The Passat
Environmental Commendation
Background Report

The Life Cycle Assessment of the Passat

Volkswagen's objective is to develop vehicles in such a way that, in their entirety, they present better environmental properties than their predecessors. To document the environmental performance of its vehicles and technologies, Volkswagen uses Environmental Commendations. Our Environmental Commendations provide our customers, shareholders and other stakeholders inside and outside the company with detailed information about how we are making our products and production processes more environmentally compatible and what we have achieved in this respect. The Commendations are primarily based on detailed Life Cycle Assessments (LCA) in accordance with ISO 14040/44, which have been verified by independent experts, in this case from TÜV NORD. As part of an integrated product policy, the LCA considers not only individual environmental aspects, such as the driving emissions of the vehicle, but its entire life cycle. This means that all processes from manufacturing via service life to recycling and disposal are examined.

Since 1996, Volkswagen has been drawing up Life Cycle Assessments of its vehicles and individual components with the aim of enhancing their environmental compatibility. The environmental improvement of the Passat is an especially important step for us as we advance towards sustainable mobility for all. This Environmental Commendation presents the results of a comprehensive Life Cycle Assessment and documents the continuous progress achieved by Volkswagen in the field of environmental product optimisation.

For the Life Cycle Assessment of the Passat Estate we compared the diesel-engined 2.0 TDI BlueMotion Technology (103 kW) with a similarly engined predecessor. For the petrol-engined models we compared a 1.4 TSI with a similar predecssor, also with a 1.4-litre TSI engine, and with the current 1.4 TSI BlueMotion Technology model (all with 90 kW).

The evaluation of these vehicles' environmental profiles is not based solely on emissions during their service life, i.e. the „driving time“, but on the entire life cycle from production through to recycling. It emerged relatively quickly that the successor models presented improvements – some of them quite significant – in almost all the environmental impact categories. The biggest advances were made in those areas where the quantitative environmental impacts are greatest: global warming potential (greenhouse effect), acidification, and photochemical ozone creation potential (summer smog). In the water eutrophication and ozone depletion categories the impact of the vehicles assessed was very minor by comparison. It was also found that the improvements were primarily due to reduced fuel consumption – which also means a lower environmental impact from the fuel production process – and the resultant lower driving emissions. On top of this, lightweight design measures were also beneficial.

The improvements achieved in fuel consumption and the associated CO_2 emissions were significant. As regards fuel economy, the BlueMotion Technology models in particular reveal the level of potential that we were able to exploit. In terms of global warming potential and photochemical ozone creation potential, the Passat presents a much better balance sheet over its entire life cycle, thereby attaining the environmental goal set by the Technical Development department.

For the assumed lifetime mileage of 150,000 kilometres, our calculations indicate emissions of 18 metric tons of carbon dioxide for the diesel-engined model. Over the entire life cycle, this equates to an overall reduction in global warming potential of 15 percent compared to the predecessor model. The petrol-engined 1.4 TSI emits some 22.4 metric tons of CO_2 during its service life, while the Passat 1.4 TSI BlueMotion Technology generates 21.3 metric tons. For the petrol models this equates to improvements of five and eight percent respectively.

The total reduction in emissions of greenhouse gases over the full life cycle is significant, since the Passat 2.0 TDI BlueMotion Technology emits approximately five metric tons less CO_2 than its predecessor. In overall terms, we have therefore achieved our objective of continuing the technical development of our vehicles at the same time as improving their environmental compatibility.

The Passat models assessed

Volkswagen's Environmental Commendation for the Passat describes and analyses the environmental impacts of the Estate versions[1] of selected Passat models. To this end, we compared selected diesel and petrol models from the current Passat series with their respective predecessors. The results are based on Life Cycle Assessments in accordance with the standards DIN EN ISO 14040 [ISO 2006] and 14044. All the definitions and descriptions required for preparing these Life Cycle Assessments were drawn up in accordance with these standards and are explained below.

Objective and target group of the assessment

Volkswagen has been conducting Life Cycle Assessments for over ten years to provide detailed information on the environmental impacts of its vehicles and components for our customers, shareholders and other stakeholders within and outside the company. The objective of the present Life Cycle Assessment was to describe the environmental profiles of the current Passat models with diesel and petrol engines and compare them with their predecessors.

For the Life Cycle Assessment of the Passat, we compared the 2.0 TDI (103 kW)[2] with its equally powerful successor, the 2.0 TDI BlueMotion Technology (103 kW)[3]. For the petrol models we compared the 1.4 TSI (90 kW)[4] with a similar successor model, also equipped with a 1.4-litre TSI engine (90 kW)[5], as well as with the 1.4 TSI BlueMotion Technology model (90 kW)[6].

Function and functional unit of the vehicle systems assessed

The functional unit used for the Life Cycle Assessment is the transport of passengers (5-seater) over a total distance of 150,000 kilometres in the New European Driving Cycle (NEDC), with comparable utilisation characteristics (e.g. performance) – see technical data in Table 1.

[1] The current models represent the model range available when this report was finalised.
[2] 5.7 l/100km (NEDC) 148 g CO_2/km
[3] 4.6 l/100km (NEDC) 120 g CO_2/km
[4] 6.8 l/100km (NEDC) 158 g CO_2/km
[5] 6.4 l/100km (NEDC) 149 g CO_2/km
[6] 6.1l/100km (NEDC) 142 g CO_2/km

Table 1: Technical data of the vehicles compared

	Passat 2.0 TDI (predecessor)	Passat 2.0 TDI BlueMotion Technology	Passat 1.4 TSI (predecessor)	Passat 1.4 TSI	Passat 1.4 TSI BlueMotion Technology
Engine capacity [cm^3]	1968	1968	1390	1390	1390
Output [kW]	103	103	90	90	90
Gearbox	6-speed-manual	6-speed-manual	6-speed-manual	6-speed-manual	6-speed-manual
Fuel	Diesel	Diesel	Petrol	Petrol	Petrol
Emission standard	Euro 5	Euro 5	Euro 5	Euro 5	Euro 5
Maximum speed [km/h]	206	210	200	200	202
Acceleration 0-100 km/h [s]	10.1	10.0	10.8	10.6	10.6
Max. torque [Nm] at rpm	320/ 1750-2500	320/ 1750-2500	200/ 1500-4000	200/ 1500-4000	200/ 1500-4000
Unladen weight [kg][7]	1572	1571	1504	1473	1484
Luggage space [l]	603/1731	603/1731	603/1731	603/1731	603/1731
Fuel tank capacity [l]	70	70	70	70	70

Scope of Assessment

The scope of the assessment was defined in such a way that all relevant processes and substances are considered, traced back to the furthest possible extent and modelled at the level of elementary fl ows in accordance with ISO 14040. This means that only substances and energy flows taken directly from the environment or released into the environment without prior or subsequent treatment cross the boundaries of the system. The material fractions generated during recycling are the only exception.

The vehicle manufacturing phase was modelled including all manufacturing and processing stages for all vehicle parts and components. The model included all Stepps from the extraction of raw materials and the manufacture of semi-finished products right through to assembly.

Regarding the vehicle's service life, the model includes all relevant processes from fuel production and delivery through to driving. The analysis of the fuel supply process includes shipment from the oilfield to the refinery and the refining process, as well as transport from the refinery to the filling station. Vehicle maintenance is not included in the assessment as previous studies demonstrated that maintenance does not cause any significant environmental impacts [Schweimer and Levin 2000].

