21 show the consumption of relevant material and energy resources. The demand of material resources for the production of the E-Class plug-in hybrid changes significantly compared to the predecessor. For example, the consumption of bauxite increases due to the higher share of light metals and the consumption of non-ferrous metals rises as a result of the additional hybrid-specific components.

However, regarding the energy resources there is a clearly reduced consumption visible. Best results can be achieved by using renewably generated electricity for charging the E 350 e battery. Thus crude oil consumption can be reduced by 72 percent compared with the predecessor.

Figure 2-20: Selected material resources E 350 e and predecessor [kg/car]

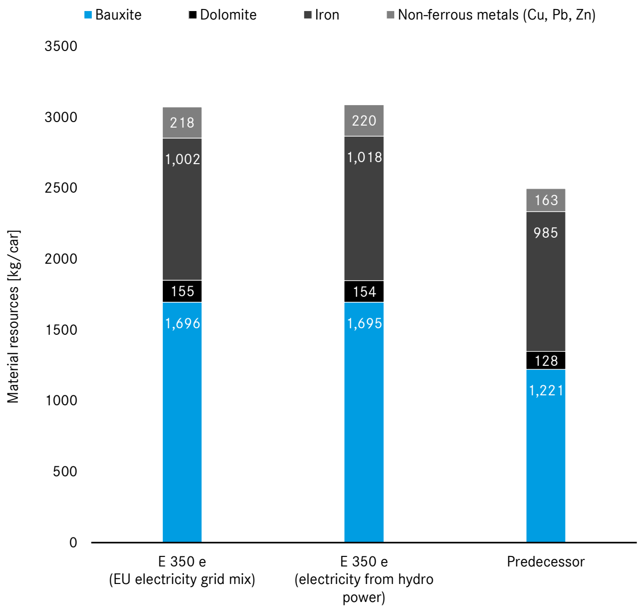
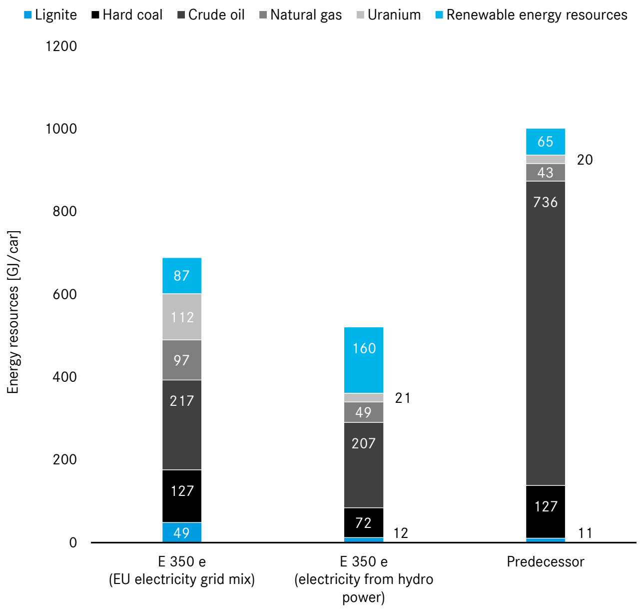


Figure 2-21: Selected energy resources E 350 e and predecessor [GJ/car]



In order to comprehensively assess the use of resources in products, various aspects must also be considered in addition to pure raw material consumption. Questions pertaining to safeguarding the supply of raw materials in the medium and long term in particular as well as maintaining social and environmental standards along the supply chain play a key role. As part of the Research project ESSENZ, funded by the Federal Ministry of Education and with the involvement of Daimler AG, a new holistic approach was developed that brings together the different perspectives.

As an indicator of long-term supply security, the geological availability of resources is taken as an underlying basis with respect to changing needs. Medium-term effects on supply security are determined by leveraging socio-economic indicators such as country/company concentration, political stability of growing countries and price developments as well as growth in demand. Maintaining environmental and social standards are bundled in the dimension of social acceptance and provides indication of possible risks when extracting resources at the national level. In the process, indicators of working conditions and effects on the local ecosystem are taken into account.

The case study dealt with here – the E 350 e plug-in hybrid as compared to the conventionally powered E 350 CGI preceding model – makes it clear as to why a comprehensive assessment is necessary.

The increased demand for material resources for the plug-in hybrid particularly impacts the dimensions of socio-economic availability and social acceptance. Due to the lower consumption of fossil fuels, however, the E 350 e demonstrates distinct advantages in the dimension of physical availability.

To assess resource efficiency, it is therefore of great significance that material and energy resources are considered across the entire life cycle and are also factored into the overall calculation.

Figure 2-22: Summary of resource efficiency dimensions of the ESSENZ method – E 350 e compared with the preceding model

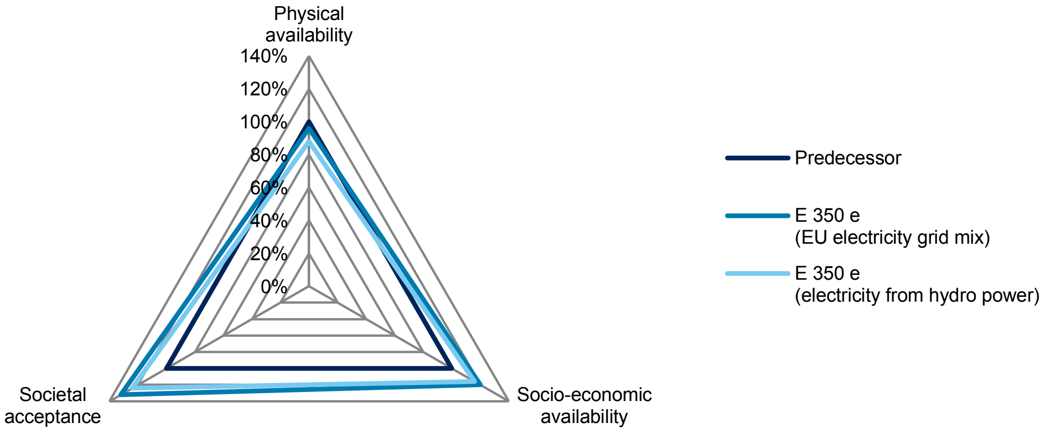


Table 2-5: Overview of LCA parameters E 350 e Saloon compared with the predecessor (I)

