The Commercial Vehicle –
environmentally friendly and efficient
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Ladies, gentlemen, dear readers,

Climate protection has assumed a central position in the consciousness of man and is conceived as the central element in the conservation of the basis of life. All sectors of the economy and of society must make their contribution in this regard, independent of their respective share in CO₂ emissions. In pursuing an integrated approach all sectors are required to contribute, be it the public sector responsible for the provision of infrastructure, be it the customers using products responsibly. It is unquestionable that the automobile industry has an important contribution to make to the long term reduction of CO₂ emissions. Our objective is to ensure sustainable mobility, also in future.

Each and every national economy is dependent on mobility. The welfare of a society increases when the advantages of spatial connections are utilised. As such the free movement of goods forms the basis for welfare and growth. In this regard it is self-evident that the need for mobility will increase rather than decrease in importance. International markets are becoming increasingly integrated. Especially in Europe we could witness how, after the collapse of the Iron Curtain, the reunification of Germany and the expansion of the EU, mobility was the essential integrating factor in growing together and in the development of national economies.

The commercial vehicle is versatile. From the small van for innercity distribution traffic to the modern tractor with semi-trailer for long distance haulage commercial vehicles offer solutions for every transport task. No other mode of transport offers such flexibility and a tailor-made concept for each transport need at such quality levels.

In the transportation of persons the commercial vehicle leads the way. The autobus simply is the environmentally friendliest mode of transportation for people. Simultaneously an optimal solution is offered for each transport task, be it minibuses, city buses or comfortable coaches.

In the field of environmental protection commercial vehicles have an exemplary record. Despite a marked increase in transport- and driving performance, the sumtotal of emissions of road traffic e.g. nitrogen-oxides, hydro-carbons, or particulate matter has decreased by up to 94 per cent from 1990 to present. Also in the field of environmental protection an exemplary track record has been maintained, because parallel to the reduction of emissions, consumption e.g. by long distance trucks has been reduced by approximately 30 per cent over the past three decades, and that, coincidentally, with significantly higher transport efficiency. From the beginning fuel consumption has been a basic sales argument in respect of commercial vehicles. This commercial instrument enjoys stronger leverage than any official regulation could ever have. Further potentials for CO₂ reductions could be utilised in optimising transport infrastructures, logistical transport chains and driver qualification.

The automobile industry has undertaken much to make commercial vehicles not only environmentally friendlier and more economical but also safer. We will proceed along this way. How and in which competitive environment this is taking place, is illustrated in this brochure. Simultaneously it provides an overview of future developments. May you find it interesting reading!

Sincerely

Matthias Wissmann, President of the VDA
1. Decreasing CO₂ emissions with increasing driving performance

Over a number of years the German commercial vehicle industry has been involved in making the most important mode of transport even more economical and hence more CO₂-efficient through the use of extremely innovative technology. The successes are obvious: although the driving performance of commercial vehicles increased sharply over the last two decades and more than 80 per cent of all goods are transported by road, CO₂ emissions, as illustrated by the calculation model TREMOD developed on commission of the German Federal Environment Agency, have not increased since the year 2000.

Despite increasing driving performance road freight traffic CO₂ emissions have remained constant since 2000.

The increase in the efficiency of commercial vehicles of the past years is therefore already contributing to climate protection today. Although further increases in traffic in Germany are definite, an increase in the absolute CO₂ emissions by road freight traffic until 2020 is not expected.

This illustrates a marked increase in the efficiency of road transport over the past few years. The increase in efficiency is illustrated below for each road transport sector; simultaneously perspectives for future developments are presented. We will continue to drive forward such improvements in efficiency. In doing so, it has to be emphasised that road transport in Germany causes less than 20 per cent of total CO₂-emissions.
2. Commercial vehicles – optimal for every transport task

2.1 The optimal vehicle concept for efficient transport

Each transport task is solved by means of a special set of instruments. Two 7.5-ton trucks cannot replace one 15-ton truck. Hence for each application of a particular class of truck highest efficiency has to be guaranteed. In this respect commercial vehicles demonstrate their strength through a very varied offer of individual modes of transport for each transport task. As illustrated in the adjoining graph the various truck concepts with their different payloads and operational areas have been optimised for their respective tasks.

This specialisation increases efficiency and reduces fuel consumption. The CO₂ efficiency and economy of a commercial vehicle are essential arguments in deciding to purchase a vehicle. An example sets this out clearly: given an annual mileage of 100,000 kilometres, one less litre of fuel consumed per 100 kilometres results in savings of Euro 1,500 per vehicle per year. Even with small vehicle fleets dimensions open up which have a considerable influence on the calculations of the companies.

