Since the beginning of 2009, “Life Cycle” has documented the environmental certificate for Mercedes-Benz vehicles.

Above all the principal aim of this documentation series is to provide the best possible service to as many interested parties as possible. On the one hand, the wide-ranging and complex topic of the „automobil and the environment“ needs to be communicated to the general public in a manner which is easy to understand. On the other hand, however, specialists also need to have access to detailed information. “Life Cycle” fulfils these requirements with its variable concept.

Anyone who needs a quick, general overview can concentrate on the short summaries which appear at the start of each chapter. These summaries highlight the most important information in note form, while standardised graphics also help to simplify orientation. If more detailed information on the environmental commitment of Daimler AG is required, clear tables, graphics and informative text passages have also been provided. These describe the individual environmental aspects in great detail.

With its service-oriented and striking “Life Cycle” documentation series, Mercedes-Benz is once again demonstrating its pioneering role in this important area. This has already been seen in the past, when in 2005 the S-Class became the very first car to receive an environmental certificate from TÜV Süd. At the beginning of 2009, this certificate was also awarded to the GLK, the first SUV to receive it. The A, B and C Class are now also included among the model series which have been awarded certificates, and others are set to follow.
Interview

“Daimler AG is an environmentally-focused automotive company”

How is TÜV Süd confirming the environmental activities of Daimler AG and Mercedes-Benz?

Prof. Kohler: Our comprehensive commitment in respect of various aspects of the environment is confirmed by means of the "environmental certificate", which is based on the strict international ISO standard 14062, "Design for Environment". TÜV only issues this certificate after conducting extremely detailed examinations for the appropriate model series being tested. Mercedes-Benz was the first automotive manufacturer in the world to receive this certificate, which was awarded for the S-Class – a clear reflection of our pioneering role in this field.

Are the statutory requirements insufficient?

Prof. Kohler: No, those requirements are proper and they make sense. However, they represent just “snapshots”, for example, the standardised measurement of exhaust-gas emissions and fuel consumption on the chassis dynamometer. Of course, these results represent only one particular aspect.

What additional aspects are taken into account?

Prof. Kohler: Daimler AG is an environmentally-focused automotive company, and we acknowledge that we have a special responsibility. We analyse the environmental compatibility of our vehicles over their entire life cycle – from the development process, through production and long years of use, to end-of-life vehicle recycling. This goes beyond the statutory requirements.

How detailed are these analyses as part of the environmental certificate?

Prof. Kohler: Absolutely, in the meantime the independent auditors have also awarded this certificate to the C-Class and also the A and B-Class. At the start of 2009, the GLK became the first compact SUV to be awarded the environmental certificate. Other models are set to follow.

Can these results be proven?

Prof. Kohler: Mercedes-Benz passenger cars generate enthusiasm not only with their excellent design, tangible motoring pleasure and highest levels of driving comfort and safety. They also rank among the trendsetters when it comes to environmental compatibility. We are documenting this with hard data, facts and figures which can be confirmed by a neutral body – such as TÜV Süd.

Interview with Professor Dr. Herbert Kohler, Chief Environmental Officer of Daimler AG

Professor Dr. Kohler, as the Chief Environmental Officer you represent what we might refer to as the "green element" within a successful global automotive company. So what significance, does ecology have in a modern industrial concern?

Prof. Kohler: Your question perhaps suggests that exciting automobiles and ecological responsibility are a contradiction, but this simply isn’t the case at Daimler. We are pursuing these ideals – fascination combined with responsibility – with equal effort. Our designers and engineers are producing remarkable results in both fields.

Have any other model series been awarded this certificate?

Prof. Kohler: Absolutely, in the meantime the independent auditors have also awarded this certificate to the C-Class and also the A and B-Class. At the start of 2009, the GLK became the first compact SUV to be awarded the environmental certificate. Other models are set to follow.

What is the significance of this environmental certificate?

Prof. Kohler: For Mercedes-Benz, sustainable mobility means more than the mere fulfilment of rigid environmental guidelines and laws. We follow a holistic way of thinking when it comes to aspects relating to environmental protection. The environmental certificate confirms our approach.

Are the statutory requirements insufficient?

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Exceptional safety, outstanding comfort, trend-setting assistance systems: the Mercedes-Benz E-Class

The E-Class from Mercedes-Benz represents the pacemaker in the model range when it comes to safety, comfort and environmental compatibility. With its unique combination of driver assistance systems, this saloon has been able to further consolidate its leading position in the luxury class. Its features include a drowsiness detection system, Adaptive Highbeam Assist and the proximity control system, which is capable of performing automatic emergency braking when there is acute danger of a collision.

Less is more: the new E-Class engines

The outstanding safety and comfort of the E-Class are matched by its environmental compatibility and economy. With three completely newly developed four-cylinder diesel engines, the E-Class remains one generation ahead. These engines feature latest-generation common-rail direct injection, fast piezo injectors and improved exhaust-gas recirculation. Also new is the innovative twin turbocharger, making for fast responsiveness and excellent performance characteristics.

- Completely newly developed four-cylinder diesel engines with common-rail direct injection, fast piezo injectors, improved exhaust-gas recirculation and twin turbocharger
- Four-cylinder petrol engines with a displacement of 1.8 litres, newly developed direct petrol injection, turbocharging and variable intake and exhaust camshafts
- Reduced fuel consumption thanks to a lower drag coefficient of Cd 0.25, making the E-Class the world’s most aerodynamically efficient luxury saloon
- Entire model range exceeds the EU5 standard, which comes into effect from September 2009
- Unique combination of the latest assistance and protection systems
- Highest level of passive and active safety
- Outstanding comfort thanks to a variable chassis
The E 250 CDI BlueEFFICIENCY with 150 kW/204 hp and 500 Newton metres develops a 23 percent less fuel at 5.3 litres per 100 kilometres\(^*\) (139 g CO\(_2\)/km). The new diesel-engine genera-
tions also powers the E 200 CDI BlueEFFICIENCY with 100 kW/136 hp and the E 220 CDI BlueEFFICIENCY with 125 kW/170 hp, which also have a fuel consumption of 5.3 litres per 100 kilometres\(^*\). The top model in the diesel range is the six cylinder E 350 CDI BlueEFFICIENCY with an output of 170 kW/231 hp, which uses 0.5 litres less fuel per 100 kilometres than the previous top-of-the-line diesel model. From autumn 2009 the E 350 BlueTEC will also be available featuring the world’s best emission-con-
trol technology. The 155 kW/211 hp version meets the EU-6 exhaust emission standards planned for 2014. All the other engine variants in the E-Class meet the EU-5 limits.

Mercedes-Benz equips the BlueEFFICIENCY petrol models E 200 CGI and E 250 CGI with the newly developed four-
cylinder direct petrol injection engine with a displace-
ment of 1.8 litres, turbocharging and variable intake and
exhaust camshafts. The E 200 CGI BlueEFFICIENCY (135 kW/184 hp) is equipped with the ECO start/stop function as standard and consumes 6.8 litres of premium petrol per 100 kilometres\(^*\). This equates to 159 grams of CO\(_2\) per kilometre. The E 250 CGI BlueEFFICIENCY (150 kW/204 hp), maximum torque is 310 Newton metres and fuel consumption is 7.3 litres per 100 kilometres\(^*\), equating to 174 grams of CO\(_2\) per kilometre.

The range of engine variants also includes the E 350 CGI BlueEFFICIENCY with direct petrol injection (215 kW/
292 hp) and the top-of-the-line E 500 (285 kW/388 hp) with V8 engine.