[7] Unladen weight with driver (68 kg), 7 kg of luggage and fuel tank 90% full, calculated in line with RL 92/91/ EEC [EU 1992] as amended in 04/2009.

The recycling phase has been modelled in accordance with the VW SiCon process. In contrast to conventional recycling approaches, this process allows non-metallic shredded residual material to also be recycled and used as a substitute for primary raw materials (Krinke et. al. 2005a). This VW SiCon process allows around 95 percent of the vehicle by weight to be recycled.

In this Life Cycle Assessment, no environmental credits were awarded for secondary raw material substitution. Only the environmental impacts of the recycling processes required were included. This corresponds to a worst case assumption, since in reality secondary raw material from vehicle recycling is returned to the production cycle. This recycling and substitution of primary raw materials could avoid consumption of primary raw materials and the environmental impact of their production.

Fig. 1 is a schematic diagram indicating the scope of the Life Cycle Assessment. Europe (EU 15) was chosen as the reference area for all processes in the manufacture, service-life and recycling phases.

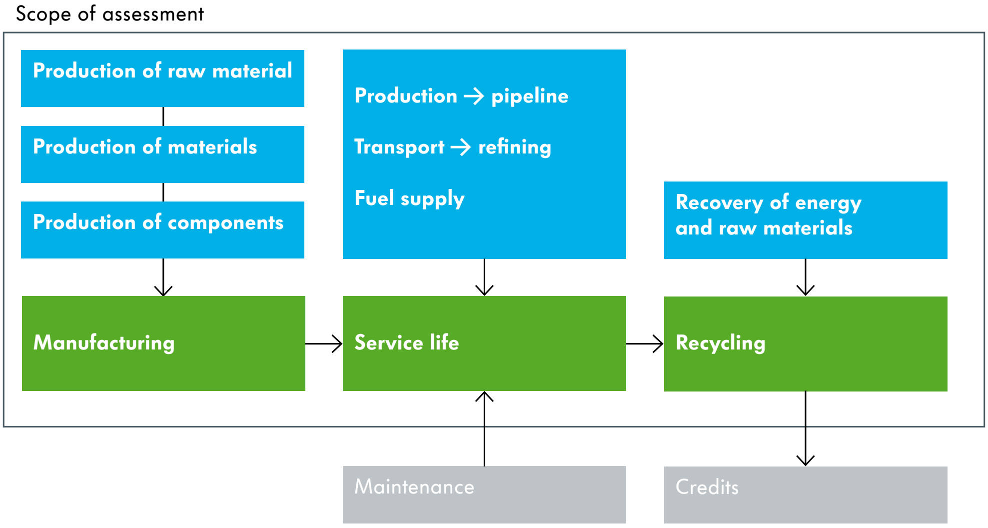

Fig. 1: Scope of the Life Cycle Assessment

Environmental Impact Assessment

The Impact Assessment is based on a method developed by the University of Leiden in the Netherlands (CML methodology) [Guinée and Lindeijer 2002]. The assessment of environmental impact potentials in accordance with this method is based on recognised scientific models. A total of five environmental impact categories[8] were identified as relevant and were then assessed in this study:

- eutrophication potential
- ozone depletion potential
- photochemical ozone creation potential
- global warming potential for a reference period of 100 years
- acidification potential

The above environmental impact categories were chosen because they are particularly important for the automotive sector, and are also regularly used in other automotive-related Life Cycle Assessments [Schmidt et al. 2004; Krinke et al. 2005b]. The environmental impacts determined in the Life Cycle Assessments are measured in different units. For instance, the global warming potential is measured in CO_2 equivalents and the acidification potential in SO_2 equivalents (each in kilograms). In order to make them comparable, a normalisation process is required. In this Life Cycle Assessment the results were normalised with reference to the annual average environmental impact caused by Western Europe (EU 15). For example, in the global warming category, the impact caused by Western Europe was about 4.4 billion metric tons of CO_2 equivalents (see Table 2).

Table 2: EU 15 normalisation factors in accordance with CML 2001
(in thousand metric tons)

Environmental category	per capita	Unit
Eutrophication potential	15906	PO_4 equivalents
Ozone depletion potential	31	R11 equivalents
Photochemical ozone creation potential	7228	C_2H_4 equivalents
Global warming potential	4440050	CO_2 equivalents
Acidification potential	21553	SO_2 equivalents

This normalisation allows statements to be made regarding the contribution of a product to total environmental impacts within Western Europe. The results can then be presented in one graph using the same scale. This approach also makes the results more comprehensible and allows environmental impacts to be compared.

[8] A more detailed description of these environmental impact categories is given on the internet at www.environmental-commendation.com.

In Table 2, we have listed the normalisation factors for the individual impact categories used for the CML method. In this context it must be pointed out that the normalisation does not give any indication of the relevance of a particular environmental impact, i.e. it does not imply any judgement on the significance of individual environmental impacts.

Basis of data and data quality

The data used for preparing the Life Cycle Assessment can be subdivided into product data and process data. "Product data" describes the product itself, and among other things includes:

- Information on parts, quantities, weights and materials
- Information on fuel consumption and emissions during utilisation
- Information on recycling volumes and processes.

"Process data" includes information on manufacturing and processing steps such as the provision of electricity, the production of materials and semi-finished goods, fabrication and the production of fuel and consumables. This information is either obtained from commercial databases or compiled by Volkswagen as required.

We ensure that the data selected are as representative as possible. This means that the data represent the materials, production and other processes as accurately as possible from a technological, temporal and geographical point of view. For the most part, published industrial data are used. In addition, we use data that are as up-to-date as possible and relate to Europe. Where European data are not available, German data are used. For the various models assessed, we always use the same data on upstream supply chains for energy sources and materials. This means that differences between the latest models and their predecessors are entirely due to changes in component weights, material compositions, manufacturing processes at Volkswagen and driving emissions, and not to changes in the raw material, energy and component supply chains.

The Life Cycle Assessment model for vehicle production was developed using Volkswagen's slimLCI methodology (Koffler et. al. 2007)[9]. Vehicle parts lists were used as data sources for product data, and the weight and materials of each product were taken from the Volkswagen material information system (MISS). This information was then linked to the corresponding process data in the Life Cycle Assessment software GaBi. Material inputs, processing procedures and the selection of data in GaBi are standardised to the greatest possible extent, ensuring that the information provided by slimLCI is consistent and transparent. SlimLCI methodology thus not only ensures highly detailed modelling but also high quality standards for LCA models. For the modelling of the vehicle's service life, representative data for upstream fuel supply chains were taken from the GaBi database. It was assumed that fuel used in Europe was transported over a distance of 200 kilometres on average.

[9] For more information about how Volkswagen draws up Life Cycle Assessment, visit www.environmental-commendation.com.

For the regulated emissions CO_2, NO_X and HC, direct driving emissions were modelled in accordance with Euro 5 emission standard (see Table 1 and Table 3).

Table 3: Relevant emission limits in accordance with Euro 5

Emission limit	Euro 5	
	Petrol [g/km]	Diesel [g/km]
Carbon monoxide emissions (CO)	1.00	0.50
Nitrogen oxide emissions (NO_X)	0.06	0.18
Hydrocarbon emissions (HC)	0.10	
of which NMHC	0.068	
NO_X + HC emissions		0.23
Particulate emissions	0.005*	0.005

* with direct injection

This model too represents a worst case assumption, since actual emissions are in some cases far below the applicable statutory limits (see Table 4). This means that the regulated service-life emissions indicated in the graphs are higher than those that actually occur.

