The Polo

Environmental Commendation Background Report

The Life Cycle Assessment of the Polo

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 [Volkswagen AG 2009a, Volkswagen AG 2009b]. 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 Polo 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 Polo we compared three diesel-engined models with 55 kW (1.2 TDI, 1.2 TDI BlueMotion) or 66 kW (1.2 TDI BlueMotion Technology) with a similarly powerful predecessor. For the petrol models, a Polo 1.2 TSI (77 kW) and a 1.4 MPI (63 kW) with seven-speed DSG® dual-clutch transmission were compared with an almost equally powerful predecessor.

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. Lightweight design and the use of smaller engines with the same output were also beneficial.

Compared to its predecessor the new Polo is slightly larger, but despite the wide range of safety and comfort requirements that it meets, it is no heavier. Significant improvements have been achieved in fuel consumption and the related CO_2 emissions. In terms of fuel efficiency, the BlueMotion version in particular reveals the potential we have been able to exploit. Compared to its predecessor, the new Polo presents a much better balance sheet over its entire life cycle with regard to the global warming and photochemical ozone creation potential, thereby attaining the environmental goal set by the Technical Development departmen with only slight deviations for the manufacturing phase. Depending on the individual model and environmental impact category, the environmental impacts during production of the new models may be slightly higher than for their predecessors. However, the savings during their subsequent service life rapidly compensate for this increase.

Over their entire life cycle, the three diesel models emit 22.1 metric tons (1.2 TDI), 21.7 metric tons (BlueMotion Technology) and 20.3 metric tons (BlueMotion) of carbon dioxide equivalents. This corresponds to a saving of about 13 percent for the 1.2 TDI and 15 percent for the BlueMotion Technology compared to the predecessor model. The BlueMotion model achieves even greater savings, at 20 percent. During their service lives, the petrol-engined 1.4 MPI equipped with seven-speed DSG® emits 30.1 metric tons and the 1.2 TSI 28 metric tons of CO_2 equivalents. Over their full life cycle, the petrol-engined models therefore achieve reductions in emissions of 12 percent and 18 percent respectively. The overall reduction in emissions of greenhouse gases over the full life cycle is significant, since the 1.4-litre model, for example, emits approximately 4.2 metric tons less CO_2 equivalents than its predecessor. The true scale of this reduction is illustrated by the fact that the entire production process for a Polo 1.4 MPI with seven-speed DSG® generates approximately five metric tons of greenhouse gases.

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 Polo models assessed

Volkswagen's Environmental Commendation for the Polo describes and analyses the environmental impacts of selected Polo models. To this end, we compared selected diesel and petrol models from the current Polo series (Polo V)[1] with their respective predecessors (Polo IV). 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 Polo models with diesel and petrol engines and compare them with their predecessors.

For the Life Cycle Assessment of the Polo, we compared the 1.4 TDI with diesel particle filter (DPF®) (59 kW)[2] with its almost equally powerful successor, the new 1.2 TDI DPF® (55 kW)[3] and the especially economical Polo BlueMotion Technology (1.6 TDI DPF®, 66 kW)[4] and Polo BlueMotion (1.2 TDI DPF®, 55 kW)[5]. For the petrol models we compared a Polo with 1.6-litre MPI engine (77 kW)[6] with a similar successor model, equipped with a 1.4-litre MPI engine (63 kW) and 7-speed DSG[7] and the 1.2 TSI (77 kW)[8].[9]

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 Polo range available when this report was finalised.
[2] 4.5 l/100km (NEDC) 119 g CO_2/km
[3] 3.8 l/100km (NEDC) 99 g CO_2/km
[4] 3.7 l/100km (NEDC) 96 g CO_2/km
[5] 3.3 l/100km (NEDC) 87 g CO_2/km
[6] 6.7 l/100km (NEDC) 159 g CO_2/km
[7] 5.8 l/100km (NEDC) 135 g CO_2/km
[8] 5.3 l/100km (NEFZ) 124 g CO_2/km
[9] In each case, the engine/gearbox pairing with the lowest consumption was chosen for comparison. Normally, this is a vehicle with manual transmission. However, in the case of the Polo 1.4 MPI DSG, the 7-speed DSG® version has the lowest consumption. The additional comfort and convenience of the DSG® gearbox is not taken into consideration in the comparison.