| Input parameters | E 350 e (EU electricity grid mix) | E 350 e (electricity from hydro power) | Predecessor | Delta E 350 e (EU electricity grid mix) to predecessor | Delta E 350 e (electricity from hydro power) to predecessor | Comments |
|---|---|---|---|---|---|---|
| **Material resources** | | | | | | |
| Bauxite [kg] | 1,696 | 1,695 | 1,221 | **39%** | **39%** | Aluminium production, higher primary content (mainly body shell, engine and axles). |
| Dolomite [kg] | 155 | 154 | 128 | **21%** | **21%** | Magnesium production, slightly higher mass of magnesium. |
| Iron [kg]* | 1,002 | 1,018 | 985 | **2%** | **3%** | Steel production, lower mass of steel (delta mainly body shell and engine). |
| Non-ferrous metals (Cu, Pb, Zn) [kg]* | 218 | 220 | 163 | **34%** | **35%** | Higher content of non-ferrous metals (mainly hybrid-specific drivetrain components). |
| * as elementary resources | | | | | | |
| **Energy resources** | | | | | | |
| **ADP fossil** ** **[GJ]** | 491 | 340 | 917 | **-46%** | **-63%** | E 350 e 71 % (electricity grid mix) resp. 58 % (electricity from hydro power), predecessor 87 % from use phase. |
| Primary energy [GJ] | 690 | 522 | 1,002 | **-31%** | **-48%** | Consumption from energy resources is clearly lower compared to the predecessor, due to higher energy efficiency of E350 e. |
| Proportionately | | | | | | |
| Lignite [GJ] | 49 | 12 | 11 | **331%** | **2%** | E 350 e 21 % (electricity grid mix) resp. 90 % (electricity from hydro power) from car production, predecessor 76 %. |
| Natural gas [GJ] | 127 | 72 | 127 | **0%** | **-43%** | E 350 e 40 % (electricity grid mix) resp. 71 % (electricity from hydro power) from car production, predecessor 32 %. |
| Crude oil [GJ] | 217 | 207 | 736 | **-70%** | **-72%** | E 350 e 84 % from driving operation, predecessor 96 %. |
| Hard coal [GJ] | 97 | 49 | 43 | **124%** | **13%** | E 350 e 49 % (electricity grid mix) resp. 97 % (electricity from hydro power) from car production, predecessor 91 %. |
| Uranium [GJ] | 112 | 21 | 20 | **460%** | **6%** | E 350 e 17 % (electricity grid mix) resp. 92 % (electricity from hydro power) from car production, predecessor 73 %. |
| Renewable energy resources [GJ] | 87 | 160 | 65 | **34%** | **147%** | E 350 e 72 % (electricity grid mix) resp. 85 % (electricity from hydro power) from use phase, predecessor 72 %. |
| ** CML 2001, as of April 2015 | | | | | | |

Table 2-6: Overview of LCA parameters E 350 e Saloon compared with the predecessor (II)

| **Output parameters** | **E 350 e (EU electricity grid mix)** | **E 350 e (electricity from hydro power)** | **Predecessor** | **Delta E 350 e (EU electricity grid mix) to predecessor** | **Delta E 350 e (electricity from hydro power) to predecessor** | **Comments** |
|---|---|---|---|---|---|---|
| **Emissions in air** | | | | | | |
| GWP** [t $CO_2$-equiv.] | 40 | 26 | 70 | **-43%** | **-62%** | Mainly due to $CO_2$-emissions. |
| AP** [kg $SO_2$-equiv.] | 132 | 64 | 113 | **17%** | **-43%** | Mainly due to $SO_2$-emissions. |
| EP** [kg phosphate-equiv.] | 9 | 6 | 12 | **-19%** | **-50%** | Mainly due to NOx-emissions. |
| POCP** [kg ethene-equiv.] | 14 | 10 | 24 | **-40%** | **-57%** | Mainly due to NMVOC and CO-emissions. |
| $CO_2$ [t] | 38 | 25 | 67 | **-44%** | **-63%** | E 350 e 26 % (electricity grid mix) resp. 40 % (electricity from hydro power) from car production, predecessor 12 %. |
| CO [kg] | 69 | 60 | 68 | **1%** | **-12%** | E 350 e 35 % (electricity grid mix) resp. 40 % (electricity from hydro power) from car production, predecessor 33 %. |
| NMVOC [kg] | 20 | 17 | 50 | **-61%** | **-65%** | E 350 e 75 % (electricity grid mix) resp. 71 % (electricity from hydro power), predecessor 93 % from use phase. |
| $CH_4$ [kg] | 65 | 40 | 91 | **-29%** | **-56%** | E 350 e 65 % (electricity grid mix) resp. 43 % (electricity from hydro power), predecessor 80 % from use phase. |
| NOx [kg] | 54 | 32 | 54 | **0%** | **-42%** | E 350 e 59 % (electricity grid mix) resp. 30 % (electricity from hydro power), predecessor 67 % from use phase. |
| $SO_2$ [kg] | 83 | 37 | 68 | **21%** | **-45%** | E 350 e 68 % (electricity grid mix) resp. 29 % (electricity from hydro power), predecessor 65 % from use phase. |
| | | | | | | |
| Emissions in water | | | | | | |
| **BOD [kg]** | 0.17 | 0.13 | 0.21 | **-19%** | **-38%** | E 350 e 42 % (electricity grid mix) resp. 24 % (electricity from hydro power), predecessor 61 % from use phase. |
| Hydrocarbons [kg] | 1.3 | 1.2 | 2.5 | **-49%** | **-51%** | E 350 e 41 % (electricity grid mix) resp. 39 % (electricity from hydro power), predecessor 78 % from use phase. |
| $NO^{3}$- [g] | 4,134 | 2,676 | 9,089 | **-55%** | **-71%** | E 350 e 88 % (electricity grid mix) resp. 81 % (electricity from hydro power), predecessor 97 % from use phase. |
| $PO_4^{3}$- [g] | 277 | 240 | 755 | **-63%** | **-68%** | E 350 e 75 % (electricity grid mix) resp. 72 % (electricity from hydro power), predecessor 93 % from use phase. |
| $SO_4^{2}$- [kg] | 43.6 | 18.2 | 29.2 | **50%** | **-38%** | E 350 e 69 % (electricity grid mix) resp. 26 % (electricity from hydro power), predecessor 64 % from use phase. |
| ** CML 2001, as of April 2015 | | | | | | |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# 3. Material selection