The fuel consumption of the vehicles was calculated in each case from the measured CO_2 emissions and is shown in Table 4. All consumption figures and emissions were determined on the basis of EU Directives 80/268/EEC and 70/220/EEC [EU 2001; EU 2004] and regulation 692/2008 [EU 2008] for type approval and correspond with the values presented to the German Federal Motor Transport Authority (Kraftfahrtbundesamt) for type approval. A fuel sulphur content of 10 ppm was assumed.[10]

Vehicle recycling was modelled on the basis of data from the VW SiCon process and using representative data from the GaBi database.

[10] In some countries, fuel with a sulphur content of 10 ppm is not yet available. However, even if the sulphur content were higher, the contribution of sulphur emissions during the vehicle's service life would still remain negligible.

Table 4: Fuel consumption and emissions of vehicles assessed

	Passat 2.0 TDI 103 kw (predecessor)	Passat 2.0 TDI 103 kW BlueMotion Technology	Passat 1.4 TSI 90 kW (predecessor)	Passat 1.4 TSI 90 kW	Passat 1.4 TSI 90 kW BlueMotion Technology
Fuel	Diesel	Diesel	Petrol (Super)	Petrol (Super)	Petrol (Super)
Fuel consumption (urban/ highway/ combined) [l/100 km]*	7.3/ 4.7/ 5.7	5.6/ 4.0/ 4.6	8.9/ 5.6/ 6.8	8.1/ 5.1/ 6.4	8.0/ 5.0/ 6.1
Emission standards	Euro 5	Euro 5	Euro 5	Euro 5	Euro 5
Carbon dioxide emissions, combined [g/km]	148	120	158	149	142
CO [g/km]	0.3049	0.2244	0.2205	0.3934	0.3566
HC [g/km]			0.0274	0.0355	0.0381
of which NMHC [g/km]				0.0282	0.0291
NO_X [g/km]	0.1635	0.0966	0.0486	0.0298	0.0297
NO_X + HC [g/km]	0.1972	0.1344			
Particulate emissions [g/km]	0.00013		0.0026	0.0015	0.0018

* Total average consumption (NEDC)

In sum, all information relevant to the aims of this study was collected and modelled with a sufficient degree of completeness.[11] The modelling of vehicle systems on the basis of vehicle parts lists ensures that the model is complete, especially with respect to the manufacturing phase. In addition, as the work processes required are automated to a great extent, any differences in the results are due solely to changes in product data and not to deviations in the modelling system.

[11] Completeness, as defined by ISO 14040, must always be considered with reference to the objective of the investigation. In this case, completeness means that the main materials and processes have been reflected. Any remaining gaps in the data are unavoidable and apply equally to all the vehicles compared.

Model assumptions and findings of the Life Cycle Assessment

All the framework conditions and assumptions defined for the Life Cycle Assessment are outlined below.

Table 5: Assumptions and definitions for the Life Cycle Assessment

Aim of the Life Cycle Assessment
• Comparison of the environmental profiles of predecessor and successor versions of selected Passat models with petrol and diesel engines
Scope of assessment
Function of systems • Transport of passengers in a five-seater car
Functional unit • Transport of passengers in a five-seater car over a total distance of 150,000 kilometres in the New European Driving Cycle (NEDC), with comparable utilisation characteristics (e.g. performance)
Comparability • Comparable performance figures • Cars with standard equipment and fittings
System boundaries • The system boundaries include the entire life cycle of the cars (manufacture, service life and recycling phase).
Cut-off criteria • The assessment does not include maintenance or repairs • No environmental impact credits are awarded for secondary raw materials produced • Cut-off criteria applied in GaBi data records, as described in the software documentation (www.gabi-software.com) • Explicit cut-off criteria, such as weight or relevance limits, are not applied
Allocation • Allocations used in GaBi data, as described in the software documentation (www.gabi-software.com) • No further allocations are used

Data basis

- Volkswagen vehicle parts lists
- Material and weight information from the Volkswagen Material Information System (MISS)
- Technical data sheets
- Technical drawings
- Emission limits (for regulated emissions) laid down in current EU legislation
- The data used come from the GaBi database or were collected in cooperation with VW plants, suppliers or industrial partners

Life Cycle Inventory results

- Life Cycle Inventory results include emissions of CO_2, CO, SO_2, NO_X, NMVOC, CH_4, as well as consumption of energy resources
- The impact assessment includes the environmental impact categories eutrophication potential, ozone depletion potential, photochemical ozone creation potential, global warming potential for a reference period of 100 years and acidification potential
- Normalisation of the results

Software

- Life Cycle Assessment software GaBi, and GaBi DfX Tool and VW slimLCI interface as support tools

Evaluation

- Evaluation of Life Cycle Inventory and impact assessment results, subdivided into life cycle phases and individual processes
- Comparisons of impact assessment results of the vehicles compared
- Interpretation of results

Results of the Life Cycle Assessment

Results of the Life Cycle Inventory

The information on the life cycle inventories is divided into the three life cycle phases: manufacturing, service life and recycling. The service life differentiates between the environmental impact caused by the upstream fuel supply chain and direct driving emissions. The contribution shown for recycling only indicates the impacts of recycling processes and does not include any environmental impact credits for secondary raw materials produced.

Diesel models

Fig. 2 clearly shows that the emissions of the predecessor model, the Passat 2.0 TDI, e.g. carbon dioxide (CO_2), carbon monoxide (CO) and nitrogen oxides (NO_X), are mainly generated during the service life of the vehicle. In contrast, both methane (CH_4) emissions and primary energy demand are dominated by the fuel production process – from well to pump. As a result of the low sulphur content assumed for the fuel used, the manufacturing phase accounts for a major part of the overall sulphur dioxide emissions (SO_2). CO_2 emissions over the entire life cycle of the Passat 2.0 TDI (predecessor model) reach approximately 32 metric tons. The total energy demand amounts to about 454 GJ.[12]

Life Cycle Inventory

Passat 2.0 TDI [103 kW] (predecessor)

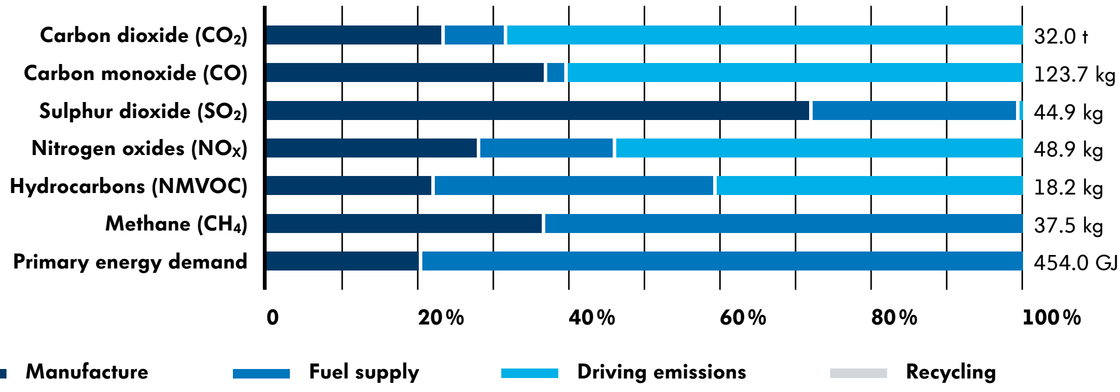

Fig. 2: Life Cycle Inventory data for the Passat 2.0 TDI [103 kW] (predecessor)

In qualitative terms, the Life Cycle Inventory for the current Passat Estate 2.0 TDI BlueMotion Technology differs only slightly from that of the predecessor model (see Fig. 3). However, the lower energy demand and the in some cases lower emissions of the new model compared with its predecessor are clearly evident. Thus, the energy requirement is reduced from 454 GJ to 379.9 GJ and CO_2 emissions are only 27.1 metric tons, compared with 32 metric tons for the predecessor model.