Table 1: Technical data of vehicles assessed

	Polo IV 1.4 TDI	Polo V 1.2 TDI	Polo V 1.6 TDI Blue Motion Technology	Polo V 1.2 TDI Blue Motion	Polo IV 1.6 MPI	Polo V 1.4 MPI DSG	Polo V 1.2 TSI
Engine capacity [cm³]	1422	1199	1598	1199	1598	1390	1197
Output [kW]	59	55	66	55	77	63	77
Gearbox	5-speed-manual	5-speed-manual	5-speed-manual	5-speed-manual	5-speed-manual	7-speed-DSG	6-speed-manual
Fuel	Diesel	Diesel	Diesel	Diesel	Petrol (Super)	Petrol (Super)	Petrol (Super)
Emission standard	Euro 4	Euro 5	Euro 5	Euro 5	Euro 4	Euro 5	Euro 5
Maximum speed [km/h]	174	170	180	173	192	177	190
Acceleration 0-100 km/h [s]	12.8	13.9	11.5	13.9	10.4	11.9	9.7
Max. torque [Nm] at rpm	195/ 1800-2200	180/ 2000	230/ 1500-2500	180/ 2000	153/ 3800	132/ 3800	175/ 1550-4100
Unladen weight [kg][10]	1166	1132	1165	1150	1104	1104	1088
Luggage capacity [kg]	559	563	560	515	559	551	557
Fuel tank capacity [l]	45	45	45	45	45	45	45

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

[10] Unladen weight with 68 kg driver, 7 kg luggage and fuel tank 90% full, determined in accordance with directive 92/21/EEC [EU 1992] in the version currently in force (04/2009).

in the assessment as previous studies demonstrated that maintenance does not cause any significant environmental impacts [Schweimer und Levin, 2000] [Schweimer und Roßberg, 2001].

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.

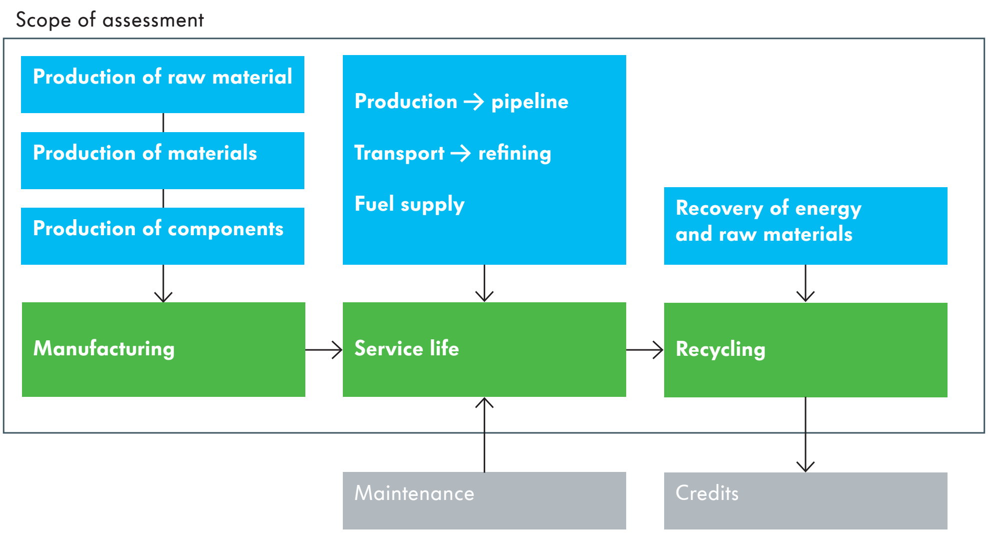

Fig. 1: Scope of the Life Cycle Assessment

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[11] 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.

[11] 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)[12]. 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.

[12] 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 the Euro 4 and Euro 5 emission standards (see Table 1 and Table 3).

Table 3: Relevant emission limits in accordance with Euro 4 and Euro 5

Emission limit	Euro 4		Euro 5	
	Petrol [g/km]	Diesel [g/km]	Petrol [g/km]	Diesel [g/km]
Carbon monoxide emissions (CO)	1.00	0.50	1.00	0.50
Nitrogen oxide emissions (NO_X)	0.08	0.25	0.06	0.18
Hydrocarbon emissions (HC)	0.10		0.10	
of which NMHC			0.068	
NO_X + HC emissions		0.30		0.23
Particulate emissions		0.025	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.[13]