The low drag coefficient of Cd 0.25 \(-\) making the E-Class
the world’s most aerodynamically efficient luxury saloon - also contributes to reducing fuel consumption. This value is another four percent lower than the figure for the preceding model, which represents a fuel saving of around 0.25 litres per 100 kilometres when driving at a motorway
speed of 130 km/h. One of the measures taken to improve the aerodynamics is the adoption of automatically adjust-
able fan louvres which control the airflow to the engine
compartment in line with the engine’s cooling require-
ments.

Safety: unique combination of assistance
and protection systems

The assistance and protection systems make the E-Class
an “intelligent” partner, able to see, feel, react reflexively
in critical situations and, if necessary, act independently
to prevent accidents or mitigate their consequences. With
this concept, the new Mercedes-Benz model not only protects
its own occupants, but also contributes decisively to the
greater safety of other road users. The E-Class is therefore
the first car in the world to be available with an optional
light system in which the headlamps adapt to the traf-
cic situation and respond automatically to provide the
driver with the best possible illumination of the road and
avoid dazzling other drivers. The Lane Tracking pack-
age for the E-Class includes the Blind Spot Assist system
familiar from the S Class, and as a new development,
Lane Keeping Assist, which seeks to prevent the vehicle
from drifting out of its lane unintentionally. The system
incorporates a windscreen camera which is used by the
optionally available Speed Limit Assist, which recognises
speed-limit signs and displays the relevant speed limit in
the speedometer.

Night View Assist from the S-Class is now also available
as an optional extra for the new E-Class. Mercedes-Benz
has improved this system with a special pedestrian detec-
tion function: as soon as Night View Assist Plus recog-
nises pedestrians ahead of the car, they are highlighted
in the onboard display to provide a greatly enhanced
warning effect. Thanks to an innovative technology, the
new E-Class is very sensitive to its driver’s attention level,
and warns him or her of drowsiness in good time with the
ATTENTION ASSIST drowsiness detection system, which
is standard equipment.

The assistance and protection systems
from the S-Class are now also optionally available for the E Class.
The systems are able to assist the driver with emergency
braking. Their sensors are linked to the Brake Assist PLUS
system, which automatically calculates the braking pres-
sure to prevent a collision in critical situations. The driver
is given an audible and visual warning at the same time.
When the brake pedal is pressed, the system immediately
provides the calculated level of braking assistance. If the
driver fails to respond to the warnings, the radar system
first initiates partial braking action. As a second stage, if
there is still no driver response and a collision is unavoid-
able, emergency braking is initiated. This can reduce the
severity of an impact considerably as the system can be
regarded as a kind of "electronic crumple zone".
With the E-Class, the crumple-zone principle invented by Mercedes safety pioneer Béla Barényi has been improved. The front-end deformation zone of the E-Class acts on four independent levels, and is thus even more effective than before. The increased use of extra-high-strength steel alloys also helps to ensure that the bodyshell is able to withstand high impact forces. Around 72 percent of all the body panels are made from these high-tech steels — an unrivalled figure. With seven airbags as standard, belt tensioners, belt force limiters, crash-responsive head restraints and ISOFIX child seat attachments, the E-Class provides a complete set of safety features which also includes an Active Bonnet to improve pedestrian safety protection. Another standard feature is the unique PRE-SAFE® anticipatory occupant protection system. In potentially hazardous situations this reflexively activates precautionary protective measures for the vehicle occupants, so that the seat belts and airbags are able to fulfil their protective function to the full during an impact.

Mercedes-Benz has improved the already exemplary long-distance comfort of the E-Class even further in the new saloon, principally through the use of intelligent bodyshell technology with up to 30 percent greater rigidity, further-improved seats and a newly developed suspension whose shock absorbers automatically adjust to the current driving situation. A version with dynamic damping characteristics and a lowered suspension, or a version with air suspension, are also available as optional alternatives to the standard suspension.
1 Product documentation

This section documents important environmentally relevant technical data of the different variants of the new E-Class, on which the statements made in the section on general environmental issues (Chapter 2.1) are also based.

The detailed analyses relating to materials (Chapter 1.2), the life cycle assessment (Chapter 2.2) or the recycling concept (Chapter 2.3.1) refer to the base variant of the E-Class, the E 220 CDI BlueEFFICIENCY, with standard specification.
### 1.1 Technical data

The table below shows essential technical data for the variants of the new E-Class. The relevant environmental aspects are explained in detail in the environmental profile in Chapter 2.

| Characteristic            | E 220 CDI BlueEFFICIENCY | E 250 CDI BlueEFFICIENCY | E 350 CDI BlueEFFICIENCY | E 350 CDI BlueEFFICIENCY | E 500  
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------
| Engine type               | Diesel engine             | Diesel engine             | Petrol engine             | Petrol engine             |  
| Number of cylinders       | 4                         | 4                         | 6                         | 6                         | 8                         
| Displacement (effective)  | 2143                      | 2143                      | 2987                      | 3498                      | 5461                      
| Output (kW)               | 125                       | 150                       | 170                       | 215                       | 285                       
| Transmission type manual  | x                         | x                         | x                         | x                         | x                         
| Transmission type automatic| optional extra            | optional extra            | x                         | x                         | x                         
| Emission standard (net)   | EU 5                      | EU 5                      | EU 5                      | EU 5                      | EU 5                      
| Weight (w/o driver and luggage) [kg] | 1660/-10*                 | 1660/-10*                 | 1750*                     | 1660*                     | 1755*                     
| Exhaust emissions [g/km]  |                           |                           |                           |                           |                           
| CO2                       | 139-144/159-164*          | 139-144/159-164*          | 179-186*                  | 199-205*                  | 256-251*                  
| NOx                       | 0.157/0.192*              | 0.157/0.192*              | 0.156*                    | 0.025*                    | 0.02*                     
| CO                        | 0.175/0.134*              | 0.175/0.134*              | 0.32*                     | 0.125*                    | 0.269*                    
| THC (petrol engine)       | -                         | -                         | -                         | 0.07*                     | 0.023*                    
| THC (diesel engine)       | 0.043*                    | 0.043*                    |                            |                            |                            
| THC+NOx (diesel engine)   | 0.173/0.165*              | 0.173/0.165*              | 0.022*                    |                            |                            
| PM (diesel engine, with DPF) | 0.001/0.001*             | 0.001/0.001*             | 0.002*                    | 0.001*                    |                            
| Fuel consumption NEDC [l/100km] | 5,3-5.5/5.0-5.2*         | 5,3-5.5/5.0-5.2*         | 6.8-7.1*                  | 8.5-8.8*                  | 10.9-11.2*                
| Driving noise [dBA]       | 73/-71*                   | 73/-71*                   | 70*                       | 70*                       | 72*                       

*Values for automatic transmission

** NEDC consumption of base variant E 220 CDI with standard tyres and manual transmission: 5.3/1.100 km, market launch: 09/2009

### 1.2 Material composition

The weight and material data for the E 220 CDI BlueEFFICIENCY was taken from in-house documentation of the vehicle’s components (parts list, drawings). To determine the recyclability rate and the life cycle assessment, the „kerb weight according to DIN” is taken as the basis (no driver and luggage, fuel tank 90 percent full).

Figure 1-1 shows the material composition of the E-Class according to VDA 231-106.