### 3.1 Avoidance of potentially hazardous materials

The avoidance of hazardous substances is a matter of top priority in the development, manufacturing, use and recycling of Mercedes-Benz vehicles. For the protection of humans and the environment, substances and substance classes whose presence is not permitted in materials or components of Mercedes-Benz passenger cars have been listed in the internal standard (DBL 8585) since 1996. This standard is already made available to the designers and materials experts at the advanced development stage for both the selection of materials and the definition of manufacturing processes.

Materials used for components with contact to air of  the passenger compartment are also subject to emission limits that are laid down in the  vehicle specifications book and in part specific supplier specification DBL 5430. The reduction of interior emissions is a key aspect in the development of components and materials for Mercedes-Benz vehicles.

### 3.2 Allergy tested interior

The current E-Class has also been awarded the Seal of Quality from the European Centre for Allergy Research Foundation (ECARF). The ECARF Seal of Quality is used by ECARF to designate products that have been scientifically tested and proven to be suitable for allergy sufferers. The conditions involved are extensive: numerous components from each equipment variant of a vehicle have to be tested for inhaled allergens, for example. Furthermore, the function of the pollen filter must be tested in both new and used condition. In addition, tests are undertaken with human “guinea pigs”. Driving tests were conducted in the E-Class with people suffering from severe asthma, for example, with lung function tests providing information about the impact on the bronchial system. In addition, all materials that might come in contact with the skin were dermatologically tested. So-called epicutaneous skin tests were undertaken with test subjects suffering from contact allergies in order to test the tolerance levels for known contact allergens. To this end, substances from the interior were adhered to the skin as potential allergens, using plasters. The air-conditioning filters also have to meet the stringent criteria of the ECARF Seal in both new and used condition: amongst other things the tests measure their retention efficiency with regard to dust and pollen.

Figure 3-1: Test chamber to messure car cabin emissions

### 3.3 Use of secondary raw materials

In addition to the requirements for attainment of recycling rates, manufacturers are obliged by Article 4, Paragraph 1 c) of the European ELV Directive 2000/53/EC to make increased use of recycled materials in vehicle production and thereby to establish or extend the markets for recycled materials. To comply with these stipulations, the specifications books for new Mercedes models prescribe continuous increases in the share of the secondary raw materials used in car models.

The studies relating to the use of recycled material, which accompany the development process, focus on thermoplastics. In contrast to steel and ferrous materials, to which secondary materials are already added at the raw material stage, recycled plastics must be subjected to a separate testing and approval process for the relevant component. Accordingly, details of the use of secondary raw materials in passenger cars are only documented for thermoplastic components, as only this aspect can be influenced during development.

The quality and functionality requirements placed on a component must be met both with secondary raw materials and with comparable new materials. To ensure passenger car production is maintained even when shortages are encountered on the recycled materials market, new materials may also be used as an alternative.

In the base variant of the E-Class Saloon, a total of 72 components with an overall weight of 54.4 kilograms can be manufactured partly from high-quality recycled plastics. Thus, the weight of secondary raw material components could be increased significantly around 30 percent compared to the previous model. Typical areas of use are wheel arch linings, cable ducts and underbody panels, which consist for the most part of polypropylene.

With the material Dinamica® a high-quality secondary raw material is now also used in the interior of the new E-Class. Dinamica® is a microfiber made of recycled polyester and water-borne polyurethane. The recycled polyester contained in Dinamica® derives e.g. from textiles and PET bottles. Dinamica® has a suede leather optic and haptic and is used in the interior e.g. as seat cover, roof and pillar liner.

A further objective is to obtain secondary raw materials wherever possible from vehicle-related waste flows, so as to achieve closed cycles. To this end, established processes are also applied for the E-Class: a secondary raw material comprised of reprocessed starter batteries and bumper panelling is used for the wheel arch linings, for example.

Figure 3-2: Use of secondary raw materials in the E-Class Saloon

### 3.4 Use of renewable raw materials

In automotive production, the use of renewable raw materials is concentrated primarily in the vehicle interior. Established natural materials such as flax and cellulose fibres, wool, cotton and natural rubber are also used, of course, in series production of the E-Class.

The use of these natural materials gives rise to a whole range of advantages in automotive production:

- Compared with glass fibre, natural fibres normally result in a reduced component weight.
- Renewable raw materials help to reduce the consumption of fossil resources such as coal, natural gas and crude oil.
- They can be processed by means of conventional technologies. The resulting products are generally readily recyclable.
- If recycled in the form of energy they have an almost neutral $CO_2$-balance, as only as much $CO_2$ is released as the plant absorbed during its growth.

In the base variant of the new E-Class Saloon, a total of 90 components with an overall weight of 33.1 kilograms are made using natural materials. The total weight of components manufactured with the use of renewable raw materials has thus increased by 59 percent compared with the preceding model. Figure 3-3 shows the components in the new E-Class which are produced using renewable raw materials.