[13] 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

	Polo IV 1.4 TDI	**Polo V 1.2 TDI**	**Polo V 1.6 TDI Blue Motion Technology**	**Polo V 1.2 TDI Blue Motion**	**Polo IV 1.6 MPI**	**Polo V 1.4 MPI DSG**	**Polo V 1.2 TSI**
Fuel	Diesel	Diesel	Diesel	Diesel	Petrol (Super)	Petrol (Super)	Petrol (Super)
Fuel consumption (urban/ highway/ combined) [l/100 km]*	5.8/ 3.8/ 4.5	4.6/ 3.3/ 3.8	4.6/ 3.2/ 3.7	4.0/ 2.9/ 3.3	9.5/ 5.1/ 6.7	7.7/ 4.7/ 5.8	6.8/ 4.5/ 5.3
Emission standards	Euro 4	Euro 5	Euro 5	Euro 5	Euro 4	Euro 5	Euro 5
Carbon dioxide emissions, combined [g/km]	119	99	96	87	159	135	124
CO [g/km]	0.144	0.308	0.124	0.213	0.152	0.135	0.469
HC [g/km]					0.038	0.064	0.044
of which NMHC [g/km]						0.0575	0.0373
NO_X [g/km]	0.177	0.142	0.094	0.137	0.035	0.024	0.024
NO_X + HC [g/km]	0.186	0.191	0.138	0.168			
Particulate emissions [g/km]	0.018	0.00023	0.00095	0.0001			

* Total average consumption (NEDC)

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

In sum, all information relevant to the aims of this study was collected and modelled with a sufficient degree of completeness.[14] 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.

[14] 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 Polo 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 to average impact per inhabitant values

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 Polo IV 1.4 TDI, such as carbon dioxide (CO_2), carbon monoxide (CO) and nitrogen oxides (NO_X), are mainly generated during the service life of the car. In contrast, both methane (CH_4) emissions and primary energy demand are dominated by the fuel supply phase – from well to pump. As a result of the low sulphur content assumed for the fuels used, the manufacturing phase accounts for the greater part of overall sulphur dioxide (SO_2) emissions. CO_2 emissions over the entire life cycle of the Polo IV 1.4 TDI reach about 24.7 metric tons. The total energy demand amounts to about 347.5 GJ.[15]

Life Cycle Inventory
Polo IV 1.4 TDI [59 kW] (predecessor)

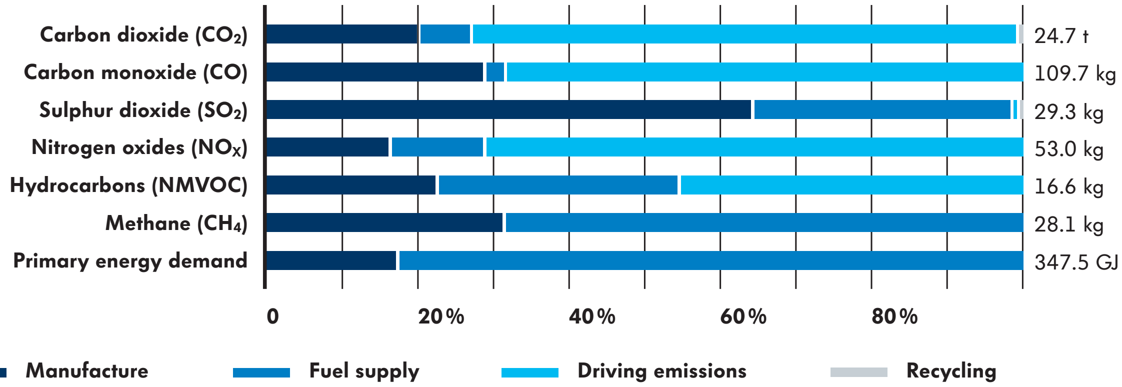

Fig. 2: Life Cycle Inventory data for Polo IV 1.4 TDI [59 kW] (predecessor model)

In qualitative terms, the life cycle inventories for the current Polo V 1.2 TDI, the Polo BlueMotion Technology and the Polo BlueMotion show only slight differences (see Figures 3 to 5).

However, the lower energy demand and emissions of both models compared with their predecessors are clearly evident. Thus, compared with its predecessor the energy

[15] 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.

requirement for the 1.2 TDI is reduced from approx. 347.5 GJ to less than 300 GJ and CO_2 emissions are only 21.4 metric tons instead of 24.7 metric tons,. The BlueMotion-Technology turns in even better figures. Over the entire life cycle it only requires about 293 GJ of energy and produces only 21 metric tons of CO_2 emissions. These figures are beaten only by the Polo BlueMotion with the 1.2-litre TDI engine, with energy requirements of only 272.3 GJ and CO_2 emissions of only 19.6 metric tons.