Respectively different solutions exist both for different transport tasks and for the division of labour between carriers. Therefore the German automobile industry has been one of the biggest customers of the Bahn (German railways). Whilst rail or inland waterways lend themselves particularly to the transport of mass goods over long distances, trucks have their advantage when it comes to smaller loads and distribution. Hence the respective carriers are not interchangeable. On the contrary, they
complement one another in the transport chains. The demand by some to shift from road transport to other carriers often fails because of the differing requirements on the part of customers.

A comparison of carriers however also illustrates that a forced shift is not only economically difficult to achieve, but ecologically would also have negligible effects. Looking at the CO₂ emissions per ton-kilometre for a heavy truck, rail and inland waterways at normal capacity the values lie very close to one another. Higher values in respect of road transport as illustrated by an evaluation of aggregates can be explained by the inclusion of smaller vehicles, which cannot, however, be replaced by rail.

Because of the fact that each carrier today is optimally utilised in the market, big shifts from road transport to other carriers are not expected.

A remarkable fact: during a test drive of 12,000 kilometres only recently conducted with a fully loaded truck, a record value of only 20.5 grams CO₂ per kilometre and per transported ton was achieved.
Since 1990 harmful emissions have been reduced by 85 per cent on average.

### 2.2 Tailor-made solutions for long distance haulage and distribution traffic

#### 2.2.1 Clean trucks

The emissions of heavy duty commercial trucks were considerably reduced in the last few years with modern exhaust emission technologies and innovative logistical procedures. Since 1990 harmful emissions have been reduced by 85 per cent on average. With the near completion of the definition of the exhaust standards Euro V and Euro VI, emissions, e.g. in respect of NO\(_x\), will even decrease up to 97 per cent on average when compared to 1990.

**Development of exhaust emissions for heavy commercial vehicles**

[Graph showing CO, HC, NO\(_x\), and PM emissions reduction from Euro 0 to Euro VI.]

*Source: VDA*
2.2.2 Decreasing fuel consumption per truck

Since the end of the sixties the fuel consumption of a 40-ton tractor-trailer could be reduced by one third. As a result of research conducted over many years a 40-ton tractor-trailer today requires about 32 litres of fuel per 100 kilometres. During testdrives however, average consumption of only about 20 litres per 100 kilometres could even be achieved. At their best performance such commercial vehicle engines achieve efficiency outputs of just over 50 per cent. Given the latter, fuel consumption by diesel engines has just about reached its most sensibly optimal goal, and it is important to retain this advantage in the further intensification of exhaust values.

The progress made in reducing fuel consumption could have been even more impressive had it not been for the opposing effects which complicated the savings efforts of the engineers. As such the intensified exhaust regulations required technical adjustments in the vehicles which prevented a further reduction in fuel consumption. This is confirmed in a study by the TU Vienna, which works on the basis of a negative effect on consumption of 15 to 20 percent when comparing the current Euro V standard with the Euro II standard, in short: a commercial vehicle not subject to the requirement to meet the Euro V emissions standards would consume considerably less fuel. In addition the continuous improvement in the efficiency of the utilisation of trucks in freight road transport is to be recorded. In this manner transportation tasks today are realised with fewer driven kilometres and hence also with less fuel consumption and CO₂ emissions.

Since the end of the 1960s the fuel consumption of a 40-ton tractor with semi-trailer could be reduced by about one third.

Development in the fuel consumption of a 40-ton tractor with semi-trailer from 1967 to 2006

The progress made in reducing fuel consumption could have been even more impressive had it not been for the opposing effects which complicated the savings efforts of the engineers. As such the intensified exhaust regulations required technical adjustments in the vehicles which prevented a further reduction in fuel consumption. This is confirmed in a study by the TU Vienna, which works on the basis of a negative effect on consumption of 15 to 20 percent when comparing the current Euro V standard with the Euro II standard, in short: a commercial vehicle not subject to the requirement to meet the Euro V emissions standards would consume considerably less fuel. In addition the continuous improvement in the efficiency of the utilisation of trucks in freight road transport is to be recorded. In this manner transportation tasks today are realised with fewer driven kilometres and hence also with less fuel consumption and CO₂ emissions.

Since the end of the 1960s the fuel consumption of a 40-ton tractor with semi-trailer could be reduced by about one third.
2.2.3 Continued reduction in empty runs

Efficient and environmentally friendly transportation today also implies the reduction of empty runs, i.e. trips without the carriage of goods, or, putting it differently, the increased utilisation of capacity. In this area considerable improvement of efficiency has been achieved through the use of innovative systems of interlinked transport management. The share of empty runs in the freight road transport in Germany has in the past years decreased from 28 per cent to below 20 per cent. In the long distance haulage sector the empty run percentage in the meantime entails a mere ten per cent. With reference to current driving performance this translates into a saving of 2.6 billion truck kilometres or 850 million litres of diesel per annum. This is the equivalent of over 2.2 million tons of CO₂.
The share of empty runs has decreased from around 28 per cent to below 20 per cent in the past years.