Figure 3-3: Components in the E-Class Saloon produced using renewable materials


Feld
2

# 4. Design for recovery

With the adoption of the European ELV Directive (2000/53/EC) on 18 September 2000, the conditions for recovery of end-of-life vehicles were revised. The aims of this directive are to avoid vehicle-related waste and encourage the take-back, reuse and recycling of vehicles and their components. The resulting requirements for the automotive industry are as follows:

- Establishment of systems for collection of end-of-life vehicles (ELVs) and used parts from repairs.
- Achievement of an overall recovery rate of 95 percent by weight by 01.01.2015 at the latest.
- Evidence of compliance with the recycling rate as part of type approval for new passenger cars as of December 2008.
- Take-back of all ELVs free of charge from January 2007.
- Provision of dismantling information to ELV recyclers within six months of market launch.
- Prohibition of lead, hexavalent chromium, mercury and cadmium, taking into account the exceptions in Annex II.

## 4.1 Recycling concept for new E-Class

The calculation procedure is regulated in ISO standard 22628, “Road vehicles – Recyclability and recoverability – Calculation method.” The calculation model reflects the real ELV recycling process and is divided into four stages.

1. Pretreatment (removal of all service fluids, tyres, the battery and catalytic converters, ignition of airbags).
2. Dismantling (removal of replacement parts and/or components for material recycling).
3. Separation of metals in the shredder process.
4. Treatment of non-metallic residual fraction (shredder light fraction – SLF).

The recycling concept for the E-Class was devised in parallel with development of the vehicle; the individual components and materials were analysed for each stage of the process. The volume flow rates established for each stage together yield the recycling and recovery rates for the entire vehicle. With the process chain described below, an overall material recyclability rate of 85 percent and a recoverability rate of 95 percent were verified on the basis of the ISO 22628 calculation model for the E-Class as part of the vehicle type approval process (see Figure 4-1).

At the ELV recycler’s premises, the fluids, battery, oil filter, tyres, and catalytic converters are removed as part of the pretreatment process. The airbags are able to get triggered with a device that is standardized amongst all European car manufacturers. During dismantling, the prescribed parts are first removed according to the European ELV Directive. To improve recycling, numerous components and assemblies are then removed and are sold directly as used spare parts or serve as a basis for the manufacturing of replacement parts. In addition to used parts, materials that can be recycled using economically appropriate procedures are selectively removed in the vehicle dismantling process. These include components of aluminium and copper as well as selected large plastic components.

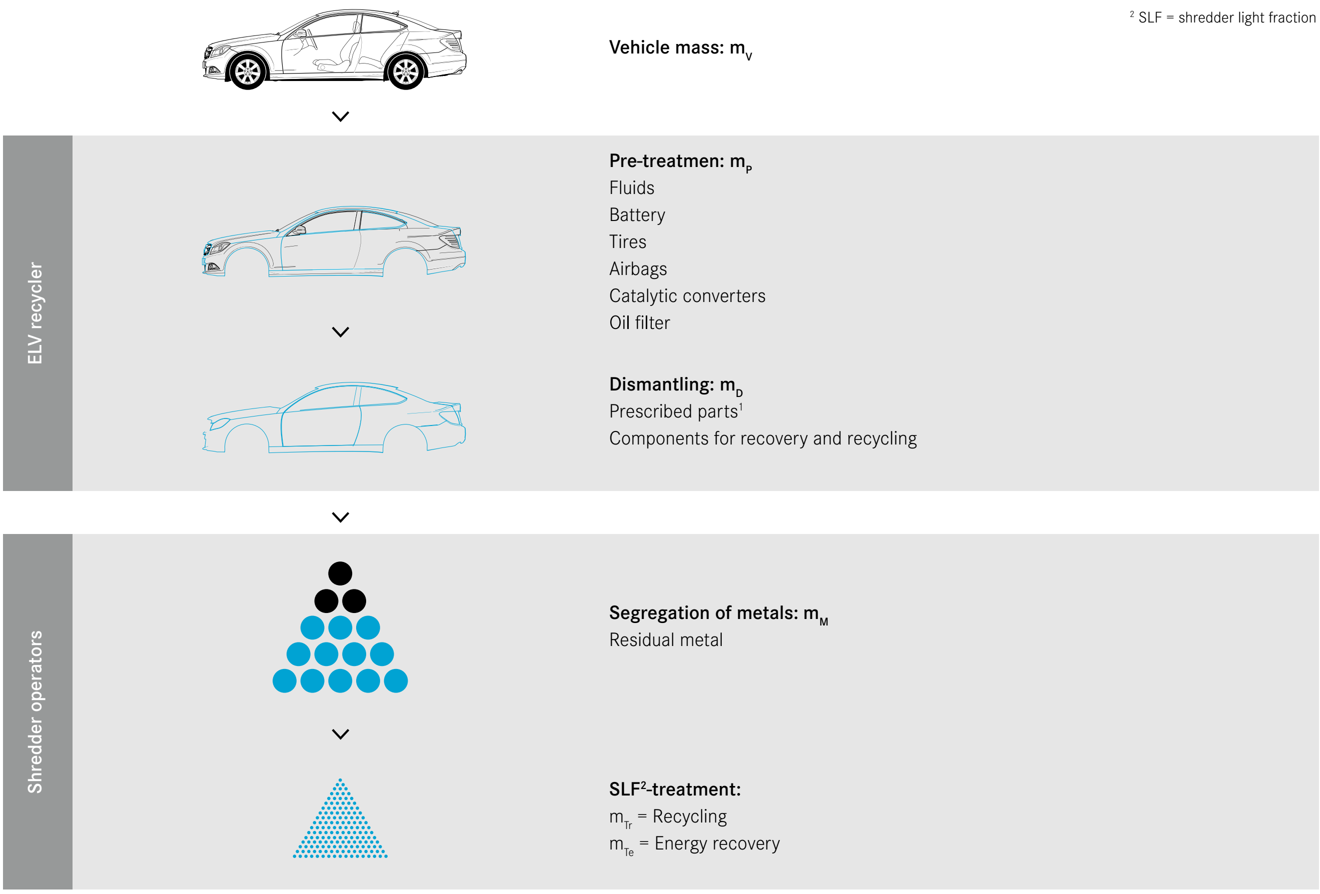
During the development of the E-Class, these components were specifically prepared with a view to their subsequent recycling. Along with the segregated separation of materials, attention was also paid to ease of dismantling of relevant thermoplastic components such as bumpers, wheel arch linings, outer sills, underfloor panelling and engine compartment coverings. In addition, all plastic parts are marked in accordance with international nomenclature.