Life Cycle Inventory
Polo V 1.2 TDI [55 kW]

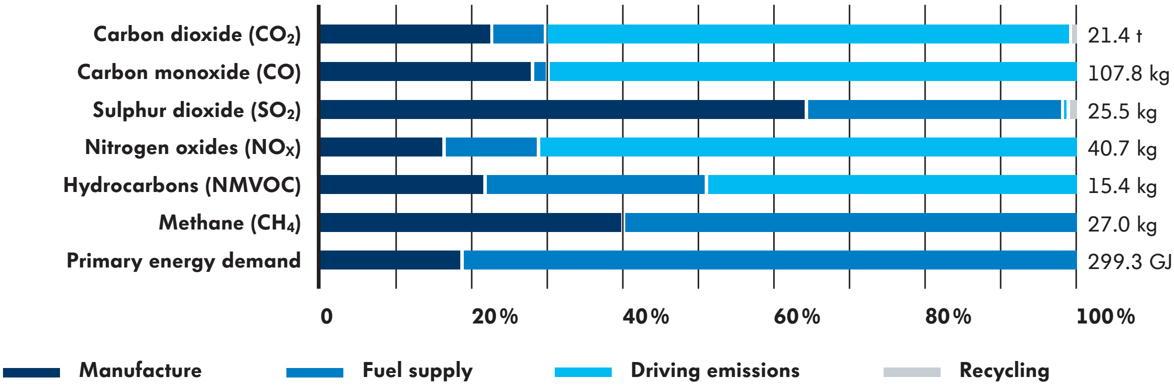

Fig. 3: Life Cycle Inventory data for Polo 1.2 TDI [55 kW]

Life Cycle Inventory
Polo V 1.6 TDI BlueMotion Technology [66 kW]

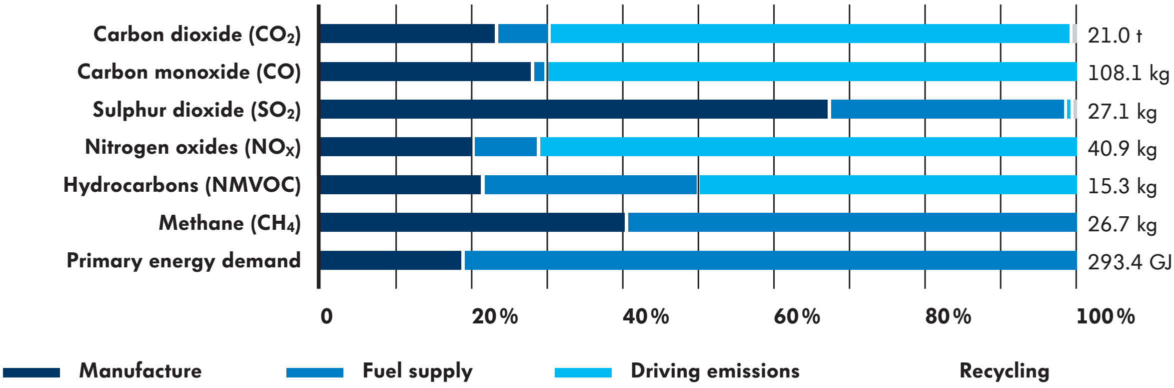

Fig. 4: Life Cycle Inventory data for Polo V 1.6 TDI BlueMotion Technology [66 kW]

Life Cycle Inventory
Polo V 1.2 TDI BlueMotion [55 kW]

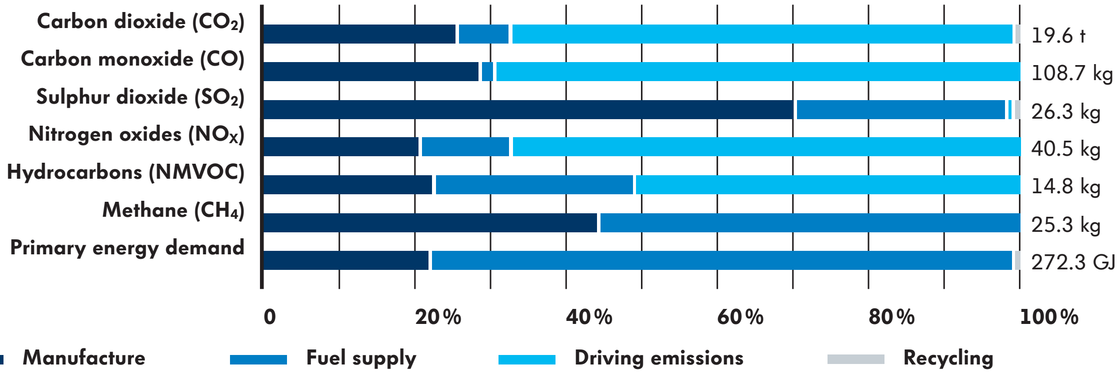

Fig. 5: Life Cycle Inventory data for Polo BlueMotion with 1.2-litre TDI engine [55 kW]

Petrol models
The next three graphs, Figures 6, 7 and 8, 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
Polo IV 1.6 MPI [77 kW] (predecessor)