[11] On account of more recent data and more advanced calculation methods, results may vary from those published in earlier Environmental Commendations for the same models.

Life Cycle Inventory
Passat 2.0 TDI BlueMotion Technology [103 kW]

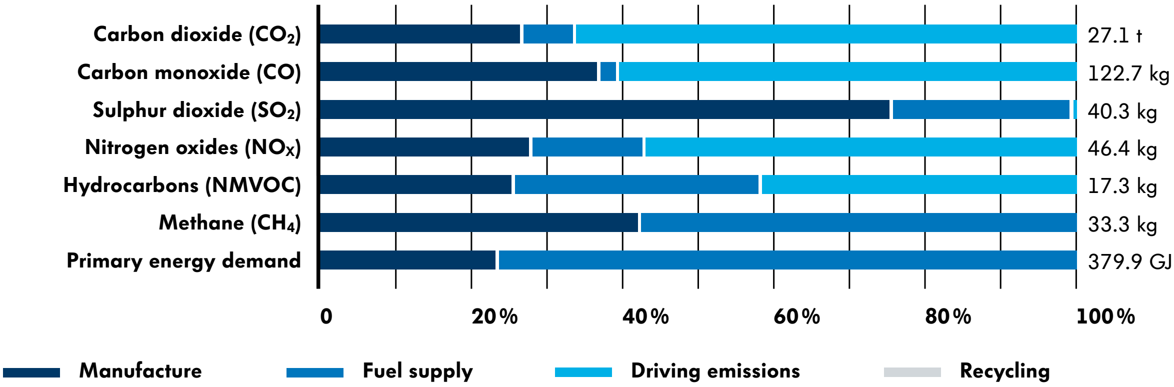

Fig. 3: Life Cycle Inventory data for the Passat 2.0 TDI BlueMotion Technology [103 kW]

Petrol models
The next three graphs, Figs. 4, 5 and 6, show the results of the Life Cycle Inventories for the three petrol-engined models assessed. It is evident that, for the petrol-engined cars, the proportion of the total environmental impact resulting from the manufacturing phase is less than for the diesel models. On the one hand this is due to the fact that the production of petrol-engined models causes a lower environmental impact than that of diesel models in absolute terms, and on the other to the fact that the service life accounts for a higher proportion of the total environmental impact, owing to the higher fuel consumption of petrol-engined models.

Life Cycle Inventory
Passat 1.4 TSI [90 kW] (predecessor)

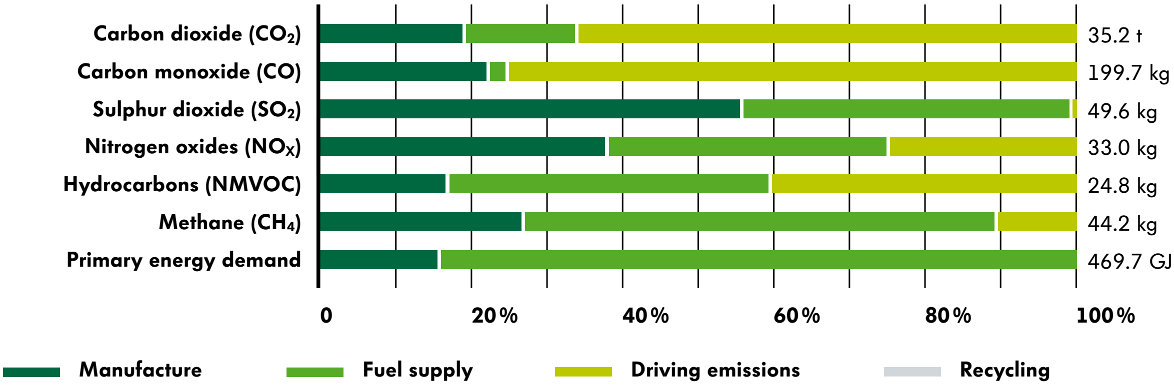

Fig. 4: Life Cycle Inventory data for the Passat 1.4 TSI [90 kW] (predecessor)

Over its entire life cycle, the Passat 1.4 TSI predecessor model causes total CO_2 emissions of 35.2 metric tons and has primary energy requirements of approx. 470 GJ (see Fig. 4). The current model with the 1.4-litre TSI engine generates 1.7 metric tons less CO_2 emissions and has a much lower total energy demand of 454.2 GJ (see Fig. 5). This is a direct result of its lower fuel consumption compared with the predecessor model. As a result of the significant influence of the service life phase – i.e. fuel supply and driving emissions – on the final result, the considerable drop in fuel consumption also leads to a reduction in all the other Life Cycle Inventory figures.

The Passat 1.4 TSI BlueMotion Technology outperforms even these very good results. Its energy requirements of 437.6 GJ and CO_2 emissions of 32.4 metric tons are below the values for the predecessor model by an even clearer margin (see Fig. 6).

Life Cycle Inventory
Passat 1.4 TSI [90 kW]

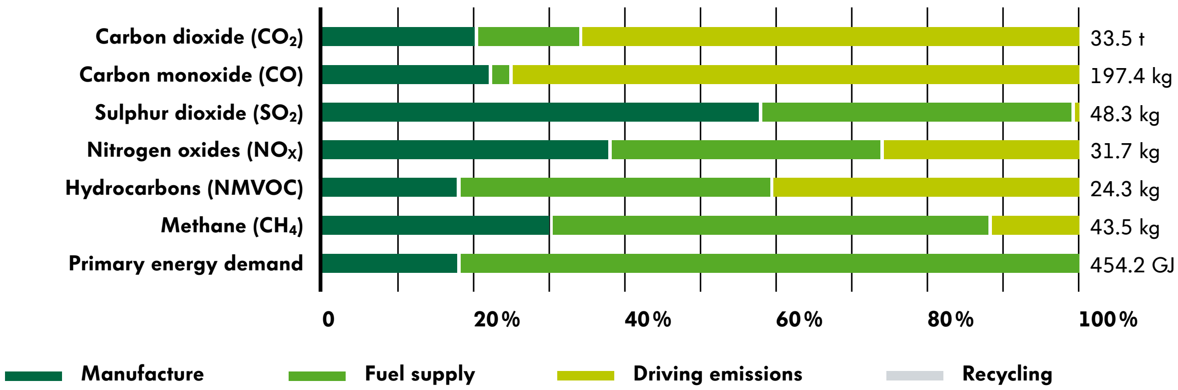

Fig. 5: Life Cycle Inventory data for the Passat 1.4 TSI [90 kW]

Life Cycle Inventory
Passat 1.4 TSI BlueMotion Technology [90 kW]