The graph below illustrates the degree of utilisation in relation to the CO₂ emissions. The current degree of utilisation of over 80 per cent has nearly approached the optimum.

**CO₂ emissions depending on the degree of utilisation**

Source: Federal Agency for the Transportation of Goods (BAG)

Source: PE INTERNATIONAL
2.2.4 Diminishing CO₂ emissions per ton-kilometre

The increase in efficiency and the efforts in reducing fuel consumption of commercial vehicles manifest themselves in a clear reduction of CO₂ emissions per ton-kilometre: between 1991 and 2004 alone by about one third. According to a forecast by the Federal Ministry of Transport it is possible to further lower the CO₂ emissions per ton-kilometre between 2004 and 2025 by well over 20 per cent. This applies to all vehicle classes from vans to heavy commercial vehicles.

![CO₂ emissions chart](chart.png)

Source: UBA, IFEU

2.3 Light duty vans are indispensable

Vans belong to the group of light commercial vehicles. They are utilised in distribution traffic and are indispensable in supplying the general population. These light commercial vehicles have a permissible gross weight of up to 3.5 tons. The van segment starts with vehicles with a loading capacity of about three cubic metres. These can often not be distinguished from a normal passenger car on first sight and perform superbly in the transportation of small goods. The upper end of vans constitutes vehicles with a loading capacity of up to 17 cubic metres, which makes them suitable for inner city traffic.

The van, the smallest class of commercial vehicle, is optimised for the important tasks of transportation and distribution in local areas as well as delivery traffic. The unsur-
passable flexibility of freight road transport and in this case especially the mobility of vans fit modern formats of distribution like a glove. E-commerce with ordering in the internet and services like personalised door-to-door delivery would not be possible without delivery vans. Whether it is a book or a stationery article – within 24 hours the goods are expected to arrive both at the private customer and the business client. “Business to Customer”, or “B2C” for short, is the key – from manufacturer straight to the end user. There simply is no sensible alternative to the van.

2.3.1 Clean vans

In view of the fact that vans often travel to neighbourhoods and working areas, it is of particular importance that modern vans have become clean. As such the emissions of vans could be dramatically reduced over the past years. Since 1990 harmful emissions have been reduced by an average of 95 per cent. Already today vans are often fitted with diesel particle filters, this trend is on the increase. The next emission levels have already been defined in terms of their limits and implementation dates and in comparison to 1990 will lead to an average reduction of emissions of 98 per cent.

![Development of exhaust emissions of light commercial vehicles](image-url)

Source: VDA
2.3.2 Further reduction in fuel consumption

Over the years there has been a clear reduction in fuel consumption. Today a van emits one third less CO\textsubscript{2} than was the case in 1980. The commercial vehicle of today is not only an efficient mode of transport but it also fulfils current requirements as far as safety, comfort and environmental friendliness are concerned. Environmental and safety requirements, which as a consequence of additional vehicle and engine requirements create the additional burden of an increase in emission of over 30 g/km, could be more than compensated for through improved vehicle technologies.

Modern and clean common-rail-turbodiesel engines of the latest generation have made these positive developments possible. In addition all relevant components of a light commercial vehicle have been optimised to ensure efficient propulsion. It includes the matching of the transmission, an improvement in the rolling characteristics of tyres, a reduction in the air resistance and improved accessories like the generator or the hydraulic pump.

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Today a van consumes one third less than as recently as 1980.

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**Development in the CO\textsubscript{2} emissions of light commercial vehicles**

![Diagram showing the development in CO\textsubscript{2} emissions from 1980 to 2008.](Source: Ford)
2.4 The autobus – environmentally the friendliest mode of transporting people

For a long time buses have been producing markedly better results in the CO₂ balance per passenger-kilometre than the railways: given average seat utilisation the Federal Environment Agency assumes in its calculations in respect of modern coaches for fuel consumption to be 1.4 litre diesel per person per hundred kilometres or 33 grams carbon dioxide per person per kilometre. The railways ends up with 54 grams of carbon dioxide emissions per passenger per kilometre, an aircraft performs even worse with 157 grams of carbon dioxide per passenger and kilometre. The railways also occupies second place as far as energy consumption is concerned, because a coach requires only 61 per cent of the same energy generated by the railways for the same route (100 kilometres).