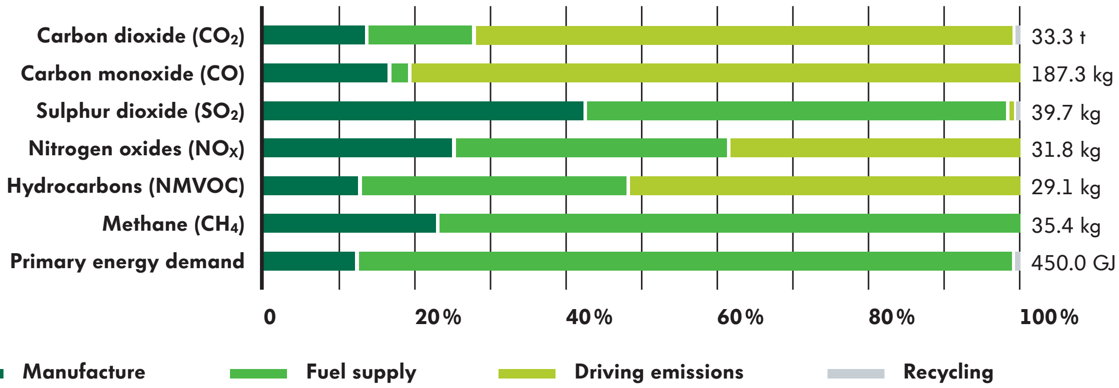

Fig. 6: Life Cycle Inventory data for Polo IV with 1.6-litre MPI engine [77 kW] (predecessor model)

The Polo IV 1.6 MPI causes total CO_2 emissions of 33.3 metric tons and has a total energy demand of approx. 450 GJ (see Fig. 6). The successor model Polo 1.4 MPI with DSG® causes 4.2 tons less CO_2 emissions and also has significantly lower energy requirements of 393.9 GJ (see Fig. 7). This is a direct result of its lower fuel consumption compared with the predecessor model. The significant influence of the service life phase – i.e. fuel supply and driving emissions – on the final result means that the considerably reduced consumption also leads to a reduction in all the other Life Cycle Inventory parameters with the exception of methane emissions.[16]

Life Cycle Inventory
Polo V 1.4 MPI 7-speed DSG [63 kW]

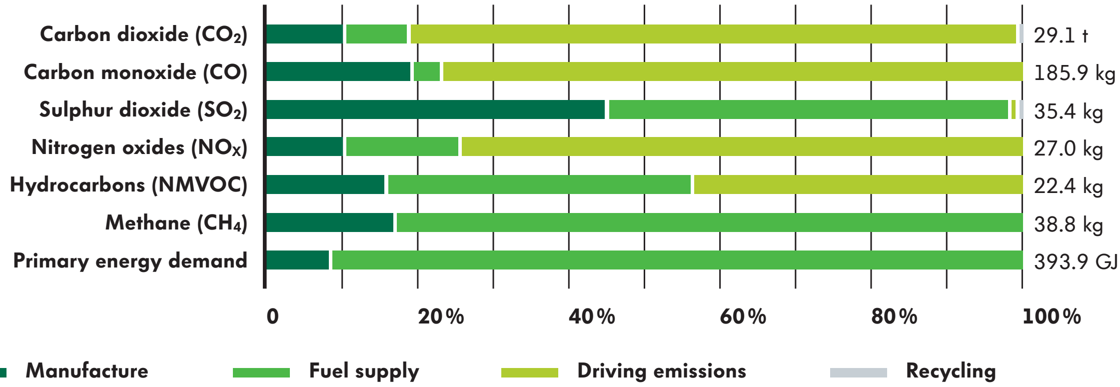

Fig. 7 Life Cycle Inventory data for Polo V 1.4 MPI with 7-speed DSG® [63 kW]

The Polo 1.2 TSI outperforms even these very good results. Its energy requirements of 363.8 GJ and CO_2 emissions of 27.1 metric tons are below the values for the predecessor model by an even clearer margin (see Fig. 8).

[16] In contrast to the Polo IV 1.6 MPI, the Life Cycle Inventory for the current models indicates that the service life contributes a significant share of the methane emissions. This is a result of the requirements of the new Euro 5 exhaust emissions standard which applies to the new vehicle but did not apply to the predecessor model (see Table 1 and Table 3). Under the provisions of the Euro 4 standard, a limit is only imposed on total hydrocarbon emissions (HC). In Fig. 6, these are all included in NMVOC driving emissions. For vehicles type-approved to Euro 5 requirements, there is also an explicit limit for non-methane hydrocarbons (NMHC). The difference between this limit and the HC limit is the model value for the methane driving emissions of the current models in Figures 7 and 8.