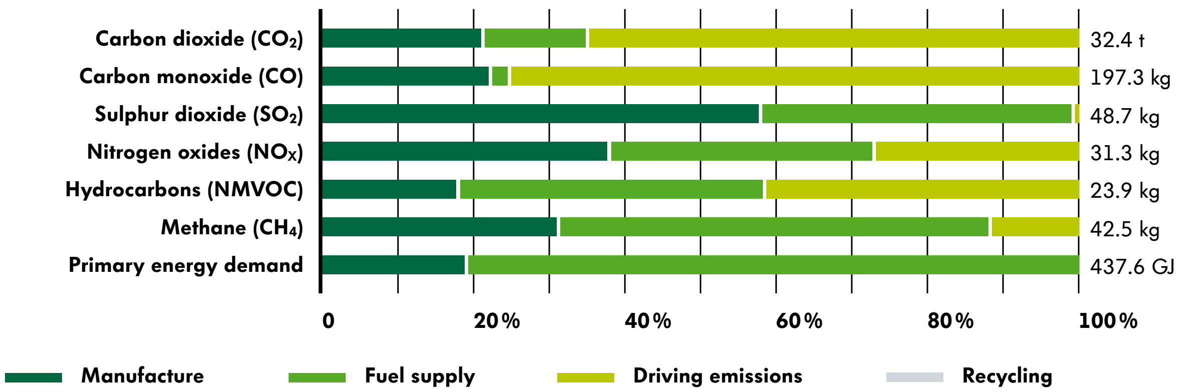

Fig. 6: Life Cycle Inventory data for the Passat 1.4 TSI BlueMotion Technology [90 kW]

Comparison of Life Cycle Impacts

On the basis of the Life Cycle Inventory data, Life Cycle Impact Assessments are drawn up for the environmental impact categories described. The interactions of all the emissions recorded are considered and potential environmental impacts are determined based on scientific models.[13]

Diesel models

Fig. 7 clearly shows that the successor model achieves improvements compared with its predecessor in almost all the environmental impact categories considered. One exception here, however, is ozone depletion potential. The higher values here can be explained by the fact that, in contrast to its predecessor, the current model is equipped with an air conditioning system. The higher emissions of ozone depleting substances are due in particular to the upstream production chain of the refrigerant used in this system.

Comparative environmental profiles
normalised

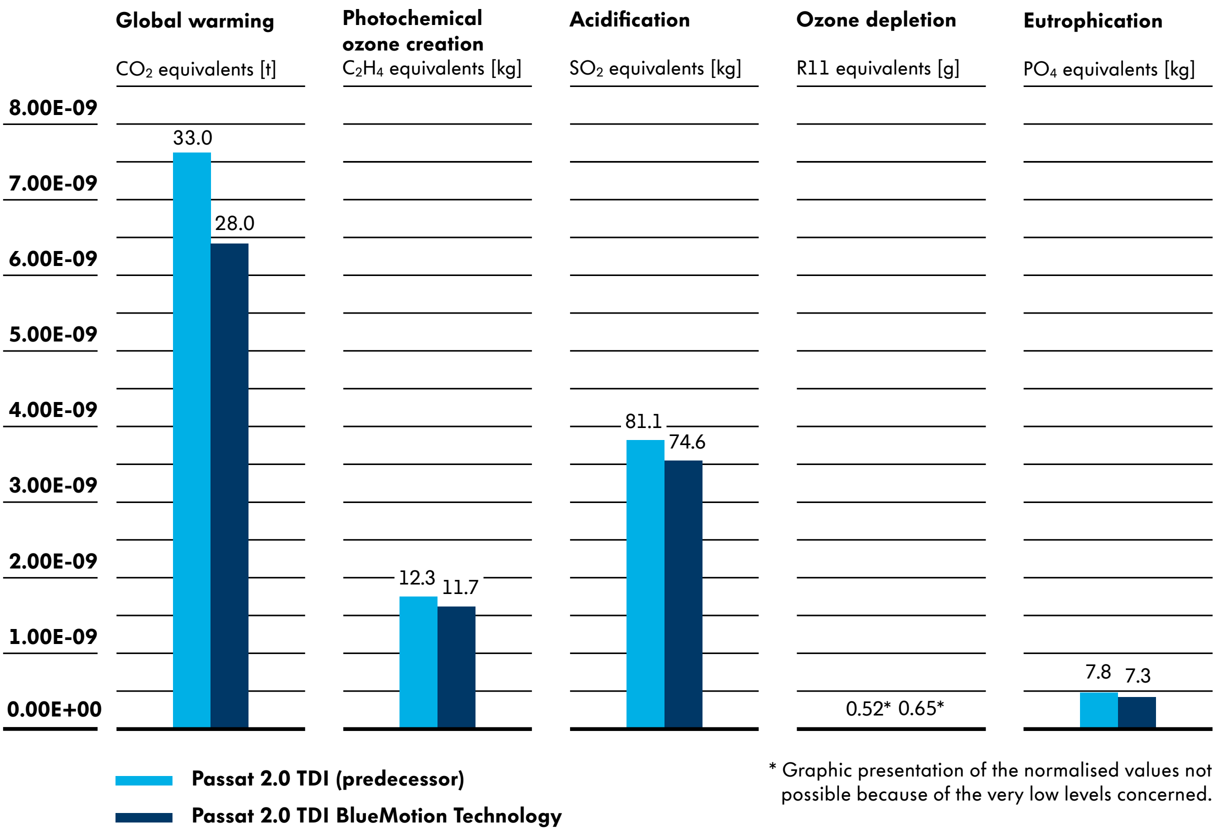

Fig. 7: Environmental impacts of the Passat 2.0 TDI (predecessor) and 2.0 TDI BlueMotion Technology (absolute)

With reference to overall environmental impacts in the European Union, Fig. 7 indicates that the vehicles considered here make their largest contributions to overall environmental impacts in the categories of global warming potential (greenhouse effect),

[13] You will find information on the environmental impact categories used here on the Internet at www.environmental-commendation.com.

acidification, and photochemical ozone creation (summer smog). Contributions to the categories eutrophication and ozone depletion potential are low by comparison. Consequently, the notes below focus on the first three environmental impact categories.

As Fig. 8 below shows, the environmental impacts of the current model in the three categories considered are lower than those of the predecessor model – the Passat 2.0 TDI. The reduction of 15 percent in greenhouse gas emissions over the vehicle life cycle in the case of the Passat 2.0 TDI BlueMotion Technology corresponds to savings of around five metric tons of CO_2 equivalents. In relation to acidification potential the savings are slightly less. This is due to the additional components installed from the BlueMotion-Technologies range (e.g. regenerative braking and engine start-stop system).