In the subsequent shredding of the residual body, the metals are first separated for reuse in the raw material production processes.

The largely organic remaining portion is separated into different fractions for environment-friendly reuse in raw material or energy recovery processes.

With the process chain described below, an overall material recyclability rate of 85 percent and a recoverability rate of 95 percent were verified on the basis of the ISO 22628 calculation model for the E-Class as part of the vehicle type approval process (see Figure 4-1).

Figure 4-1: Material flows in the recycling concept



[1] in acc. with 2000/53/EC

[2] SLF = shredder light fraction

$$R_{cyc} = (m_P + m_D + m_M + m_{Tr}) / m_V * 100 > 85 \text{ percent}$$

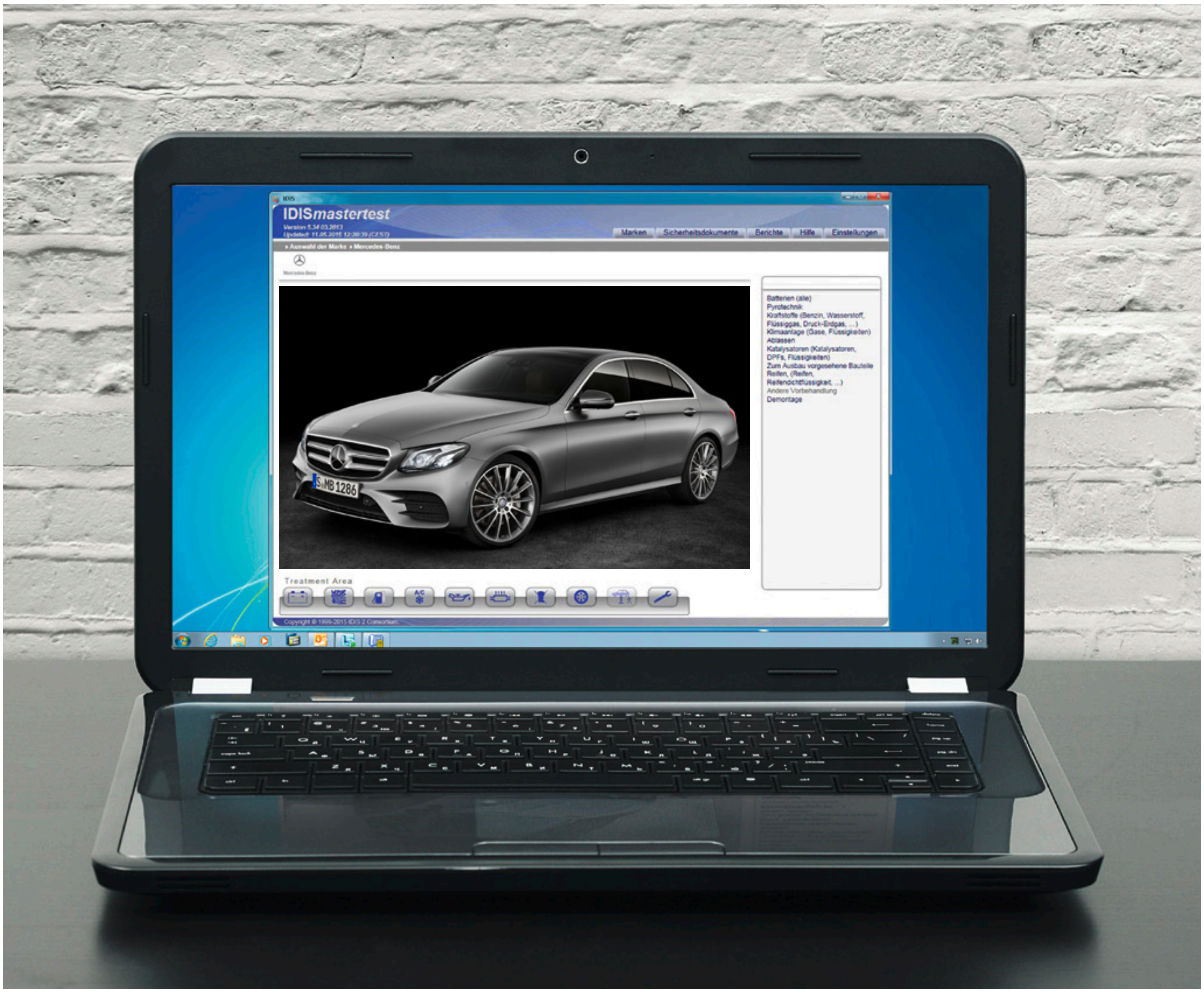
$$R_{cov} = R_{cyc} + m_{Te} / m_V * 100 > 95 \text{ percent}$$

### 4.2 Dismantling information

Dismantling information plays an important role for ELV recyclers when it comes to implementing the recycling concept. For the E-Class too, all necessary information is provided in electronic form via the International Dismantling Information System (IDIS). This IDIS software provides vehicle information for ELV recyclers, on the basis of which vehicles can be subjected to environmentally friendly pretreatment and recycling techniques at the end of their operating lives.