Life Cycle Inventory
Polo V 1.2 TSI [77 kW]

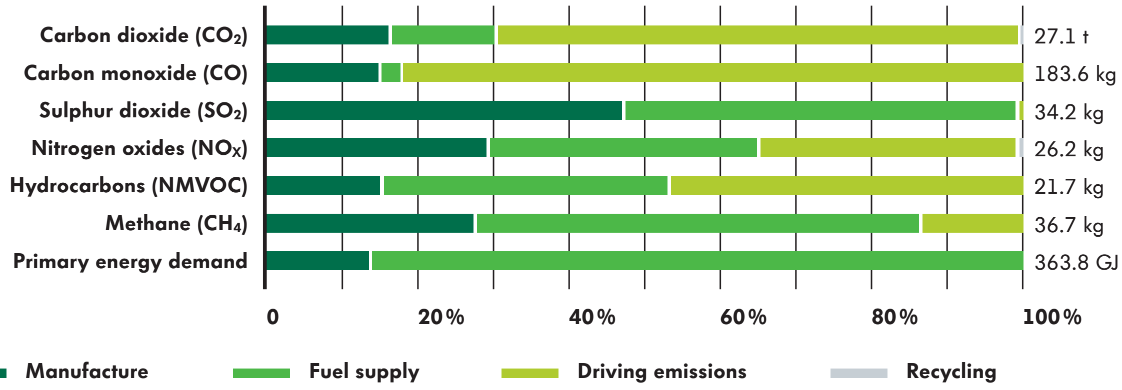

Fig. 8: Life Cycle Inventory data for Polo 1.2 TSI [77 kW]

Comparison of Life Cycle Impacts
On the basis of the Life Cycle Inventory data, Life Cycle Impact Assessments are drawn up for all the environmental impact categories. The interactions of all the emissions recorded are considered and potential environmental impacts are determined based on scientific models[17].

Diesel models
With reference to overall environmental impacts in the European Union [to average impact per inhabitant in the EU], Fig. 9 clearly shows that all the vehicles considered here make their largest contributions to overall environmental impacts in the categories of global warming potential (greenhouse effect), acidification and photochemical ozone creation (summer smog). Contributions to the categories eutrophication and ozone depletion potential are smaller. Consequently, the notes below focus on the first three environmental impact categories.