<table>
<thead>
<tr>
<th>CO₂ emission at given average seat utilisation</th>
<th>How much does a trip generate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coach</td>
<td>E. g. a trip from Hamburg to Munich (about 800 km)</td>
</tr>
<tr>
<td>33</td>
<td>13</td>
</tr>
<tr>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Rail</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>20</td>
</tr>
<tr>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Aircraft</td>
<td></td>
</tr>
<tr>
<td>157</td>
<td>43*</td>
</tr>
<tr>
<td>101*</td>
<td></td>
</tr>
</tbody>
</table>

* incl. airport transfer

From an ecological perspective the bus as a mode of transportation for people is unbeatable and can therefore make an enormous contribution to the realisation of climate protection targets. This applies to both long distance travel and urban public transport. In the field of public transport, especially in large cities and areas of high population density the autobus is fully recognised as an environmentally friendly and highly efficient mode of transport. In this manner buses contribute in a sustainable manner to the reduction of local and global emissions. Given an average, realistic utilisation of 35 per cent or an average of 28 passengers the fleet consumption of a public transit-bus entails about 1.2 litre diesel per 100 kilometres, given full utilisation even only half a litre. In this manner favourable CO₂ emission values are achieved and the environment is conserved.
Besides the continuous improvement of established vehicle technologies and the introduction of new alternative engines and fuels, the German automobile industry is working intensively on fuel-cell- and hydrogen-propulsion technologies. Progressive fuel-cell- and hydrogen-propulsion technologies are of particular interest in the field of urban bus transportation.

Currently diverse models are being tested in practice. Thanks to the fuel-cell local emissions can be prevented completely: when regeneratively produced hydrogen, i.e. hydrogen generated by solar-, wind-, water- or bio-energy sources, is used, the vehicle drives environmentally neutral.
3. Commercial vehicles – entering the future efficiently and environmentally friendly

Commercial vehicles are a capital good. When purchasing a vehicle efficiency and fuel consumption are important arguments. Hence the development of efficient and economical commercial vehicles enjoys highest priority.

Commercial vehicles today already form part of the most efficient and cleanest modes of transport. They enable one to maximise the effectiveness of goods transportation, yet simultaneously minimising the total effect on the environment and society.

Because of the big progress in the development of diesel engines and in the cleaning up of exhaust emissions it has been possible especially in the last two decades to meet the dramatically intensified limits for exhaust emissions on the one hand, and simultaneously to additionally reduce fuel consumption despite a realised increase in performance. Essential technologies to be named in connection with this progress are:

- Direct fuel injection
- Clearly improved injection pressures
- Electronic engine management
- Exhaust-gas turbo-charging with inter-cooling
- Exhaust-gas recirculation
- Oxidation catalytic converters
- Change-over to four-piston-technology
- Common-rail-fuel-injection systems
- Diesel particulate filters
- SCR Systems

Lower fuel consumption and hence lower CO₂ emissions are in the own interest of the transport industry. In the past four years the sales price of diesel fuel has increased by about 50 per cent. Fuel consumption therefore has become an even greater determining cost factor and the decisive sales factor.

In consideration of the strict requirements of future exhaust gas regulations numerous other developments are driven forward which will contribute to a further reduction in fuel consumption and hence to a reduction in CO₂ emissions over the next years. Innovations in the area of commercial vehicles create new potentials for savings. In each sector, from the engine to aerodynamics, from the chassis to the trailer, possibilities for the reduction of CO₂ emissions are being searched and realised.
3.1 The diesel engine

The Clean Diesel is the undisputed workhorse in commercial vehicles. This is the result especially of its excellent efficiency. Commercial vehicles lend themselves to the diesel engine being operated with optimal efficiency. The diesel principle, however, offers further development potential.

This applies in the first instance to the combustion process. Common-rail-injection systems with improved injection pressure levels, multiple injection, the formation of the injection sequence and the precise steering of even the smallest volumes injected enable further progress as it relates to degrees of efficiency as well as a the reduction in the exhaust emissions and in fuel consumption. Piezo injectors lead to an even quicker and more precise control of the injection. This saves fuel and improves the responsiveness of the engines. The trend thus points in the direction of growing precision in combustion with ever-increasing common-rail-injection pressures.

The diesel process offers ideal preconditions for the realisation of even the highest turbocharger levels. Controlled and in certain cases even staggered exhaust turbocharging in combination with intensive inter-cooling and the recirculation of exhaust gases will not only take over the classical functions of enhancing performance, torque and nominal rotation speed, but will also contribute decisively to the reduction in fuel consumption and in the emission of noxious gases.

In order to implement the emission requirements of the future, the trend for the recirculation of exhaust gases will gain in importance. Hence exhaust gas recirculation forms the cornerstone in many concepts for the reduction in nitrogen-oxide emissions without increasing fuel consumption.