The IDIS data are made available to ELV recyclers and incorporated into the software six months after the respective market launch.

Figure 4-2: Screenshot of the IDIS software



# 5. Process - Design for Environment

Reducing the environmental impact of a vehicle's emissions and resource consumption throughout its lifecycle is crucial to improving its environmental performance. The environmental burden of a product is already largely determined in the early development phase; subsequent corrections to product design can only be implemented at great expense. The earlier environmentally compatible product development ("Design for Environment") is integrated into the development process, the greater the benefits in terms of minimised environmental impact and cost. Process and product-integrated environmental protection must be realised in the development phase of a product. The environmental burden can often only be reduced at a later date by means of downstream "end of pipe" measures.

We strive to develop products that are highly responsible to the environment in their respective market segments – this is the second Environmental Guideline of the Daimler Group. Its realisation requires incorporating environmental protection into products from the very start. Ensuring that this happens is the task of environmentally compatible product development. It follows the principle "Design for Environment" (DfE) to develop comprehensive vehicle concepts. The aim is to improve environmental performance in objectively measurable terms and, at the same time, to meet the demands of the growing number of customers with an eye for environmental issues such as fuel economy and reduced emissions or the use of environmentally friendly materials.

In organisational terms, responsibility for improving environmental performance was an integral part of the development project for the E-Class. Under the overall level of project management, employees are appointed with responsibility for development, production, purchasing, sales, and further fields of activity. Development teams (e. g. body, drive system, interior etc.) and crossfunctional teams (e. g. quality management, project management etc.) are appointed in accordance with the most important automotive components and functions.

One such cross-functional group is known as the DfE team. It consists of experts from the fields of lifecycle assessment, dismantling and recycling planning, materials and process engineering, and design and production. Members of the DfE team are also represented in a development team, in which they are responsible for all environmental issues and tasks. This ensures complete integration of the DfE process into the vehicle development project. The members have the task of defining and monitoring the environmental objectives in the technical specifications for the various vehicle modules at an early stage, and of deriving improvement measures where necessary.

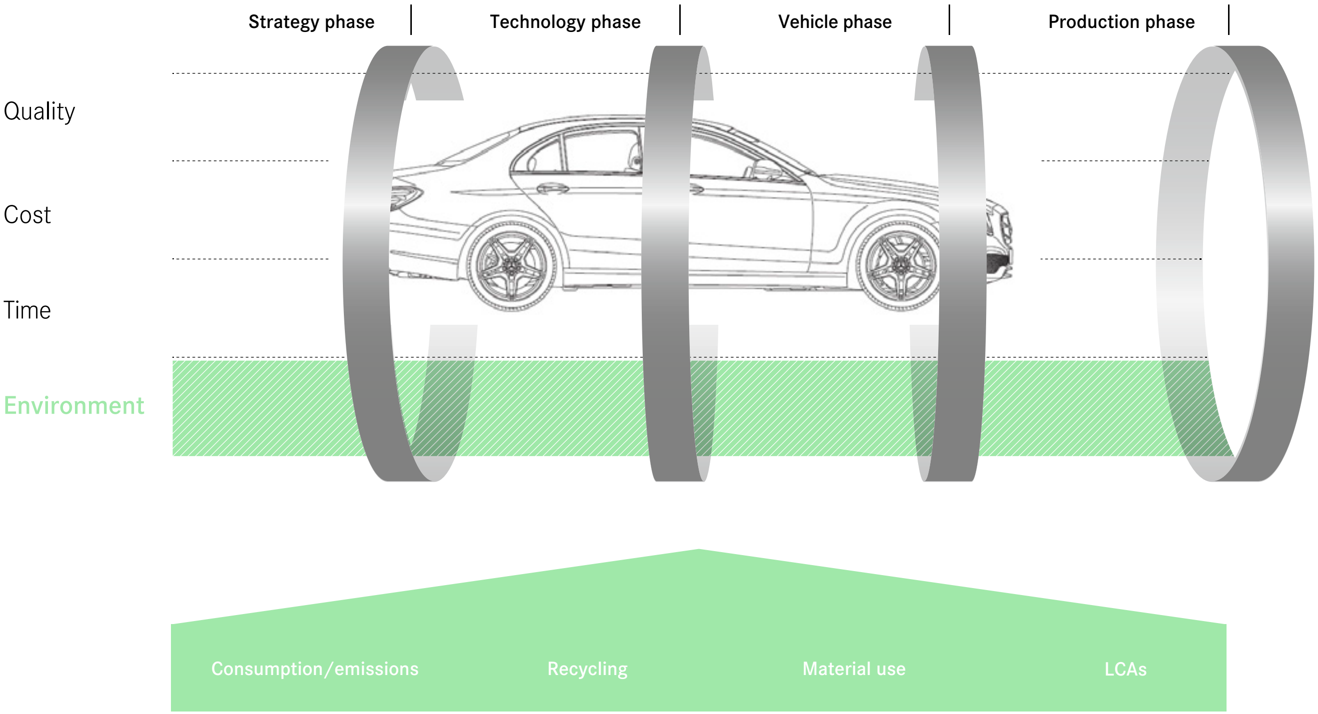
Integration of Design for Environment into the operational structure of the development project for the E-Class ensured that environmental aspects were not sought only at the time of launch, but were given consideration from the earliest stages of development. The targets were coordinated in good time and reviewed in the development process in accordance with the quality gates. Requirements for further action up to the next quality gate are determined by the interim results, and the measures are implemented in the development team.

The process carried out for the E-Class meets all the criteria for the integration of environmental aspects into product development, which are described in ISO standard TR 14062.

Over and above this, in order to implement environmentally compatible product development in a systematic and controllable manner, integration into the higher-level ISO 14001 and ISO 9001 environmental and quality management systems is also necessary.