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

Comparative environmental profiles
normalised

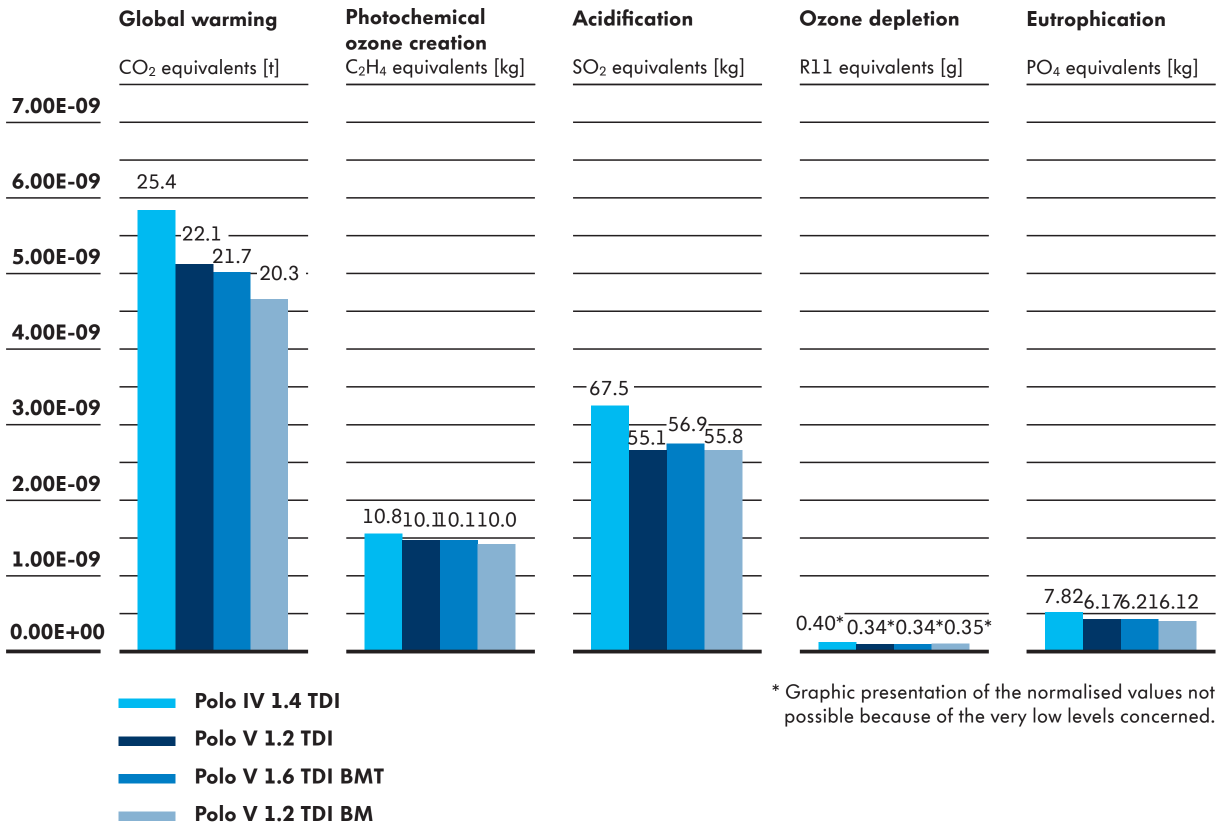

Fig. 9: Environmental impacts of the Polo IV 1.4 TDI and its successors, the Polo V 1.2 TDI, Polo V 1.6 TDI BlueMotion Technology and Polo V 1.2 TDI BlueMotion (absolute)

As Fig. 10 below shows, the environmental impacts of the current model in all the categories considered are lower than those of the predecessor model – the Polo IV 1.4 TDI. The reduction of 13 percent in greenhouse gas emissions over the vehicle life cycle in the case of the Polo 1.2 TDI corresponds to savings of around 3.3 metric tons of CO_2 equivalents. In the case of the Polo 1.6 TDI BlueMotion Technology, the saving is 3.7 metric tons of CO_2 equivalents (15 percent) thanks to the additional systems used (regenerative braking and engine start-stop system). The Polo 1.2 TDI BlueMotion achieves the greatest saving over its predecessor, at 20 percent.

The savings with the Polo 1.6 TDI BlueMotion Technology and Polo 1.2 TDI BlueMotion in terms of global warming potential are considerably more significant. In relation to acidification potential, however, 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 in detail
normalised