In the new E-Class, more than half of the vehicle weight (60.8 percent) is accounted for by steel/ferrous materials, followed by polymers at around 19 percent and light alloys (9.7 percent) as the third-largest fraction. Service fluids account for roughly 4.4 percent, with the percentage of non-ferrous metals and other materials (predominantly glass) slightly lower at around 2.2 percent and 3.1 percent respectively. The remaining materials, i.e. process polymers, electronics and special metals, contribute roughly one percent to the vehicle’s weight. In this study the process polymers mainly consist of materials for the paint finish.

The polymers are divided into thermoplastics, elastomers, durohoms and non-specific plastics, with the thermoplastics accounting for the largest proportion at around 13 percent. Elastomers (predominantly tyres) are the second-largest fraction at 3.8 percent. The service fluids include oils, fuel, coolant, refrigerant, brake fluid and washer fluid. Only circuit boards with their components are included in the electronics group. Cables and batteries are categorised according to their materials composition.

Comparison with the preceding model reveals a number of differences, particularly in terms of steel and aluminium. The new E-Class contains a 1.5 percent higher proportion of steel, at around 61 percent, and as such the proportion of light alloys is 1.6 percent lower than its predecessor, at 9.7 percent. The proportion of polymers has increased by 0.9 percent to 18.8 percent. The most significant differences are listed below:

- Use of high-strength steel in the bodyshell for a higher level of crash safety.
- New engine with twin turbocharger and significantly lower fuel consumption.
- Rear axle with a higher proportion of high-strength steel.

![Figure 1-1: Materials used in the new E-Class](image)
2 Environmental profile

The environmental profile documents the general environmental features of the new E-Class with respect to fuel consumption, emissions or environmental management systems.

It also provides specific analyses of the environmental performance, such as life cycle assessment, the recycling concept and the use of secondary and renewable raw materials.
2.1 General environmental issues

Significant reductions in fuel consumption have been achieved with the new E-Class. In the E 220 CDI BlueEFFICIENCY base variant, consumption has been reduced compared with its predecessor from 6.3 l/100 km (at the time of market launch in 2002) and between 6.1 and 6.4 l/100 km (at the time of its withdrawal from the market in 2009) respectively, to between 5.3 and 5.6 l/100 km – depending on the tyres fitted. Compared with the time of market launch of its predecessor, this equates to a significant reduction in fuel consumption of up to 16 percent. Compared with when its predecessor was withdrawn, it equates to a reduction of up to 13 percent.

Thanks to new engines and drive technologies as well as the comprehensive implementation of BlueEFFICIENCY measures, the new E-Class is more economical and environmentally compatible than its predecessor. The improvements are particularly apparent in the E 250 CDI BlueEFFICIENCY with manual transmission. Compared with its predecessor, CO₂ emissions have been reduced by 24 percent, while output has been improved by 10 kW.

• Base variant E 220 CDI BlueEFFICIENCY consumes only 5.3–5.6 l/100 km and therefore improves on the preceding model from 2002 by 16 percent
• CO₂ emissions of the E 250 CDI BlueEFFICIENCY have been reduced by 24 percent compared with the equivalent preceding model, while output has been increased by 10 kW
• BlueEFFICIENCY technology optimises aerodynamics, rolling resistance, vehicle weight and energy management, among other items
• The new E 350 BlueTEC with SCR technology is even capable of undercutting the strict EU6 limits which will apply with effect from 2014
• The Sindelfingen E-Class production plant has implemented an environmental management system certified according to EU eco-audit regulations and ISO standard 14001 since 1996
• Effective recycling system and high environmental standards also at dealerships
The consumption benefits are achieved thanks to an intelligent package of measures, the so-called BlueEFFICIENCY technologies that are gradually being introduced as standard in the Mercedes-Benz model series. They include improvements to the drive train, energy management and aerodynamics, rolling-resistance-optimised tyres, weight reduction through lightweight design, and information for the driver regarding energy-saving driving. Figure 2.1 above shows in detail how the measures have been implemented in the new E-Class. An example of the aerodynamic enhancements is seen in the form of the fan louvres, used for the first time in the new E-Class. When the engine is running under part load and requires relatively little cooling, and the air-conditioning system is operated at moderate outside temperatures, the radiator grille can be completely closed. The sum total of all of these optimisation measures enables the new E-Class models such as the E 200 CDI BlueEFFICIENCY and E 220 CDI BlueEFFICIENCY to achieve an outstanding drag coefficient of \( C_d = 0.25 \).

In addition to the base variant, the launch of the new E-Class will also see a number of additional environmentally-friendly model variants being released onto the market: from September 2009, the new E 350 BlueTEC with SCR technology will already meet the strict EU6 limits planned for 2014. Start/stop technology will be introduced across the E-Class range, with the E 200 CGI BlueEFFICIENCY, due on the market at the end of 2009, being the first E-Class model variant to benefit from this feature. The natural-gas engine, which was already implemented with success in the preceding model, will also find its way into the new E-Class. Hybrid variants are also planned. Overall, the new E-Class is making a significant contribution to reducing the CO₂ fleet average of new Mercedes-Benz vehicles even further.

Apart from the improvements to the vehicle, the driver himself has a decisive influence on fuel consumption. For this reason, a display in the middle of the speedometer of the new E-Class tells the driver the current fuel consumption. The clearly designed bar chart reacts spontaneously as soon as the driver takes his foot off the accelerator and uses the engine’s overrun shutoff, for example. In addition to information on fuel consumption, the display also advises the driver when it is best to change gear. The Owner’s Manual for the new E-Class also contains information on how the driver can act to achieve economical and environmentally friendly operation.

In addition, Mercedes-Benz offers eco driver training to its customers. This demonstrates that an energy-conscious style of driving can help to reduce fuel consumption by up to 15 percent.

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It goes without saying that this also applies to the diesel variants of the new E-Class. When it comes to particulate emissions, therefore, compared with the preceding model from 2002 (without diesel particulate filter), the E 220 CDI BlueEFFICIENCY achieves a reduction in emissions of around 97 percent.

With the new E-Class, Mercedes-Benz is not only significantly reducing particulates, but also other emissions as well. The E 220 CDI BlueEFFICIENCY, for example, remains considerably below the emission values of the comparable preceding model, by 23 percent for nitrogen oxide (NOx) and around 57 percent for carbon monoxide (CO). These figures also significantly undercut the European emission limits of EU5, valid from September 2009, by around 13 percent for NOx and by 65 percent for CO.

The E-Class is built at the state-of-the-art Daimler plant in Sindelfingen. The production plant has implemented a certified environmental management system since 1996. It boasts a high level not only in technological terms, but also with respect to environmental protection and safety. Longevity and value retention are further enhanced by a newly developed clearcoat, employing state-of-the-art nanotechnology which ensures much greater scratch-resistance than conventional paint, while the use of water-soluble paints and fillers drastically reduces solvent emissions.