The international ISO 14006 standard published in 2011 describes the prerequisite processes and correlations. Mercedes-Benz already meets the requirements of the new ISO 14006 in full. This was confirmed for the first time by the independent appraisers from the South German Technical Inspection Authority (TÜV SÜD Management Service GmbH) in 2012.

Figure 5-1: „Design for Environment“ activities at Mercedes-Benz



ZERTIFIKAT ■ CERTIFICATE ■ 認證證書 ■ СЕРТИФИКАТ ■ CERTIFICADO ■ CERTIFICAT

TÜV SÜD Management Service

# CERTIFICATE

**The Certification Body**
**of TÜV SÜD Management Service GmbH**

certifies that

**Daimler AG**
**Mercedes-Benz Sindelfingen**
**Béla-Barényi-Straße 1**
**71063 Sindelfingen**
**Germany**

has established and applies
an Environmental Management System
with particular focus on eco design for

**Development of passenger Vehicles**.

A specific audit, Report No, Report No. **70014947**, revealed, that the entire product life cycle is considered in a multidisciplinary approach when integrating environmental aspects in product design and development and that the results are verified by means of Life Cycle Assessments.

Thereby the requirements according to

**ISO 14006:2011**
**ISO/TR 14062:2002**

are fulfilled.

This certificate is valid only in combination with the ISO 14001 certificate, registration no.: 12 104 13407 TMS, from **2015-12-07** until **2018-09-14**.

Certificate Registration No.: **12 771 13407 TMS**.

Product Compliance Management
Munich, 2015-12-08

IAF

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# 6. Conclusion

The new Mercedes-Benz E-Class not only meets the highest demands in terms of safety, comfort, agility, and design, but also shows significant improvements over the entire lifecycle compared to its predecessor. This is documented comprehensively in the underlying lifecycle assessment report and was examined in an appropriate way in the context of advanced sensitivity analyses. The result was verified by environmental experts of TÜV SÜD.

In the new E-Class, Mercedes-Benz customers benefit for example from significantly enhanced fuel economy, lower emissions of air pollutants compared to the predecessor model and a comprehensive recycling concept. In addition, it employs a great proportion of high-quality secondary and renewable raw materials. Thus all environmental development goals were fully achieved.

Mercedes-Benz has published since 2005 as the world's first automotive manufacturer environmental product information referred to as "Environmental Certificate" as a result of the Design for Environment process based on ISO TR 14062 and ISO 14040/14044. Over and above this, since 2012 the requirements of the new ISO 14006 standard relating to the integration of environmentally compatible product development into the higher-level environmental and quality management systems have been met, as also confirmed by TÜV SÜD Management Service GmbH.


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# Glossary

A: Product documentation

| Technical data | E 200 | E 220 d | E 350 e | E 220 d |
|---|---|---|---|---|
| Assembly form | Saloon | Saloon | Saloon | Estate |
| Engine type | Petrol engine | Diesel engine | Petrol engine / electric motor | Diesel engine |
| Number of cylinders | 4 | 4 | 4 | 4 |
| Displacement (effectice) [cc] | 1,991 | 1,950 | 1,991 | 1,950 |
| Output [kW] | 135 | 143 | 155 + 65** | 143 |
| Emission standard (fulfilled) | EU6 | EU6 | EU6 | EU6 |
| Weight (without driver and luggage) [kg] | 1,530 | 1,605 | 1,850 | 1,705 |
| Exhaust emissions [g/km] | | | | |
| $CO_2$ * | 142 - 132 | 112 - 102 | 57 - 49 | 120 - 109 |
| NOx | 0.005 | 0.056 | 0.008 | 0.056 |
| CO | 0.233 | 0.094 | 0.128 | 0.094 |
| HC (petrol models) | 0.029 | - | 0.018 | - |
| NMHC (petrol models) | 0.026 | - | 0.016 | - |
| HC+NOx (diesel models) | - | 0.067 | - | 0.067 |
| Particulate matter | 0.0007 | 0.0004 | 0.0003 | 0.0004 |
| Particulate count [1/km] | 1.46 E11 | 1.95 E9 | 4.68 E11 | 1.95 E9 |
| Fuel consumption NEDC combined [l/100 km]* | 6.3 - 5.9 | 4.3 - 3.9 | 2.5 - 2.1 | 4.6 - 4.2 |
| Driving noise [dB(A)] | 73 | 69 | 70 | 72 |
| Electricity consumption NEDC combines [kWh/100km]* | - | - | 14 - 11.5 | - |
| Electric range [km] | - | - | 30 - 33 | - |
| | | | | |
| Saloon E 200 and E 220 d, as of 01/2016, Saloon E 350 e and E 220 d Estate, as of 09/2016 | | | | |
| * Figures depend on tyres | | | | |
| ** Electric motor | | | | |