Comparative environmental profiles
normalised

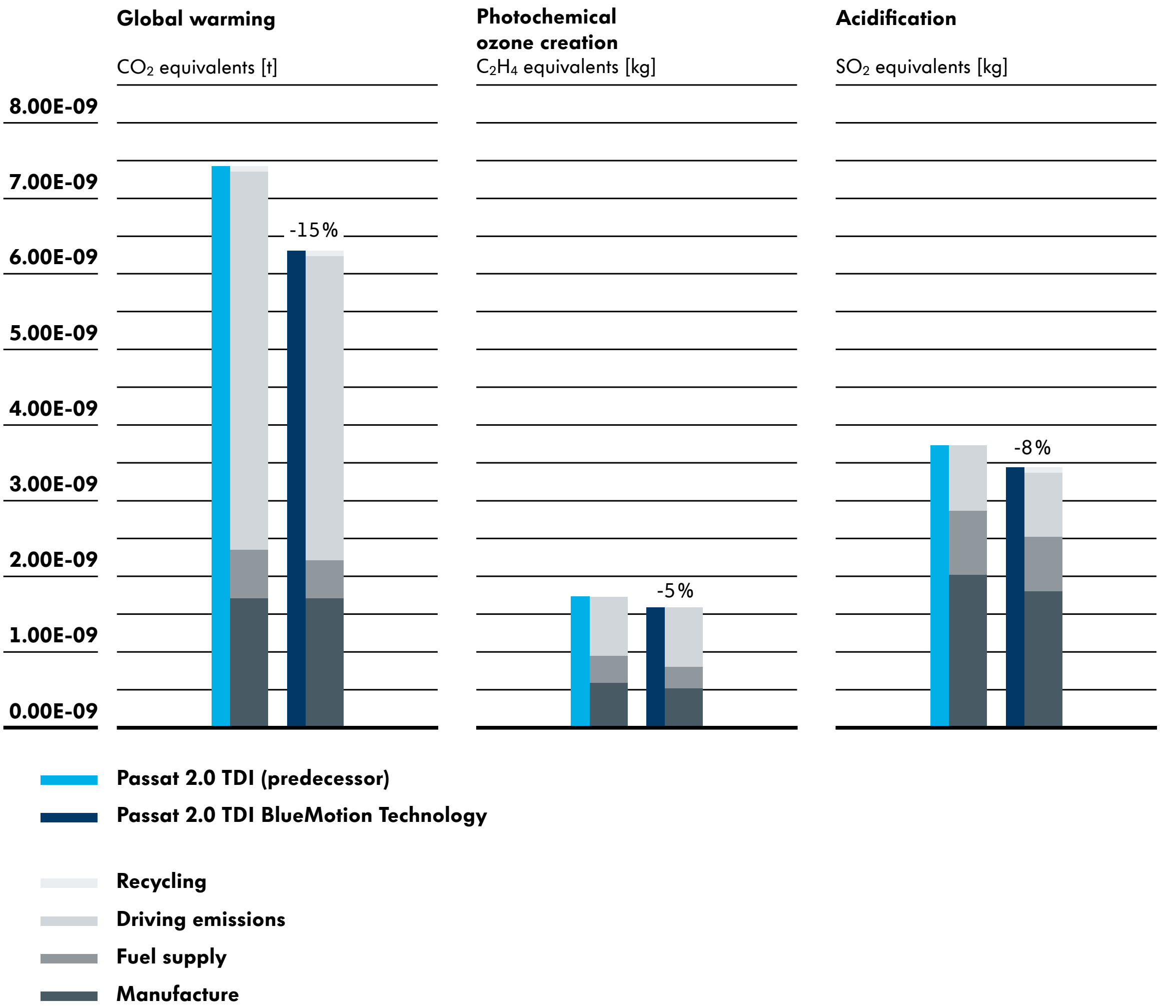

Fig. 8 Environmental impacts of the predecessor diesel model and the current Passat 2.0 TDI BlueMotion Technology (relative)

Fig. 8 also indicates how these various reductions are achieved, in that the absolute environmental impacts are allocated to the individual life cycle phases. As already shown by the Life Cycle Inventories, the most relevant changes occur during the service life of the vehicle and as a result of the corresponding impact on fuel production. Most of the improvements therefore result either directly (lower driving emissions) or indirectly (less fuel production) from lower fuel consumption.

Fig. 9 below shows the environmental impacts described in relation to each other and over the entire life cycle of the vehicle. The relations between manufacture, service life and recycling with regard to the individual environmental impacts are clearly visible. Global warming potential in particular is influenced mainly by vehicle use (highest increase over service life).

Comparison of environmental impacts over the full life cycle
normalised

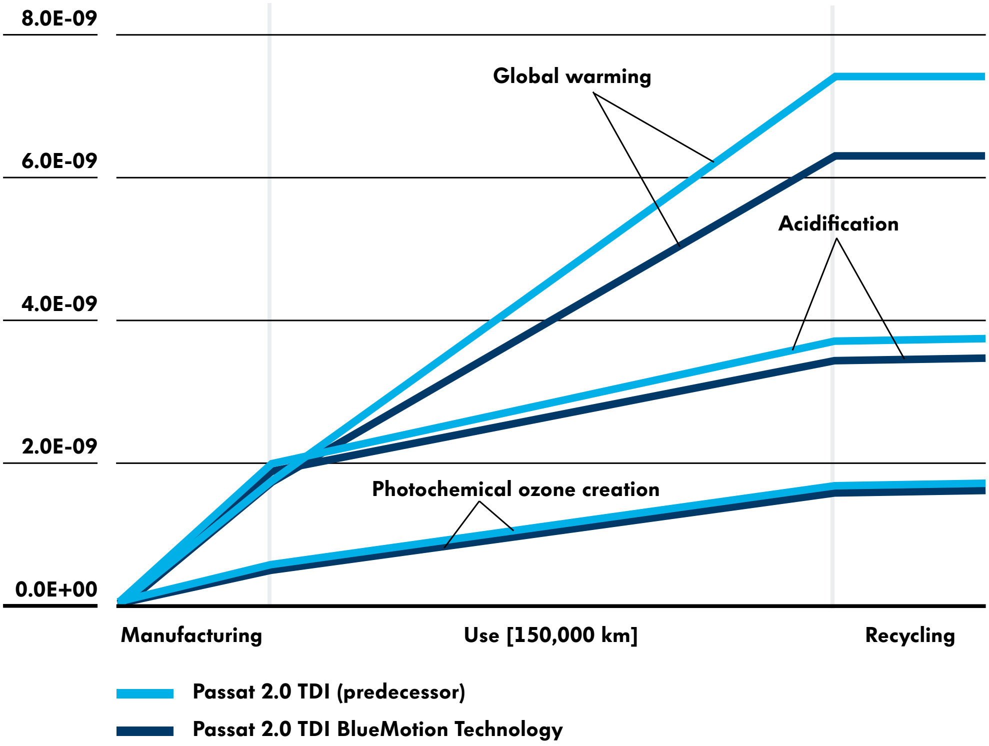

Fig. 9: Comparison of environmental impacts over the full life cycle – diesel models

Acidification and photochemical ozone creation potential, by contrast, are distributed more evenly over all the phases of the life cycle.

Petrol models

A comparison of the petrol-engined models also shows that the current models achieve improvements compared with their predecessors in all the environmental impact categories considered (see Fig. 10) with the exception of ozone depletion potential (for the same reason as in the diesel models). In the petrol models too, the largest contributions to overall environmental impacts are in the categories of global warming potential (greenhouse effect) acidification potential and photochemical ozone creation potential (summer smog).