High environmental standards are also firmly established in the environmental management system in the sales and after-sales sectors. At dealership level, Mercedes-Benz is meeting its product responsibility with the MeRSy recycling system for workshop waste, used and warranty parts and packaging materials. The take-back system introduced in 1993 means that Mercedes-Benz is a model for the automotive industry also where workshop waste disposal and recycling are concerned. This exemplary service by a manufacturer is implemented right down to customer level. The waste materials arising 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. Because of its contribution to the greenhouse effect, even the chlorine-free R134a air-conditioning refrigerant, which does not destroy ozone in the stratosphere, is collected for professional disposal. The reuse of used parts is also a long-standing tradition at Mercedes-Benz. The Mercedes-Benz Used Parts Center (GTC) was set up back in 1996. With its quality-inspected used parts, GTC is an integral element of the service and parts business of the Mercedes-Benz brand. Though this will not be the case with Mercedes-Benz passenger cars until well into the future, because of their longevity, Mercedes-Benz offers a new, innovative way to dispose of end-of-life vehicles safely, quickly and at no cost. For easy disposal, a comprehensive network of return points and dismantling facilities is available to Mercedes customers. Owners of end-of-life vehicles can dial the toll-free number 00800 1 777 7777 for information and will promptly be advised of all the important details about returning their vehicles.
The environmental compatibility of a vehicle is determined by the environmental burden caused by emissions and the consumption of resources throughout the vehicle life cycle (cf. Figure 2-2).

The standardised tool for evaluating environmental compatibility is the Life Cycle Assessment. It shows the total environmental impact of a vehicle “from the cradle to the grave”, i.e. from the extraction of the raw materials to the manufacture and use of the vehicle, through to its end-of-life treatment.

2.2 Life Cycle Assessment (LCA)

The elements of a Life Cycle Assessment (LCA) include:

1. **Terms of reference**
   define the goal and scope of an LCA.

2. **The life cycle inventory analysis**
   establishes the material and energy flows over a vehicle’s entire life:
   - how many kilograms of a raw material are used,
   - how much energy is consumed,
   - what waste and emissions are produced, etc.

3. **The life cycle impact assessment**
   gauges the potential effects of the product on humans and the environment, such as global warming potential, summer smog potential, acidification potential and eutrophication potential.

4. **The life cycle interpretation**
   draws conclusions and makes recommendations.

In Mercedes-Benz passenger-car development, life cycle assessments are used to evaluate and compare different vehicles, components and technologies.

The DIN EN ISO 14040 and DIN EN ISO 14044 standards specify the procedure and the required elements.
2.2.1 Data basis

To be able to ensure that the analysed vehicles can be compared, the ECE base variant is always examined. The E 220 CDI BlueEFFICIENCY with the new 125 kW/170 hp four-cylinder engine was defined as the base variant of the new E-Class; by way of comparison, the corresponding preceding model was chosen in the form of the E 220 CDI (as the models applicable at the time of market launch and market withdrawal). Comparison with these two variants enables a determination of the development measures already taken in the case of the preceding model up until its market withdrawal. These document the continual improvement in environmental performance over the operating life of a model generation. The main parameters on which the LCA was based are shown in the table below.

### Project goal
- Life cycle assessment of the new E-Class using the E 220 CDI BlueEFFICIENCY as ECE base variant compared with the preceding model.
- Verification of attainment of the „environmental compatibility“ objective and communication.

### Project scope
#### Functional equivalent
- E-Class car (base variant, weight according to DIN 70020).

#### Technology/

#### Product comparability
- Products can generally be compared in the form of two generations. Products can generally be compared in the form of two generations and more varied market requirements; the new E-Class presents additional scope, particularly in the areas of active and passive safety and to some extent increased performance as well. If these additional scope areas have an impact on the results of the assessment, this is commented on as part of the assessment process.

#### System boundaries
- Life cycle assessment for car manufacture, use, disposal/recycling. The system boundaries should only be exceeded by elementary flows (resources, emissions, dumping/deposits).

#### Data basis
- Weight data of car: MB parts list (as at 10/2008).
- Information on materials for model-relevant, vehicle-specific parts: MB parts list, internal MB documentation systems, specialist literature.
- Vehicle-specific model parameters (bodyshell, panelwork, catalytic converter, etc.): MB departments.
- Information on materials for standard parts: MB database.
- Site-specific supplied energy: MB database.
- Information on standard component materials: MB database.
- Use (consumption, emissions): type/approval/certification figures.
- Use (mileage): MB definition.
- Recycling model: state of the art (also refer to Chapter 2.3.1).

#### Allocations
- For material production, supplied energy, manufacturing processes and transport, use is made of GaBi life cycle assessment data and the allocation methods on which it is based.
- No further specific allocations.

---

### Table 2-1: Main parameters of the E-Class Life Cycle Assessment

#### Project scope (cont’d)

**Cutoff criteria**
- For material production, supplied energy, manufacturing processes and transport, use is made of GaBi life cycle assessment data and the cutoff criteria on which it is based.
- No explicit cutoff criteria. All available weight information is processed.
- Noise and land use are not available as LCA data today and are therefore not taken into account.
- „Fine dust“ and particulate emissions are not analysed. Significant sources of fine dust (in particular, tyre abrasion and brakes) are not dependent on vehicle type and therefore have no relevance in terms of the result of the vehicle comparison.
- Maintenance and vehicle care have no relevance in terms of the result.

#### Balancing
- Life cycle, in conformity with ISO 14040 and 14044 (product life cycle assessment).

#### Balancing parameters
- Material composition according to VDA 231-104.
- Life cycle inventory: resource consumption as primary energy, emissions, e.g. CO₂, CO, NOₓ, SO₂, NMVOC, CH₄, 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, LIRECAR. The mapping of impact potentials for human toxicity and ecosystem toxicity does not yet have sufficient scientific backing today and therefore will not deliver useful results.

- Interpretation: sensitivity analyses of car module structure; dominance analysis over life cycle.

#### 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 GaBi4.3 (http://www.pe-international.com/gabi).

#### 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 will be discussed.

#### Documentation
- Final report with all main parameters.

The assumed sulphur content in the fuel is 10 ppm. The combustion of one kilogram of fuel therefore produces 0.02 grams of sulphur dioxide emissions. The use phase is calculated using a mileage of 250,000 kilometres. The LCA reflects the environmental burden during the disposal phase using standard processes for removal of service fluids, shredding and energy recovery from shredder light fraction. Ecological credits are not granted.
2.2.2 Results for the E 220 CDI BlueEFFICIENCY

Over the entire life cycle of the new E-Class, the life cycle inventory calculations indicate, for example, a primary energy consumption of 702 gigajoules (equal to the energy content of about 21.5 tonnes of premium-grade petrol) and the input into the environment of around 47 tonnes of carbon dioxide (CO₂), about 16 kilograms of non-methane hydrocarbons (NMVOC), about 60 kilograms of nitrogen oxides (NOₓ) and almost 36 kilograms of sulphur dioxide (SO₂). In addition to the analysis of overall results, the distribution of individual environmental impacts among the different phases of the life cycle is investigated. The relevance of each life cycle phase depends on the particular environmental impact being considered. For CO₂ emissions and also primary energy consumption, the use phase dominates with a share of over 80 percent (cf. 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 its manufacture, for example the SO₂ and NOₓ emissions (cf. Figure 2-4). For this reason the manufacturing phase must be included in the analysis of ecological compatibility. For a great many emissions today, the dominant factor is not so much automotive operation itself, but the production of the fuel, for instance for hydrocarbon (NMVOC) and sulphur dioxide emissions and for the environmental impacts which they essentially entail: photochemical ozone creation potential (POCP: summer smog, ozone) and acidification potential (AP).

For comprehensive and thus sustained improvement of the environmental impact associated with a vehicle, it is also necessary to consider the end-of-life phase. With regard to energy, the use or initiation of recycling cycles is rewarding. For a complete assessment, within each life cycle phase all environmental inputs are evaluated.

In addition to the results shown above, it was established, for example, that municipal waste and tailings (particularly ore dressing residuals and overburden) originate mainly in the manufacturing phase, whereas the hazardous wastes are caused mainly by the provision of petrol during the use phase.