| **Project objective** | |
|---|---|
| Project objective | LCA over the lifecycle of the E 220 d Saloon as ECE base variant com-pared to the predecessor E 220 CDI Saloon as well as the E 200 Saloon, E 350 e Saloon and E 220 d Estate compared to the corresponding pre-decessor E 200 Saloon, E 350 CGI Saloon and E 220 CDI Estate. Verification of attainment of the objective "environmental compatibility" and communication. |
| **Project scope** | |
| Functional equivalent | E-Class passenger car (base variant, weight in acc. with DIN 70020). |
| Technology/ product comparability | With two generations of a car type, products are generally able to be compared. Due to the product comparability, the progress in development and the changing market requirements, the new E-Class provides additional scope especially in the area of the active and passive safety. If the additional scope takes relevant influence on the balance sheet result it will get commented in the course of the evaluation. |
| System boundaries | LCA for car production, use and recycling. The LCA limits must only be exceeded in the case of elementary flows (resources, emissions, non-recyclable materials). |
| Data basis | Weight data of car: MB parts list (E 220 d Saloon and E 200 Saloon as of 10/2015. E 350 e Saloon and E 220 d Estate as of 03/2016). |
| | Materials information for model-relevant, vehicle-specific parts: MB parts list, MB internal documentation systems, IMDS, technical literature. |
| | Vehicle-specific model parameters (bodyshell, paintwork, catalytic converter, etc.): MB specialist departments. |
| | Location-specific energy supply: MB database. |
| | Materials information for standard components: MB database. |
| | Use (fuel consumption, emissions): type approval/certification data. Use (mileage): MB specification. |
| | Recycling model: state of the art (see also Chapter 4.1). |
| | Material production, energy supply, manufacturing processes and transport: LCA database as of SP28; MB database. |
| Allocations | For material production, energy supply, manufacturing processes and transport, reference is made to GaBi databases and the allocation methods which they employ. |
| | No further specific allocations. |
| Cut-off criteria | For material production, energy supply, manufacturing processes and transport, reference is made to GaBi databases and the cut-off criteria they employ. |
| | No explicit cut-off criteria. All available weight information is processed. |
| | Noise and land use are currently not available as lifecycle inventory data and are therefore not taken into account. |
| | „Fine dust" or particulate emissions are not analysed. Major sources of particulate matter (mainly tyre and brake abrasion) are not dependent on vehicle type and consequently of no relevance to the result of the vehicle comparison. |
| | Vehicle maintenance and care are not relevant to the result. |
| Assessment | Lifecycle, in conformity with ISO 14040 and 14044 (LCA). |
| Analysis parameters | Material composition according to VDA 231-106. |
| | Life cycle inventory: consumption of resources as primary energy, emissions such as $CO_2$, CO, NOx, $SO_2$, NMVOC, $CH_4$, etc. |
| | Impact assessment: abiotic depletion potential (ADP), global warming potential (GWP), photochemical ozone creation potential (POCP), eutrophication potential (EP), acidification potential (AP). These impact assessment parameters are based on internationally accepted methods. They are modelled on categories selected by the European automotive industry, with the participation of numerous stakeholders, in an EU project under the name LIRECAR. The mapping of impact potentials for human toxicity and ecotoxicity does not yet have sufficient scientific backing today, and therefore will not deliver meaningful results. Resource consumption assessment is done with the ESSENZ method. This holistic approach combines different perspectives for mid and long term safeguarding the supply of raw materials supply as well as compliance with social and environmental standards along the supply chain. |
| | Interpretation: sensitivity analyses of car module structure; dominance analysis over lifecycle. |
| Software support | MB DfE tool. This tool models a car with its typical structure and typical components, including their manufacture, and is adapted with vehicle-specific data on materials and weights. It is based on the LCA software GaBi 6 (http://www.gabi-software.com). |
| Evaluation | Analysis of life cycle results according to phases (dominance). The manufacturing phase is evaluated based on the underlying car module structure. Contributions of relevance to the results are discussed. |
| Documentation | Final report with all basic conditions. |

C: Glosary

| Term | Explanation |
|---|---|
| ADP | Abiotic depletion potential (abiotic = non-living); impact category describing the reduction of the global stock of raw materials resulting from the extraction of non-renewable resources. |
| Allocation | Distribution of material and energy flows in processes with several inputs and outputs, and assignment of the input and output flows of a process the investigated product system. |
| AOX | Adsorbable organic halogens; sum parameter used in chemical analysis mainly to assess water and sewage sludge. Used to determine the sum of the organic halogens which can be adsorbed by activated charcoal; these include chlorine, bromine and iodine compounds. |
| AP | Acidification potential; impact category expressing the potential for milieu changes in ecosystems due to the input of acids. |
| Base variant | Base vehicle model without optional extras, usually Classic line and with a small engine. |
| BMBF | Federal Ministry for Education and Research |
| BOD | Biological oxygen demand; taken as measure of the pollution of waste water, waters with organic substances (to assess water quality) |
| COD | Chemical oxygen demand; used in the assessment of water quality as a measure of the pollution of waste water and water with organic substances. |
| DIN | German Institute for Standardisation (Deutsches Institut fr Normung e.V.). |
| ECE | Economic Commission for Europe; the UN organisation in which standardised technical regulations are developed. |
| EP | Eutrophication potential (overfertilisation potential); impact category expressing the potential for oversaturation of a biological system with essential nutrients. |
| ESSENZ | Integrated method for holistic measurement of resource efficiency. |
| GWP100 | Global warming potential, time horizon 100 years; impact category that describes potential contribution to the anthropogenic greenhouse effect (caused by mankind) |
| HC | Hydrocarbons |
| IDIS | International Dismantling Information System (internationales Demontage-Informationssystem) |
| IMDS | International Material Data System |
| Impact categories | Classes of effects on the environment in which resource consumptions and various emissions with the same environmental effect are grouped together (e.g. global warming, acidification etc.) |
| ISO | International Organisation for Standardisation (internationale Organisation fr Standardisierung) |
| KBA | Federal Motor Transport Authority |
| LCA | Life Cycle Assessment Compilation and assessment of the input and output flows and the potential environmental impacts of a product in the course of its life. |
| MB | Mercedes-Benz |
| NEDC | New European Driving Cycle; cycle used to establish the emissions and consumption of motor vehicles since 1996 in Europe; prescribed by law. |
| NF-metal | Non-ferrous metal (aluminium, lead, copper, magnesium, nickel, zinc etc.) |
| NMVOC | Non-methane volatile organic compounds (NMHC Non-methane hydrocarbons) |
| POCP | Photochemical ozone creation potential, (summer smog); impact category that describes the formation of photooxidants (summer smog). |
| Primary energy | Energy not yet subjected to anthropogenic conversion. |
| Process polymers | Term from the VDA materials data sheet 231-106; the material group ?process polymers? comprises paints, adhesives, sealants, protective undercoats. |
| SLF | Shredder Light Fraction; non-metallic substances remaining after shredding as part of a process of separation and cleaning. |

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