In realising low temperature diesel-combustion through the part-homogenisation of the fuel-air mixture the critical interdependence between fuel consumption and NOx emissions can be clearly reduced. Similar approaches are also being pursued to reduce fuel consumption and the NOx emissions in gasoline-engines under the codeword “controlled self-ignition”. In this case the gasoline-engine operates, at least under hot running conditions, in the part-load operational range, practically in accordance with the diesel principle. Gasoline- and diesel technologies will therefore grow ever closer.

The development of improved algorithms in engine tuning which optimally utilise the possibilities of enhanced or completely new sensor systems enjoys a particularly important role. Worth mentioning in this connection are oxygen sensors in the intake systems, piston pressure sensors and even NOx sensors in exhaust systems.

In the van sector the introduction of diesel particle filter technology will be succeeded by the fulfilment of the requirements of the next emission stages through the utilisation of efficient nitrogen-oxide after-treatment devices. In achieving this, the diesel engine will approach the same level of exhaust gas performance as the gasoline-engine with its three-way catalytic converter.

SCR-technology (selective catalytic reduction technology), which found its application in the serial production of heavy commercial vehicles for the first time, opens up the
potential to further reduce fuel consumption. Similarly the strict emission requirements will demand compromises in the efficiency of engines. As such the NO\textsubscript{x} limit reduction from Euro V to Euro VI by 80 per cent results in an increase in fuel consumption of up to 5 per cent. Nonetheless the objective of further development is to compensate as far as possible for the negative CO\textsubscript{2} effect.

Further potential for the reduction in fuel consumption especially in the utilisation of commercial vehicles in the part-load operational range lies in the reduction of friction loss inside the engine as well as the needs-driven control of all accessories. The following should be listed in this regard:

- Reduction in piston friction
- Use of lubricating oils with reduced viscosity for engine and transmission
- Stop-start-systems
- Thermal-management – needs driven cooling (faster warming-up of engine and transmission)
- Variable oil pumps
- Electric fans instead of Viscofans
- Variable water pumps
- Generators with improved efficiency range
- Electric or electro-hydraulic steering systems

With each new model and every new development cycle the technical possibilities of realising these potentials are being enhanced. Factors to be considered in this regard are the specific feasibility, cost efficiency and the application range of commercial vehicles. As such the implementation of a stop-start-system is only feasible if the vehicle is indeed utilised in stop-and-go traffic.

3.2 The natural-gas engine

The reduction of emissions of noxious gases by commercial vehicles which are utilised in the inner-city, has received renewed attention as a result of the establishment of environmental zones or green areas.

The CNG-engine (Compressed Natural Gas) as an alternative to the diesel engine in commercial vehicles is one possible response to this development, both in buses and trucks, in as far as the utilisation of these vehicles is concentrated in the inner-city and the suburbs surrounding the cities. Only in these areas is the required density of filling stations available.
Natural-gas driven vehicles are employed especially in the communal utilisation of vehicles for waste removal, street-cleaning as well as maintenance work on streets and public areas, in distribution traffic and in passenger transportation in the inner-city.

A further important point of view: emission values lie below the future levels of Euro V standards; hence the natural-gas engine is ecologically most attractive, because it can already be categorised as “enhanced environmentally friendly vehicle” (EEV). In comparison to a comparable diesel engine, the natural-gas engine generates 50 per cent less carbon monoxide (CO) as well as 80 per cent fewer hydro-carbons (HC), and to top it, 80 per cent less nitrogen oxide (NOx). Sulphur dioxide and soot-particle emissions are negligible. In addition these engines run very quietly. Hence these vehicles are well equipped and can be utilised even if additional stricter admission criteria for entering an environmental zone in the inner-city become applicable.

### Possible reduction in emissions by natural-gas vehicles

Comparative basis: gasoline vehicle (100%)

![Graph showing possible reduction in emissions by natural-gas vehicles](image)

Source: Volkswagen

Automated transmissions know the vehicle better than the customer.

### 3.3 Transmission and drive-train

New opportunities are also created by the transmission technologies of the future. Especially automated gear shift transmissions offer the opportunity to operate the vehicle at its optimal level without having to cut back on vehicle dynamics. Automated transmission also relieves the driver – a safety aspect not to be underestimated.
Automated transmissions “know” the vehicle and the engine better than the customer and therefore change gears automatically at the right moment. In doing so, the automated gear shift transmission contributes actively to saving fuel: compared to a manual transmission, five to ten per cent fuel can be saved.