Burdens on the environment due to emissions in water are a result of vehicle manufacture, in particular owing to the output of heavy metals, NO₃⁻ and SO₄²⁻-ions as well as the factors AOX, BOD and COD.

In addition to analysing the overall results, the distribution of selected environmental impacts over the production of individual modules was examined. For example, the percentage distribution of carbon dioxide and sulphur dioxide emissions for different modules is shown in Figure 2-5.

While the bodyshell is dominant with respect to carbon dioxide emissions, more relevant to sulphur dioxide emissions are the modules containing precious and non-ferrous metals as well as glass, which give rise to high sulphur dioxide emissions in materials production.
Vehicle-production emissions [%]

- Total vehicle (paintwork)
- Passenger cell/bodyshell
- Flaps/wings
- Doors
- Cockpit
- Mounted external parts
- Mounted internal parts
- Seats
- Electrics/electronics
- Drive train
- Tires
- Controls
- Fuel system
- Hydraulics
- Engine/transmission peripherals
- Engine
- Automatic transmission
- Steering
- Front axle
- Rear axle

New E-Class production total:
- CO₂: 8.3 t
- SO₂: 18.4 kg

Figure 2.5: Distribution of selected parameters (CO₂ und SO₂) among different modules
2.2.3 Comparison with the preceding model

At the same time as examining the new E-Class, an assessment of the preceding model was also undertaken using the ECE base variant (DBN weight of 1540 kilograms at the time of market withdrawal, DBN weight of 1535 kilograms at market launch).

The main underlying parameters are identical to the modelling of the new E-Class. Production was represented on the basis of an extract from the current parts list. Use of the predecessor, with a comparable engine variant, was calculated using valid certification values. For recycling, the same model, described according to the prior art, was taken as the basis.

Compared with the preceding model introduced in 2002, the following savings have been achieved:

- Reduction of 14 percent in CO₂ emissions over the entire life cycle
- Reduction of 20 percent in nitrogen oxide emissions
- Significantly reduced fuel consumption in the use phase, despite increased vehicle weight, therefore lower demand in terms of energy resources
- Reduction of 13 percent in primary energy demand over the entire life cycle, corresponding to an energy content of 3200 litres of petrol

Figure 2-6 shows that the vehicle models in production have similar carbon dioxide emissions, however the new E-Class displays clear advantages over its entire operating life.

Due to the different use of materials (increased proportion of high-strength steels, lower proportion of light alloys), production of the new E-Class gives rise to lower CO₂ emissions at the start of the life cycle than the predecessor (a total of 8.3 tonnes of CO₂). In the subsequent use phase, the new E-Class emits approx. 38 tonnes of CO₂, and as a result the total for production, use and recycling comes to around 47 tonnes of CO₂.

![Figure 2-6: Comparison of CO₂ emissions between the new E-Class and the predecessor [t/car]](image)
Taking into account the nitrogen oxide emissions over the mileage shown in Figure 2-7, the new E-Class exhibits even greater advantages than for CO2 emissions. The improvement is 18 percent (market withdrawal) and 20 percent (market launch) respectively. This is due to the significantly reduced nitrogen oxide emissions achieved by the new E-Class during operation.

In Figure 2-8 as well as Table 2-2 and Table 2-3, the results for several other parameters of the LCA are shown in summary form. The horizontal lines with grey backgrounds in the tables represent general impact categories. They group together emissions having the same impact and quantify their contribution to the particular impact by means of a characterisation factor; for example, the contribution to global warming potential in kilograms of CO2 equivalent.

Taking into account the entire life cycle, comprising production, use over 250,000 kilometres and recycling, the new model produces 11 percent (5.8 tonnes) less CO2 emissions than the predecessor at the time of market withdrawal. Due to higher fuel consumption, during use the preceding models emit 46 (2002 predecessor) and 44 (2009 predecessor) tonnes of CO2 respectively. This comes to totals of around 55 and 53 tonnes of CO2 emissions respectively.

Taking into account the nitrogen oxide emissions over the mileage shown in Figure 2-7, the new E-Class exhibits even greater advantages than for CO2 emissions. The improvement is 18 percent (market withdrawal) and 20 percent (market launch) respectively. This is due to the significantly reduced nitrogen oxide emissions achieved by the new E-Class during operation.

In Figure 2-8 as well as Table 2-2 and Table 2-3, the results for several other parameters of the LCA are shown in summary form. The horizontal lines with grey backgrounds in the tables represent general impact categories. They group together emissions having the same impact and quantify their contribution to the particular impact by means of a characterisation factor; for example, the contribution to global warming potential in kilograms of CO2 equivalent.

Production of the preceding model (at the time of market launch = 2002 predecessor and at the time of market withdrawal = 2009 predecessor) accounts for 8.3 and 8.4 tonnes of CO2 respectively. Due to higher fuel consumption, during use the preceding models emit 46 (2002 predecessor) and 44 (2009 predecessor) tonnes of CO2 respectively. This comes to totals of around 55 and 53 tonnes of CO2 emissions respectively.

The consumption of resources is indicated by the category ADP (abiotic depletion potential). The individual figures show the changes in detail: due to the slight alterations in the mix of materials, the requirements of the new E-Class in terms of material resources during production have also changed.

The demand for bauxite, for example, has fallen due to the reduction in the use of aluminium, while consumption of iron ore has increased due to the increase in the use of high-strength steels. The reduced requirements in terms of energy resources is primarily due to the significant reduction in fuel consumption during use. Over the entire life cycle, reductions of 10 (2009) and 13 (2002) percent have been achieved for primary energy, and reductions of 11 (2009) and 13 (2002) percent for abiotic depletion potential. The reduction in the primary energy demand by 82 GJ (2009) and 105 GJ (2002) respectively corresponds to an energy content of 2500 litres and around 3200 litres of fuel respectively.

In Table 2-3 the superior impact categories are again put first. The new E-Class demonstrates advantages over the preceding model in all of the impact categories examined. Overall, the objective of achieving an improvement over the predecessor in terms of environmental compatibility has therefore been fulfilled.
### Output parameters

#### Emissions in air

<table>
<thead>
<tr>
<th>Parameter</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW* (t CO₂ equiv.)</td>
<td>49</td>
<td>55</td>
<td>-11%</td>
<td>57</td>
<td>-14%</td>
<td>Mainly due to CO₂ emissions</td>
</tr>
<tr>
<td>AP* (kg SO₂ equiv.)</td>
<td>322</td>
<td>341</td>
<td>-5%</td>
<td>372</td>
<td>-13%</td>
<td>Mainly due to SO₂ emissions</td>
</tr>
<tr>
<td>EP* (kg phosphate equiv.)</td>
<td>11</td>
<td>12</td>
<td>-9%</td>
<td>13</td>
<td>-10%</td>
<td>Mainly due to NOₓ emissions from passenger-car production and use</td>
</tr>
<tr>
<td>POCP* (kg ethene equiv.)</td>
<td>11</td>
<td>15</td>
<td>-27%</td>
<td>11</td>
<td>-7%</td>
<td>Mainly due to NMVOC emissions</td>
</tr>
</tbody>
</table>