Comparative environmental profiles
normalised

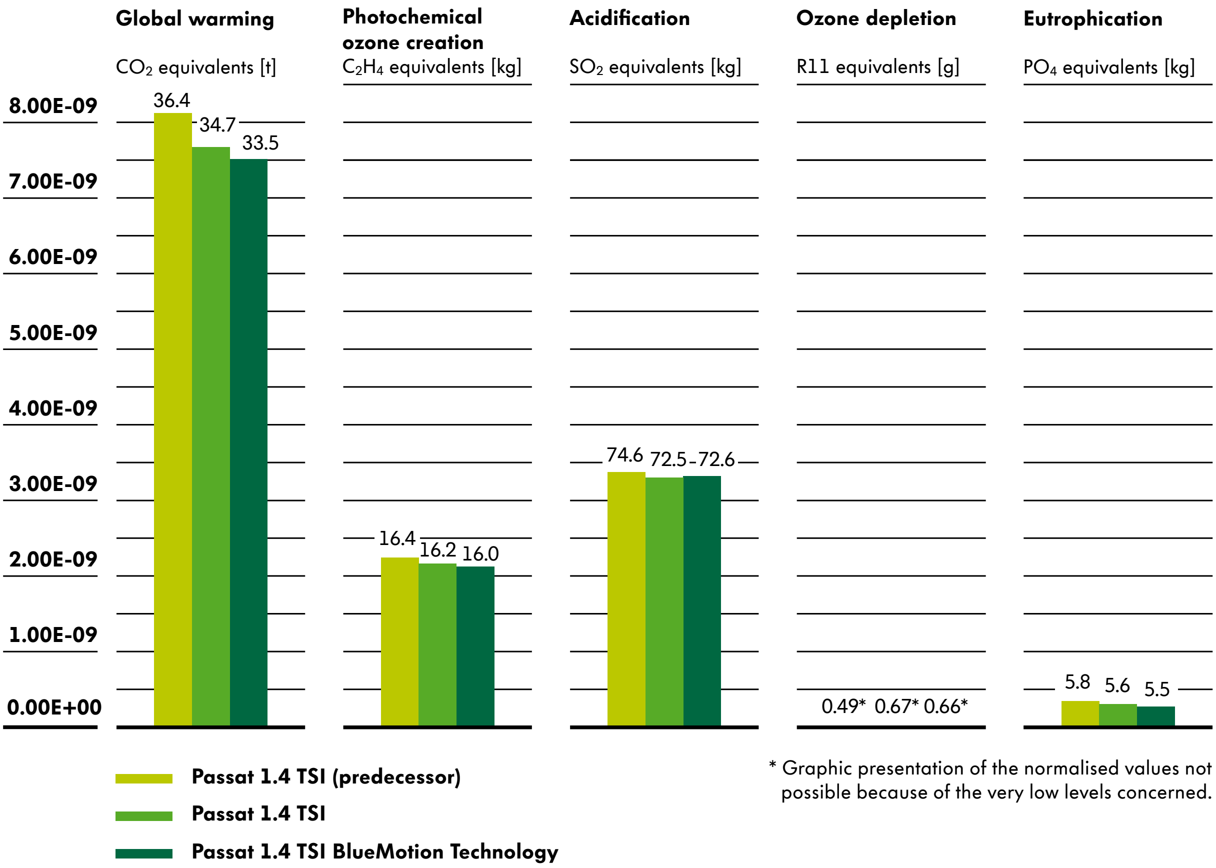

Fig. 10: Environmental impacts of Passat 1.4 TSI (predecessor), Passat 1.4 TSI and 1.4 TSI BlueMotion Technology (absolute)

The global warming potential caused by the Passat 1.4 TSI over its entire life cycle is significantly lower than that of the predecessor model. Over the assumed mileage of 150,000 kilometres, total emissions of CO_2 equivalents are reduced by 1.7 metric tons per vehicle. The saving with the Passat 1.4 TSI BlueMotion Technology is even greater, at approximately three metric tons of CO_2 equivalents.

Fig. 11 presents the changes in environmental impacts from the predecessor to the successor model in relation to each other. As the graph shows, in the case of the Passat 1.4 TSI the impacts in the categories photochemical ozone creation potential and acidification potential have fallen by two percent and three percent respectively. Global warming potential over the entire vehicle life cycle has been reduced by as much as five percent. The reduction in environmental impact with the Passat 1.4 TSI BlueMotion Technology is even more pronounced. While photochemical ozone creation potential and acidification potential are again reduced by two percent and three percent respectively, the reduction in global warming potential of almost three metric tons of CO_2 equivalents corresponds to a saving of eight percent.

Comparative environmental profiles
normalised

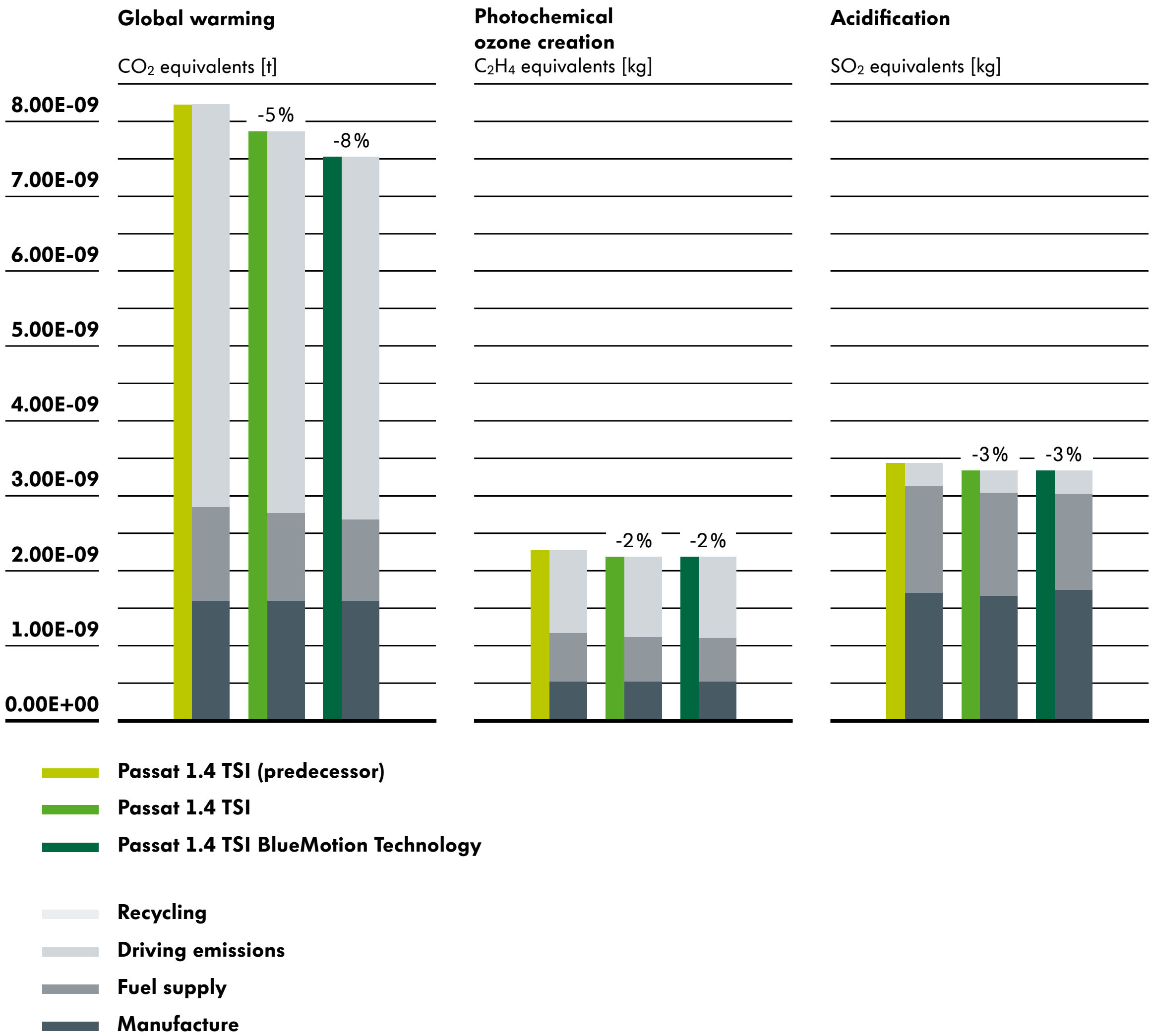

Fig. 11: Environmental impacts of Passat 1.4 TSI (predecessor), Passat 1.4 TSI and 1.4 TSI BlueMotion Technology (relative)