Next to solid opportunities in the market especially double-clutch transmissions possess extraordinary technical development potential, which, despite the first implementation of this technology, remains largely untapped. Targeted enhanced technical development to increase utilisation by the customer therefore forms a prioritised development objective. The new double-clutch technology offers the comfort of conventional automatic transmissions, however it effects savings of over ten per cent in fuel.

But even conventional transmissions have a lot of potential for improvement. This is a given i.a. whenever a commercial van is equipped with the same technology as that used in motor vehicles built up on the same platforms. However, the requirements in respect of a normal car and a van already differ on the basis of differing load factors. A transmission adapted for use in vans can thus be optimised for the utilisation requirements of the respective commercial vehicle in its gear configuration and its transmission-ratios – this of course also leads to improved fuel consumption.

Test consumption by different transmissions in the commercial vehicle in percentage

<table>
<thead>
<tr>
<th>Transmission Type</th>
<th>Test Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic transmission</td>
<td>100%</td>
</tr>
<tr>
<td>Manual transmission</td>
<td>90–95%</td>
</tr>
<tr>
<td>Double-clutch transmission</td>
<td>80–90%</td>
</tr>
</tbody>
</table>

Source: Volkswagen

3.4 The hybrid drive

The advantages of hybrid drive depend on how they are utilised. Whilst the savings potential remains relatively small for long-distance trips, it can achieve its full advantages in stop-and-go-traffic. The preferred utilisation hence is in urban traffic. The hybrid drive is predisposed for use in public transit buses and vehicles used for refuse removal, which are often driven for short distances from stop to stop. Through this continuous utilisation over short distances vehicles can achieve a high degree of

Hybrid-buses in public transit traffic can save 20–30% fuel.
brake recuperation. The CO₂-savings effect in respect of public transit buses lies between 20 and 30 per cent. But even the van, which fulfils delivery tasks in heavy urban traffic, is suitable for hybridisation.

In this manner substantial savings are already achieved with a stop-start automatic system. Especially attractive is the fact that the additional investment in simple stop-start-systems is relatively minor and therefore comparatively short amortisation periods are achievable.

The green traffic zones increasingly established across Europe require delivery traffic to have particularly clean vehicles. Depending on the size and specifications of the electrical engine the plug-in-hybrid will even enable completely emission-free driving. Recharging the battery at the plug opens up cost- and environmental advantages during electrical driving, if the power required for this purpose is obtained from renewable sources.

Of decisive importance for the implementation of hybrid technology will be the ability to offer electrical components at competitive prices. Here the hybrid drive competes directly with the very economical and cost-effective diesel engine. Hence the hybrid drive will in future be used especially where its advantages can be optimised: in inner-city traffic. On long-distance routes the Clean Diesel remains unbeatable in its efficiency-level.
The German automobile industry is working intensively on competitive hybrid concepts. Especially the hybrid drive impacts heavily on the structure of the vehicle, starting with the engine, via the transmission to the electrical propulsion system. Next to an optimised operational strategy the core element of the hybrid drive remains the battery. The German automobile industry, i.e. the automobile manufacturers and suppliers, as a first and as part of a cooperative venture is introducing a plug-in-van with lithium-ionic batteries. These cooperative ventures in the automobile industry represent an example of the success to be achieved from a bundling of know-how of the automakers and suppliers in this field.

3.5 Reduction of rolling- and air resistance

A further potential which up to present has not been fully exhausted because of legal time requirements is to be achieved in the aerodynamics of commercial vehicles. It is easy to understand that optimising aerodynamics especially in respect of long-distance haulage on highways can achieve considerable savings in consumption. In the latter case a heavy tractor with semi-trailer requires 160 hp at 85 km/h to overcome the resistance of the tyres (45 per cent), aerodynamics (40 per cent), other accessories (8 per cent) and transmissions (7 per cent).

Fuel consumption can be positively affected by choosing the correct vehicle configuration when purchasing or acquiring the vehicle. The correct adjustment of the wind deflectors on the cabin alone can reduce consumption by up to four per cent. The additional costs of wind deflectors can be amortised within a few months depending on the mileage covered.

Opportunities for aerodynamic optimising are:

- Minimising low pressure at the rearend
- Minimising air turbulence in the gap between the cabin rearend and the semi-trailer front
- Minimising turbulence around the wheels, especially the steerable front axle of the tractor and around the semi-trailer axles
- Minimising turbulences caused by the mirrors
- Lowering and modification of the bumpers
- Reduction of the effects of the gap between the tractor and the semi-trailer by using movable spoilers behind the cabin
- Mounting lowered side cover panels and rear wheel covers
- Construction of higher cabin roofs

The correct adjustment of the wind deflectors alone can save up to four per cent in fuel.
Aerodynamic optimising in respect of semi-trailers is possible too:

- Movable spoiler/extension in the rearend of the semi-trailer
- Aerodynamic tract below the semi-trailer to channel the air stream
- Side cover panels with air intakes and air channels
- Tapered extractor with a baffle and diffuser at the rearend of the semi-trailer
- New profile for the rear underride-protector

All these measures can achieve a decrease of 20 per cent in the air resistance coefficient (Cw-coefficient) which on its part expresses itself in a reduction in consumption of up to seven per cent.