CO₂ [t]

| New E-Class | 47 | 53 | -11% | 55 | -14% | Mainly from vehicle operation. CO₂ reduction is a result of the reduced fuel consumption of the new E-Class |
| CO [kg] | 81 | 141 | -42% | 73 | -10% | Equal shares from use and production in the case of the new E-Class. Differences mainly due to different emissions in the use phase |
| NMVOC [kg] | 16 | 21 | -24% | 17 | -7% | Mainly due to use and primarily from fuel production. For the new E-Class, approx. 30% from car production |
| CH₄ [kg] | 58 | 67 | -12% | 67 | -13% | Mainly from fuel production |
| NOₓ [kg] | 60.0 | 73.5 | -18% | 76.0 | -20% | Mainly from vehicle operation |
| SO₂ [kg] | 30.6 | 40.9 | -11% | 43.8 | -17% | More than 50% from vehicle production, remainder mainly from fuel production |

#### Emissions in water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD [kg]</td>
<td>0.45</td>
<td>0.44</td>
<td>3%</td>
<td>0.44</td>
<td>3%</td>
<td>Mainly from car production</td>
</tr>
<tr>
<td>Hydrocarbons [kg]</td>
<td>0.39</td>
<td>0.43</td>
<td>-10%</td>
<td>0.44</td>
<td>-13%</td>
<td>Up to approx. 70% from use phase</td>
</tr>
<tr>
<td>NOₓ [g]</td>
<td>399</td>
<td>419</td>
<td>-5%</td>
<td>419</td>
<td>-5%</td>
<td>Mainly from vehicle production</td>
</tr>
<tr>
<td>POCP [g]</td>
<td>16.92</td>
<td>19.15</td>
<td>-13%</td>
<td>19.6</td>
<td>-14%</td>
<td>Up to approx. 60% from car production</td>
</tr>
<tr>
<td>SO₄²⁻ [kg]</td>
<td>15.6</td>
<td>16.4</td>
<td>-5%</td>
<td>16.7</td>
<td>-7%</td>
<td>Up to approx. 60% from car production</td>
</tr>
</tbody>
</table>

Table 2-3: Overview of LCA results (II)

---

### Input parameters

#### Resources, ores

<table>
<thead>
<tr>
<th>Resource, ore</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADP* (kg Sb equiv.)</td>
<td>3.22</td>
<td>3.61</td>
<td>-11%</td>
<td>3.72</td>
<td>-13%</td>
<td>Mainly due to fuel production</td>
</tr>
<tr>
<td>Bauxite (kg)</td>
<td>532</td>
<td>597</td>
<td>-11%</td>
<td>598</td>
<td>-11%</td>
<td>Mainly due to aluminium production, lower proportion of aluminium</td>
</tr>
<tr>
<td>Iron ore (kg)</td>
<td>3977</td>
<td>3821</td>
<td>4%</td>
<td>3769</td>
<td>5%</td>
<td>Mainly due to steel production, higher proportion of high-grade steels</td>
</tr>
<tr>
<td>Copper ore (kg)</td>
<td>34</td>
<td>37</td>
<td>-7%</td>
<td>37</td>
<td>-7%</td>
<td>Mainly due to copper production, lower wiring-harness weight</td>
</tr>
<tr>
<td>Zinc ore (kg)</td>
<td>35</td>
<td>35.7</td>
<td>-7%</td>
<td>36</td>
<td>-7%</td>
<td>Mainly due to engine/transmission peripherals (exhaust system)</td>
</tr>
<tr>
<td>Rare earth/precious metal ore (kg)</td>
<td>793</td>
<td>934</td>
<td>-15%</td>
<td>1230</td>
<td>-36%</td>
<td>Mainly due to fuel production, lower magnesium use</td>
</tr>
<tr>
<td>Dolomite (kg)</td>
<td>9</td>
<td>61.1</td>
<td>-85%</td>
<td>61</td>
<td>-85%</td>
<td>Lower magnesium use</td>
</tr>
</tbody>
</table>

#### Energy sources

<table>
<thead>
<tr>
<th>Energy sources</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy</td>
<td>702</td>
<td>794</td>
<td>-10%</td>
<td>807</td>
<td>-13%</td>
<td>Consumption of energy resources, significantly reduced compared with the predecessor, primarily due to the fuel consumption advantage of the new E-Class (fuel production makes up over 80% of the primary energy demand)</td>
</tr>
</tbody>
</table>

#### Shares of

<table>
<thead>
<tr>
<th>Source</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite (GJ)</td>
<td>14.6</td>
<td>14.6</td>
<td>0%</td>
<td>14.5</td>
<td>-1%</td>
<td>approx. 85% from car production</td>
</tr>
<tr>
<td>Natural gas (GJ)</td>
<td>66.0</td>
<td>69.7</td>
<td>-5%</td>
<td>71.0</td>
<td>-7%</td>
<td></td>
</tr>
<tr>
<td>Crude oil (GJ)</td>
<td>544</td>
<td>621</td>
<td>-12%</td>
<td>641</td>
<td>-15%</td>
<td>Significant reduction, crude-oil consumption has fallen due to lower fuel consumption</td>
</tr>
<tr>
<td>Coal (GJ)</td>
<td>41.5</td>
<td>42.7</td>
<td>-2%</td>
<td>43.7</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Uranium (GJ)</td>
<td>25.9</td>
<td>25.8</td>
<td>1%</td>
<td>25.4</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

#### Renewable energy resources (GJ)

<table>
<thead>
<tr>
<th>Resource</th>
<th>New E-Class</th>
<th>2009 predecessor</th>
<th>Difference with respect to 2009 predecessor</th>
<th>2002 predecessor</th>
<th>Difference with respect to 2002 predecessor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5</td>
<td>11.2</td>
<td>-6%</td>
<td>11.2</td>
<td>-7%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2-2: Overview of LCA results (I)

* CML 2001, as at December 2007
2.3 Design for recovery

The requirements for the recovery of end-of-life vehicles (ELV) were redefined with the approval of the European End-of-Life Vehicle Directive (2000/53/EC) on 18 September 2000.

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:

- Set up systems for collection of end-of-life vehicles and waste used parts from repairs
- Achievement of an overall recovery rate of 95 percent by weight by 1 January 2015
- Compliance with the recovery rate in the context of type approval for new vehicles from 12/2008
- Free take-back of all end-of-life vehicles from January 2007
- Provision of dismantling information to ELV recyclers within six months after market launch
- Prohibition of heavy metals lead, hexavalent chromium, mercury and cadmium, taking into account the exceptions in Annex II.

Today the E-Class already complies with the recovery rate of 95 percent by weight applicable as of 1 January 2015.

End-of-life vehicles have been taken back free of charge since January 2007.

Heavy metals like lead, hexavalent chromium, mercury and cadmium have been eliminated.

Mercedes-Benz currently already has an efficient take-back and recycling network at its disposal.

The Mercedes Used Parts Center makes an important contribution to the recycling concept through the resale of inspected used parts.

During development of the E-Class, attention was paid to the material purity and design for dismantling ease of certain thermoplastic components such as bumpers and wheel-arch linings, and side member, underbody and engine compartment panels.

Detailed dismantling information is made available electronically to all ELV recyclers through the International Dismantling Information System, IDIS for short.
The calculation model reflects the real process of end-of-life vehicle recycling and is divided into the following four steps:

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 new E-Class was designed in parallel with the vehicle development process, including analysis of the individual components and materials for each stage of the process. On the basis of the quantitative flows stipulated for each step, the recycling rate or recovery rate for the overall vehicle is determined.

At the pretreatment stage, the ELV recycler removes the fluids, battery, oil filter, tyres and catalytic converters. The airbags are deployed using equipment standardised for all European vehicle manufacturers. The components removed first during the dismantling stage are those required by the European End-of-Life Vehicle Directive. To improve recycling, numerous components and assemblies are then dismantled for direct sale as used replacement parts or as a basis for remanufacturing.