Fig. 11 also indicates how these various reductions are achieved. As with the diesel-engined models, most of the improvements result from the lower fuel consumption of the current model. It can clearly be seen that the driving emissions and the contribution to emissions associated with the fuel supply process are both lower in the case of the current model. In the manufacturing phase there are only minor deviations between the vehicles compared. Depending on the model and impact category, the impacts generated by the current model may also be slightly higher than those of its predecessor. This is due to the additional BlueMotionTechnologies components installed. However, these increases are more than offset by the improvements in the service life phase and fuel supply process. In the petrol models too, the recycling phase has only a negligible influence in terms of environmental impacts.

The service life of the petrol models is even more predominant in terms of global warming potential than in the case of the diesel models (see Fig. 12). The lower values for the current Passat 1.4 TSI and the Passat 1.4 TSI BlueMotion Technology are clearly evident. The benefits in terms of acidification and photochemical ozone creation potential are also due to lower fuel consumption and the associated reduced environmental impact of the fuel supply process for the current model.

Comparison of environmental impacts over the full life cycle
normalised

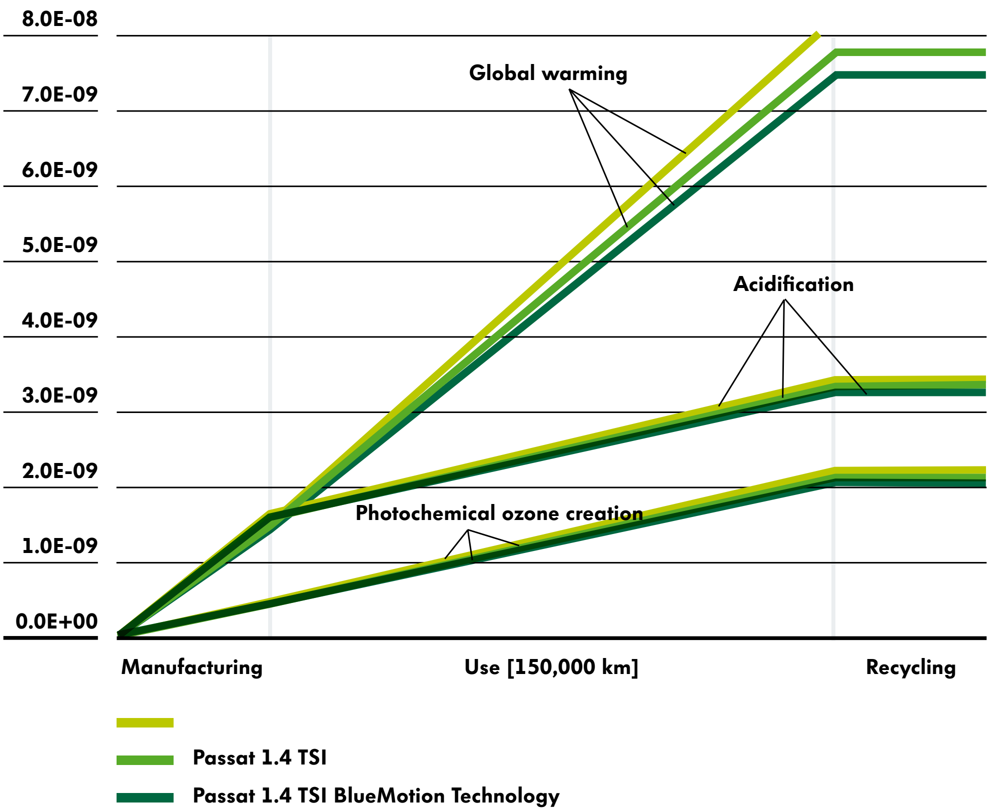

Fig. 12: Comparison of environmental impacts over the full life cycle – petrol-engined models

Certification

The statements made for the Passat Environmental Commendation are supported by the Life Cycle Assessment of the Passat. The certificate of validity confirms that the Life Cycle Assessment is based on reliable data and that the method used complies with the requirements of ISO standards 14040 and 14044.

CERTIFICATE OF VALIDITY TÜV NORD

DIN EN ISO 14040 : 2006-10
(LCA - life cycle assessment)

Evidence that the application conforms to the regulations was delivered, and is herewith certified according to the TÜV NORD CERT - procedure for

Volkswagen AG
Berliner Ring 2
38346 Wolfsburg
Germany

Range of application

Environmental Commendation Passat

The requirements were fulfilled and proven by a critical review concerning

- **Standard methodologies**
- **Representative categories of balancing and effects**
- **General transparency and consistency**

Report no. 3507 0181

Certification office of the TÜV NORD CERT GmbH | Essen, dated 2010-09-27

Dr. Winfried Hi[illegible]
Environmental verifier

TÜV NORD CERT GmbH | Langemarckstrasse 20 | 45141 Essen | www.tuev-nord-cert.com

The detailed report of TÜV NORD can be found in the appendix.

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List of abbreviations

AP	Acidification potential
CFC	Chlorofluorocarbons
CH_4	Methane
CML	Centrum voor Milieukunde Leiden (Centre for Environmental Sciences, Netherlands)
CO	Carbon monoxide
CO_2	Carbon dioxide
DIN	Deutsche Industrienorm (German Industrial Standard)
DPF	Diesel particulate filter
DSG®	Dual-cutch gearbox
EN	European standard
EP	Eutrophication potential
EU 15	15 member states before the eastern European expansion of the European Community
GJ	Gigajoule
GWP	Global warming potential
HC	Hydrocarbons
IMDS	International Material Data System
KBA	Kraftfahrtbundesamt (Federal Motor Transport Authority)
kW	Kilowatt
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
MISS	Material Information System
MPI	Intake-tube multipoint injection petrol engine
N_2O	Nitrous oxide
NEDC	New European Driving Cycle
NH_3	Ammonia
Nm	Newton metre
NMVOC	Non-methane volatile organic compounds (hydrocarbons without methane)
NO_X	Nitrogen oxides
ODP	Ozone depletion potential
PAN	Peroxyacetylnitrate
PO_4	Phosphate
POCP	Photochemical ozone creation potential
ppm	Parts per million
PVC	Polyvinyl chloride
R11	Trichlorofluoromethane (CCl_3F)
SET	Simultaneous engineering team
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
TDI	Turbocharged direct injection diesel engine
TSI	Turbocharged direct injection petrol engine
VDA	Verband der Automobilindustrie e.V. (Association of the German Automotive Industry)
VOC	Volatile organic compounds

List of figures

List of tables

Appendix

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