The same applies to tyres: super-wide tyres instead of twin tyres on the rear axle can reduce fuel consumption by up to two per cent. Furthermore the coordinated selection of tyres with optimised profile and optimised combination on the front axle of the tractor and on the semi-trailer axles can influence consumption positively even more. An increase of up to eight per cent in consumption, however, is the consequence of under-inflation of the tires. If one considers that about 30 per cent of all commercial vehicles drive with under-inflated tyres, the savings potential of a regular tyre pressure check becomes obvious.

3.6 The integrated approach to goods transport conserving the environment

The reduction in CO₂ emissions in road traffic is a holistic task, which includes all parties involved in road traffic. Hence a so-called integrated approach is required which mobilises from the vehicle to fuels to the infrastructure and the driver to effect reduction potentials. The target has to be to keep the total costs which are invested by society in every ton of CO₂ prevented from emission as low as possible, or, formulated differently, to squeeze maximum savings out of every Euro invested. This means:

- The automobile industry continues its efforts to reduce CO₂ emissions in new vehicles even more vigorously. The measures reach from a further optimising of the engines and transmissions offered currently to the reduction of weight to enabling a higher blending of biofuels.
- The mineral oil industry can make a substantial contribution to the general improvement of the climate protection balance sheet of German traffic by quickly offering large blending of quality biofuels, that are compatible with modern vehicles and that have a favourable CO₂ balance.
• The tax- and financial system possesses the ability for example to create incentives in tax legislation for consumers to decide in favour of efficient new vehicles. Simultaneously these measures can promote the renewal of the vehicle fleet.

• The political bodies responsible for infrastructure carry the further substantial responsibility for an improved contribution by the traffic sector to the climate balance sheet through the removal of bottlenecks and with the investment in even better communication between vehicles and infrastructure.

• And last but not least the driver holds it in his hands to realise substantial savings through his driving style and conduct. He has to be supported in this by means of appropriate information and educational work. Technical information in the vehicle like users-manuals and tips on changing gears increasingly render a support service to the driver.

3.6.1 Infrastructure

As a consequence of traffic congestion and poor infrastructure billions of litres of fuel are wasted senselessly today.

Fuel consumption in road traffic is increasingly being driven upward by insufficient traffic infrastructure, absent traffic flow instructions, wrong vehicle configurations, insufficient vehicle maintenance and an inappropriate driving style.

Influence of traffic flow on fuel consumption

Source: VDA
Thus the fuel consumption of a 40-ton truck can treble if the vehicle has to stop twice per kilometre instead of driving with an even speed of 50 km/h. Truck drivers are confronted daily by such situations, be it as a result of capacity bottlenecks on traffic routes or accidents.

Avoiding accidents, e.g. with modern assistance systems, simultaneously contributes to restricting unnecessary consumption and hence emissions. The development of a modern traffic guidance system can also make a substantial contribution to fluent traffic flow.

3.6.2 Innovative commercial vehicle concepts

A significant increase in vehicle efficiency and a reduction in CO₂ emissions can also be expected from the implementation of innovative commercial vehicle concepts. A more flexible definition of the current legally prescribed measurements and weights for trucks would enable a quantum leap in freight road transport so that the transportation of a specific volume of goods could be achieved with less driving, fewer emissions and reduced fuel consumption. The efficiency of the road traffic system can therefore be increased even further. A 25.25 meter commercial vehicle for example would effect fuel and emissions savings of 15 to 30 per cent per ton-kilometre when compared to a conventional 40-ton truck with standard measurements. The roadspace required for the tractor-trailer would be reduced by 25 per cent.

Innovative commercial vehicle concepts can reduce the fuel consumption by 15–30 per cent.
Traffic experts reckon that up to 23 per cent of current trips by 40-ton trucks in national traffic could be effected with innovative commercial vehicles. In Germany this would lead to an annual saving in driving performance of 2.2 billion vehicle kilometres and subsequently to an effective CO₂ saving. An open discussion should also be conducted on the efficiency reserves of the vehicle height. With an increase in the vehicle height of the current 40-ton commercial vehicle to 4.10 metres the maximum degree of volume efficiency could be increased by 50 per cent through the possibility of stacking three instead of the current two layers. A similar effect can be achieved with increased vehicle length.