Further utilisation of used parts has a long tradition at Mercedes-Benz: the Mercedes-Benz Used Parts Center (GTC) was founded as early as 1996. With its quality-tested used parts, the GTC is a major component of the service and parts business of Mercedes-Benz, and makes a major contribution to age and value-related repairs to our vehicles. In addition to used parts, the ELV recycler removes specific materials which can be recycled by economically worthwhile methods. Apart from aluminium and copper components, these include certain large plastic parts.

As part of the development process for the new E-Class, these components were specifically designed for later recycling. In addition to material purity care was taken to ensure easy dismantling of relevant thermoplastic components such as bumpers and wheel-arch linings, and side member, underbody and engine compartment panels, for example. In addition, all plastic components are marked in accordance with an international nomenclature.

During the subsequent shredder process for the remaining bodyshell, the metals are separated for recycling in raw materials production processes. The remaining, mainly organic fraction is separated into different categories and reprocessed into raw materials or energy in an environmentally sound manner. All in all, with the process chain described, a recyclability rate of 85 percent and a recoverability rate of 95 percent could be demonstrated for the new E-Class according to the ISO 22628 calculation model (see Figure 2-9) in the context of vehicle type approval.

### 2.3.1 Recycling concept for the E-Class

The method for calculating the recoverability of passenger cars is defined by ISO standard 22628, “Road vehicles - Recyclability and recoverability - calculation method”.

\[
R_{cw} = \frac{(m_p + m_d + m_m + m_tr)}{m_v} \times 100 > 85 \text{ percent}
\]

\[
R_{cvw} = R_{cw} + \frac{m_e}{m_v} \times 100 > 95 \text{ percent}
\]

1) acc. to 2000/53/EG
2) SLF = shredder light fraction

Figure 2-9: Material flows for E-Class recycling concept
2.3.2 Dismantling information

Dismantling information plays an important role for ELV recyclers when it comes to implementing the recycling concept.

All the necessary information relating to the new E-Class is made available electronically 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.

Model-specific data are shown in both graphic and text form. The pretreatment section contains specific information concerning service fluids and pyrotechnical components. The other sections contain materials-specific information for the identification of non-metallic components.

The current version (as at September 2008) contains information in 26 languages on 61 automotive brands and 1256 different vehicles. IDIS data is made available to ELV recyclers by software update six months after market launch.

2.3.3 Avoidance of potentially hazardous materials

The avoidance of hazardous materials is the top priority during development, production, operation and recycling of our vehicles. As far back as 1996, for the protection of both humans and the environment, our in house standard DBL 8585 has specified those materials and material categories that may not be incorporated into the materials or components used in Mercedes passenger cars. This DBL standard is already available to designers and materials specialists at the pre-development stage, during the selection of materials and the planning of production processes.

Heavy metals forbidden by the EU End-of-Life Vehicle Directive, i.e. lead, cadmium, mercury and hexavalent chromium are also covered by this standard. To ensure that the ban on heavy metals is implemented according to the legal requirements, Mercedes-Benz has modified and adapted numerous in house and supplier processes and requirements.

The new E-Class complies with the valid regulations. This includes the use of lead-free elastomers in the drive train, lead-free pyrotechnical activation units, cadmium-free thick-film pastes and chromium(VI)-free surfaces for the interior, exterior and major assemblies, for example.

Materials used for components in the passenger compartment and boot are subject to additional emissions limits which are also defined in DBL 8585 as well as in component-specific delivery instructions. The continuous reduction of interior emissions is a major aspect of component and materials development for Mercedes-Benz vehicles.
In addition to the required achievement of certain recycling/recovery rates, the manufacturers are called upon by Article 4 Paragraph 1 (c) of the European End-of-Life Vehicle Directive 2000/53/EC to increasingly use recycled materials in vehicle manufacture and thereby to build up and extend the markets for secondary raw 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 main focus of the recyclate research accompanying vehicle development is 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 functional requirements for the relevant component must be met by recycled materials to the same extent as by comparable new materials. To ensure that car production is maintained even in the event of supply bottlenecks in the recyclate market, new materials may also be used as an alternative.

In the new E-Class, a total of 43 components with a total weight of 41.5 kilograms can be made from high-quality recycled plastics. As such, it was possible to increase the quantity of approved recycled materials used compared with the preceding model by 80 percent. Typical applications include wheel-arch linings, cable ducts and underbody panels, which are mainly made from polypropylene. New material loops have also been closed by the E-Class: the use of recycled polyamide is approved for the blower shroud in the engine compartment, while recycled acrylonitrile butadiene styrene (ABS) is approved for the basic carrier of the centre console. Recycling polyol is partly used in the rear seat cushions. Figure 2-11 shows the components for which the use of recycled materials has been approved.

Another objective is to obtain recycled materials from vehicle-related waste flows as far as possible, thereby closing further loops. For example, for the front wheel-arch linings of the new E-Class a recyclate which is made from reprocessed vehicle components is used (see Figure 2-12): starter battery housings, bumper coverings from the Mercedes-Benz Recycling System, and production waste from cockpit units.

### Component weight

<table>
<thead>
<tr>
<th>Component</th>
<th>New E-Class</th>
<th>Predecessor</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight in kg</td>
<td>41.5</td>
<td>23.0</td>
<td>+ 80 %</td>
</tr>
</tbody>
</table>

- In the new E-Class, 43 components with an overall weight of 41.5 kilograms are made from high-grade recycled plastics.
- These include wheel-arch linings, cable ducts or underbody panels.
- The quantity of recycled components used compared with the preceding model has increased by 80 percent.
- Recycled materials are obtained from vehicle-related waste flows as far as possible: the front wheel-arch linings are made from reprocessed vehicle components.
2.5 Use of renewable raw materials

The use of renewable raw materials in vehicle production focuses on interior applications. The natural fibres predominantly used in series production of the E-Class are cellulose, cotton and wool fibres in combination with various polymers. The use of natural materials in automotive engineering has a number of advantages:

- Compared to glass-fibre, the use of natural fibres usually results in a reduced component weight.
- Renewable raw materials help to slow down the depletion of fossil resources such as coal, natural gas and crude oil.
- They can be processed using established technologies. The products made from them are usually easy to recycle.
- If recovered in the form of energy they have an almost neutral CO₂ balance, since only as much CO₂ is released as the plant absorbed during its growth.

The types of renewable raw materials and their fields of application are shown in Table 2-4. The new E-Class makes use of a total of 44 components made from natural materials with an overall weight of around 21 kilograms. By doing so, the overall weight of the components made from renewable raw materials has been reduced by 34 percent compared with the preceding model. This is primarily down to not being able to use natural fibres in the door linings and the seats. Figure 2-13 below shows the components made from renewable raw materials in the new E-Class.

The floor of the boot features a honeycomb cardboard structure, and Mercedes engineers have also used a raw material from nature to ventilate the fuel tank: olive coke serves as an activated charcoal filter. This open-pored material adsorbs hydrocarbon emissions, and the filter is self-regenerating during vehicle operation.

Natural materials also play an important part in the production of the fabric seat upholstery for the new E-Class, which contains 25 percent pure sheep’s wool. Wool has significant comfort advantages over synthetic fibres: it not only has very good electrostatic properties, but is also better at absorbing moisture and has a positive effect on climatic seating comfort in high temperatures.