3.6.3 Driver training

Naturally potential CO₂ savings exist in the appropriate training of drivers, which can be achieved with the aid of an additional qualification for driving school instructors. In this way anticipatory driving and the correct choice of gears can have a decisive influence on consumption.

The correct maintenance of the vehicle is also important. Even supposed details like badly tightened or flapping tarpaulins increase diesel consumption distinctly.

The spectrum of possible measures in the vehicle and for drivers clearly illustrates that future policies in the field of climate protection must be focussed on effecting comprehensive savings in the system. The individual influence of the driver must therefore be incorporated in the integrated approach.

3.6.4 Biofuels – an alternative to conventional diesel fuel

According to the EU biofuels and biogas should have a share of ten per cent and hydrogen a share of two per cent of total fuel consumption in the EU already by the year 2020.

Diesel fuel will for the foreseeable future indeed remain the number one energy source for commercial vehicles. However the diesel of the future will differ from today’s fuel for reasons of environmental protection, energy costs as well as security of energy supply.

As an alternative fuel biodiesel has not only gained in importance in the EU but also in many regions of the world. Politically speaking biodiesel has in the meantime become controversial, because its production can be in direct competition with the agricultural cultivation of foodstuffs, and the cultivation of plants for biodiesel is being held responsible for the price increases of basic foodstuffs in many parts of the world.

The fact remains that the price effects ascribed to the production of biofuels may be seen as rather marginal when the whole picture is viewed. Substantiated figures speak against a decisive influencing of the price. Both the total area currently cultivated for the production of biofuels and the production volumes remain below three per cent respectively.
All vehicles of the German automobile industry are suitable for a standardised biodiesel blends of seven per cent when the prescribed oil change intervals are maintained. Higher biodiesel blends are not possible especially because of the incompatibility with the particulate filter technology.

Nevertheless, in order to achieve higher degrees of admixture on the short term, the German automobile industry recommends admixing hybridised plant oils. This biofuel is of premium quality, conserves the environment and can hence be used in higher blending rations.

Biofuels of the first generation like biodiesel made from rapeseed, soy and sunflower as substitute for diesel fuel utilise only one part of the plant. As mentioned, they can partially compete with the production of foodstuffs. This will change with the production of second generation biofuels (BTL). In the latter process the whole plant is used for the production of fuel, similarly so waste materials like waste wood. This translates into a reduced need for fields and simultaneously a higher saving in CO₂. At 4,000 litres per hectare in respect of BTL the yield is about three times higher than in respect of biodiesel. In principle a gas is produced from the hackled biomass in numerous steps which is then converted to liquid fuel ("Fischer-Tropsch-synthesis") during further processing.

According to expert opinion BTL-fuels can supply in 20 per cent of the European fuel needs. The first commercially operated plant on an industrial scale entered production at the beginning of this year in Choren in Freiberg/Saxony.

A near CO₂-neutral alternative to natural gas is presented by biogas which is processed to achieve the quality of natural gas. The so-called bio-methane achieves CO₂ savings of up to 80 per cent and can be fed into and transported in the existing natural gas network. Thus every natural gas customer can gain at filling stations from the bio-methane fed into the network.

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Greenhouse gas reduction of different biofuels compared to fossil gasoline in percent

![Graph showing CO₂ reduction for different biofuels](image)

Source: VDA

BTL achieves near CO₂ neutrality.
Conclusion

The interim score card of the German commercial vehicle industry on climate- and environmental protection is extremely positive. Hence exhaust emissions could be clearly reduced and the increase in CO₂ considerably contained despite increasing driving- and transport performance. Constant innovation made this possible. Because of increased efficiency the commercial vehicle can not only confirm its leading position in the transportation of goods, but also expand its role.

The German commercial vehicle industry will continue to drive research and development forward and will continuously optimise its offer to meet the demands of the market. This naturally requires a wide spectrum of products which cater exactly for the respective transport needs.

Moreover the joint efforts in respect of further CO₂ reductions will be pursued. The enhanced development of conventional engine technologies by itself opens up substantial potential. New technologies and measures for vehicle and trailer or semi-trailer will realise new additional consumption potentials.

Certainly all institutions and industries involved in road traffic can accelerate these strategies for CO₂ reduction by a multiple if, in addition to clean vehicle efficiency, everything possible is done to prevent the production of CO₂. In this context one need only mention biofuels, vehicle maintenance and driver training as well as the urgently required expansion of the road infrastructure again. Against this background the German commercial vehicle industry looks ahead positively and optimistically into the future. It will make its contribution to the development of sustainable traffic.
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