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### Table 2-4: Areas of application of renewable raw materials in the new E-Class

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>Seat covers</td>
</tr>
<tr>
<td>Cotton</td>
<td>Various insulating elements and trims</td>
</tr>
<tr>
<td>Cellulose fibres</td>
<td>Various insulating elements and coatings</td>
</tr>
<tr>
<td>Olive kernels</td>
<td>Activated charcoal filter</td>
</tr>
<tr>
<td>Paper</td>
<td>Floor of boot, filter elements</td>
</tr>
</tbody>
</table>

Figure 2-13: Components made from renewable raw materials in the new E-Class
It is of decisive importance for the environmental compatibility of a vehicle to reduce emissions and the consumption of resources over its entire life cycle. The extent of the ecological burden caused by a product is already largely defined during the early development phase. Later corrections of the product design are only possible at great cost and effort. The earlier environmentally compatible product development (“Design for Environment”) is integrated into the development process, the greater the benefits in terms of minimising environmental effects and costs. Process- and product-integrated environmental protection must be realised during the development phase of a product. Later on, environmental effects can often only be reduced by downstream, “end-of-the-pipe” measures.

“We develop products which are particularly environmentally compatible in their market segment” – this is the second environmental guideline within the Daimler Group. Making this a reality means building environmental protection into our products from the very start, so to speak. Ensuring this is the task of environment-conscious product development: developing comprehensive vehicle concepts according to the slogan “Design for Environment” (DfE). The aim is to improve environmental compatibility in an objectively measurable way, while meeting the demands of the increasing number of customers who pay attention to environmental aspects such as lower fuel consumption and emissions or the use of environmentally friendly materials.

The responsibility for improving environmental compatibility was an integral part of the organisation of the E-Class development project. The management of the overall project appointed people to be in charge of development, production, procurement, sales and other functions. Corresponding to the most important subassemblies and functions of a car, there are development teams (bodyshell, drive system, interior appointments, etc.) and teams with cross-cutting functions (quality management, project management, etc.).

One of these cross-functional teams was the so-called DfE team. It is made up of experts from the fields of life cycle assessment, dismantling and recycling planning, materials and process engineering, as well as design and production. Each member of the DfE team is simultaneously the person responsible on a development team for all
environmental issues and tasks. This guarantees complete integration of the DfE process in the vehicle development project. The members’ duties consist of defining objectives for individual vehicle modules from an environmental angle in the specifications book early on in the process, checking on their accomplishment and, if necessary, initiating improvement measures.

The integration of Design for Environment in the process organisation of the E-Class development project ensured that no hunt for environmental aspects would begin at the time of market launch. Instead, these aspects were taken into account in the earliest stage of development.

Pertinent objectives were coordinated in good time and reviewed at the respective quality gates in the development process. From the interim results, the need for further action up to the next quality gate was determined and implemented by collaborating in the development teams.

Together with the project management for the E-Class, the DfE team defined the following, specific environmental objectives in the book of specifications:

1. Ensuring compliance with the European End-of-Life Vehicle Directive. This includes
   • Development of a recycling concept designed to meet the legally prescribed recovery rate of 95 percent by weight by the year 2015
   • Ensuring compliance with the European End-of-Life Vehicle Directive with respect to banned materials
   • Optimising product concepts with a view to recycling-compatible design, in order to reduce subsequent recovery costs.

2. Ensuring the use of 40 kilograms of recycled plastics (component weight)
3. Ensuring the use of 20 kilograms (component weight) of renewable raw materials
4. Registering all relevant environmental burdens that could be caused by the E-Class during its life cycle, and improvement of the Life Cycle Assessment compared with the predecessor.

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 14062.
The new Mercedes-Benz E-Class not only meets high standards in terms of safety, comfort, agility and design, but also satisfies all current requirements with regard to environmental compatibility.

This Environmental Certificate documents the major advances which have been achieved compared with the preceding model of the new E-Class. Both the process of design for environment and the product information contained herein have been certified by independent experts according to internationally recognised standards.

Mercedes-Benz remains the world’s only automotive brand to possess this demanding certification, which was first awarded for the S-Class in 2005 by TÜV Süd. Mercedes customers driving the new E-Class benefit from significantly reduced fuel consumption, low emissions and a comprehensive recycling concept. Moreover, a higher proportion of high-quality secondary raw materials is used. All in all, the new E-Class therefore has a significantly improved LCA compared with the preceding model.

5 Conclusion
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>ADP</td>
<td>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</td>
</tr>
<tr>
<td>Allocation</td>
<td>Distribution of material and energy flows in processes with several inputs and outputs, and assignment of the input and output flows of a process to the investigated product system</td>
</tr>
<tr>
<td>AOX</td>
<td>Adsorbable organically bound halogens; sum parameter used in chemical analysis to assess water and sewage sludge. The sum of the organic halogens which can be adsorbed by activated charcoal is determined. These include chlorine, bromine and iodine compounds</td>
</tr>
<tr>
<td>AP</td>
<td>Acidification potential; impact category expressing the potential for milieu changes in ecosystems due to the input of acids</td>
</tr>
<tr>
<td>Base variant</td>
<td>Basic vehicle model without optional extras, normally CLASSIC line and small engine</td>
</tr>
<tr>
<td>BOD</td>
<td>Biological oxygen demand; taken as measure of the pollution of wastewater, waters with organic substances (to assess water quality)</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical oxygen demand; taken as measure of the pollution of wastewater, waters with organic substances (to assess water quality)</td>
</tr>
<tr>
<td>DIN</td>
<td>German Institute for Standardisation (Deutsches Institut für Normung e.V.)</td>
</tr>
<tr>
<td>ECE</td>
<td>Economic Commission for Europe. UN organisation that develops standardised technical codes</td>
</tr>
<tr>
<td>EP</td>
<td>Eutrophication potential (overfertilisation potential); impact category expressing the potential for oversaturation of a biological system with essential nutrients</td>
</tr>
<tr>
<td>GWP100</td>
<td>Global warming potential, time horizon 100 years; impact category describing the possible contribution to the anthropogenic greenhouse effect</td>
</tr>
<tr>
<td>HC</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Impact categories</td>
<td>Classes of environmental impacts in which resource consumption and various emissions with similar environmental impact are aggregated (greenhouse effect, acidification, etc.)</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>KBA</td>
<td>German Federal Office for Motor Vehicles (new-car registration agency)</td>
</tr>
<tr>
<td>Life cycle assessment</td>
<td>Compilation and assessment of the input and output flows and the potential environmental impacts of a product in the course of its life</td>
</tr>
<tr>
<td>MB</td>
<td>Mercedes-Benz</td>
</tr>
<tr>
<td>NEDC</td>
<td>New European Driving Cycle; cycle used to establish the emissions and consumption of motor vehicles since 1996 in Europe; prescribed by law</td>
</tr>
<tr>
<td>Non-ferrous metal</td>
<td>Aluminium, copper, zinc, lead, nickel, magnesium, etc.</td>
</tr>
<tr>
<td>POCP</td>
<td>Photochemical ozone creation potential; impact category describing the formation of photo oxidants (“summer smog”)</td>
</tr>
<tr>
<td>Primary energy</td>
<td>Energy not yet subjected to anthropogenic conversion</td>
</tr>
<tr>
<td>Process polymers</td>
<td>Term from the VDA materials data sheet 231-106; the “process polymers” material group comprises paints, adhesives, sealants, protective undercoats</td>
</tr>
</tbody>
</table>