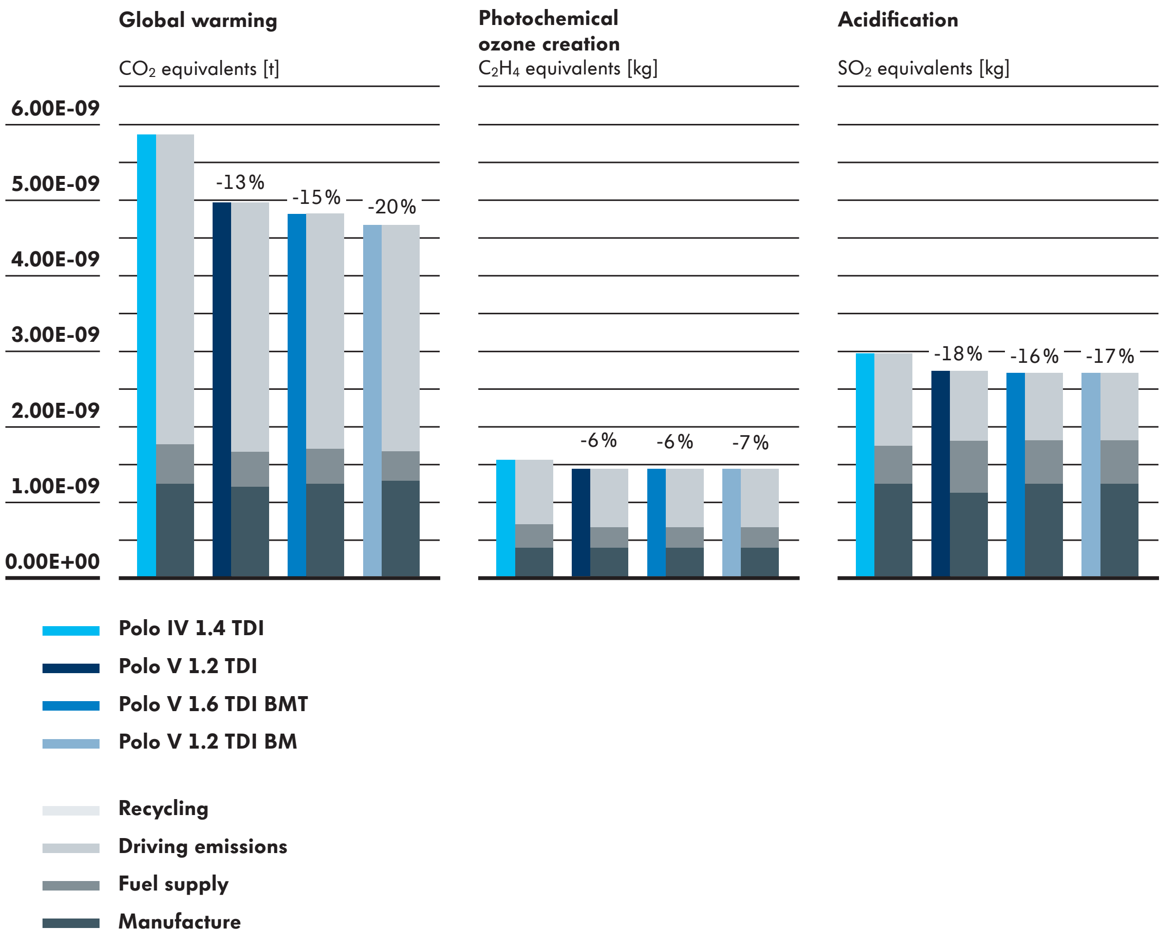

Fig. 10: Environmental impacts of the Polo IV 1.4 TDI and its successors, the Polo V 1.2 TDI, Polo V 1.6 TDI BlueMotion Technology and Polo V 1.2 TDI BlueMotion (relative)

Fig. 10 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. 11 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

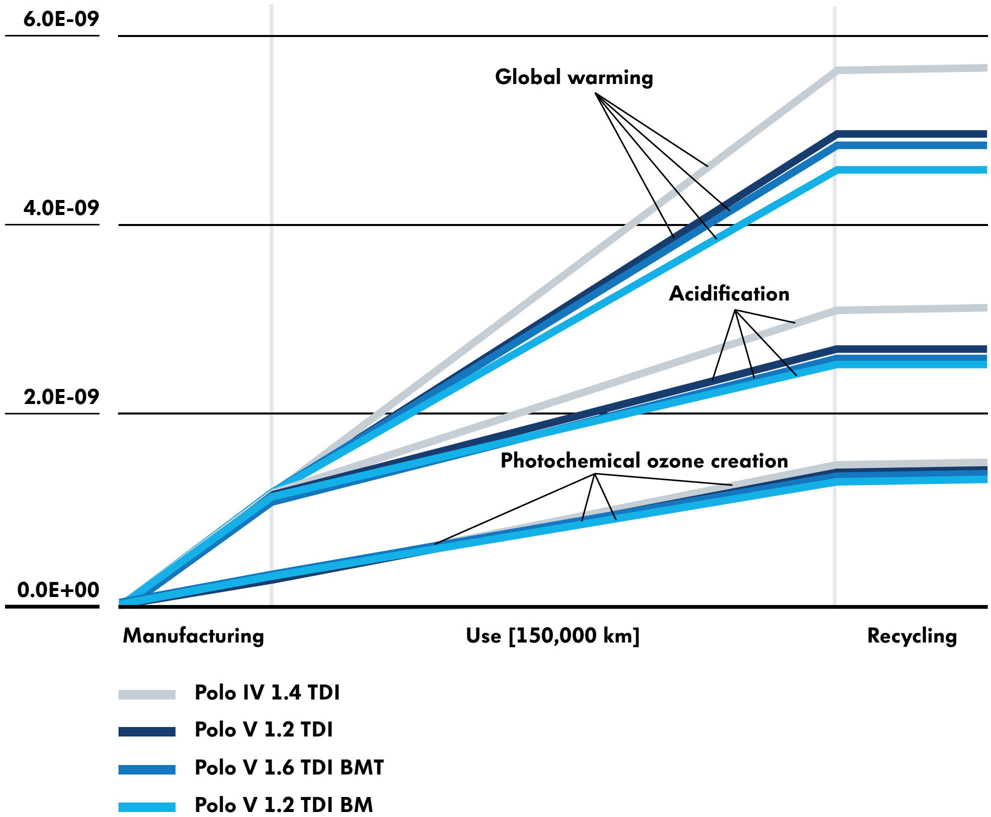

Fig. 11: Comparison of environmental impacts over the full life cycle – diesel models

Acidification and photochemical ozone creation potential, by contrast, are distributed more evenly over all the phases of the life cycle. The significant savings in these categories are chiefly due to the more stringent exhaust emission standards applied to the current models.

Petrol models

A comparison of the petrol vehicles also shows that the greatest potential environmental impacts are in the areas of photochemical ozone creation, global warming potential and acidification. In this case too, the current models represent an improvement over their predecessor in all categories (see Fig. 12).

Comparative environmental profiles
normalised

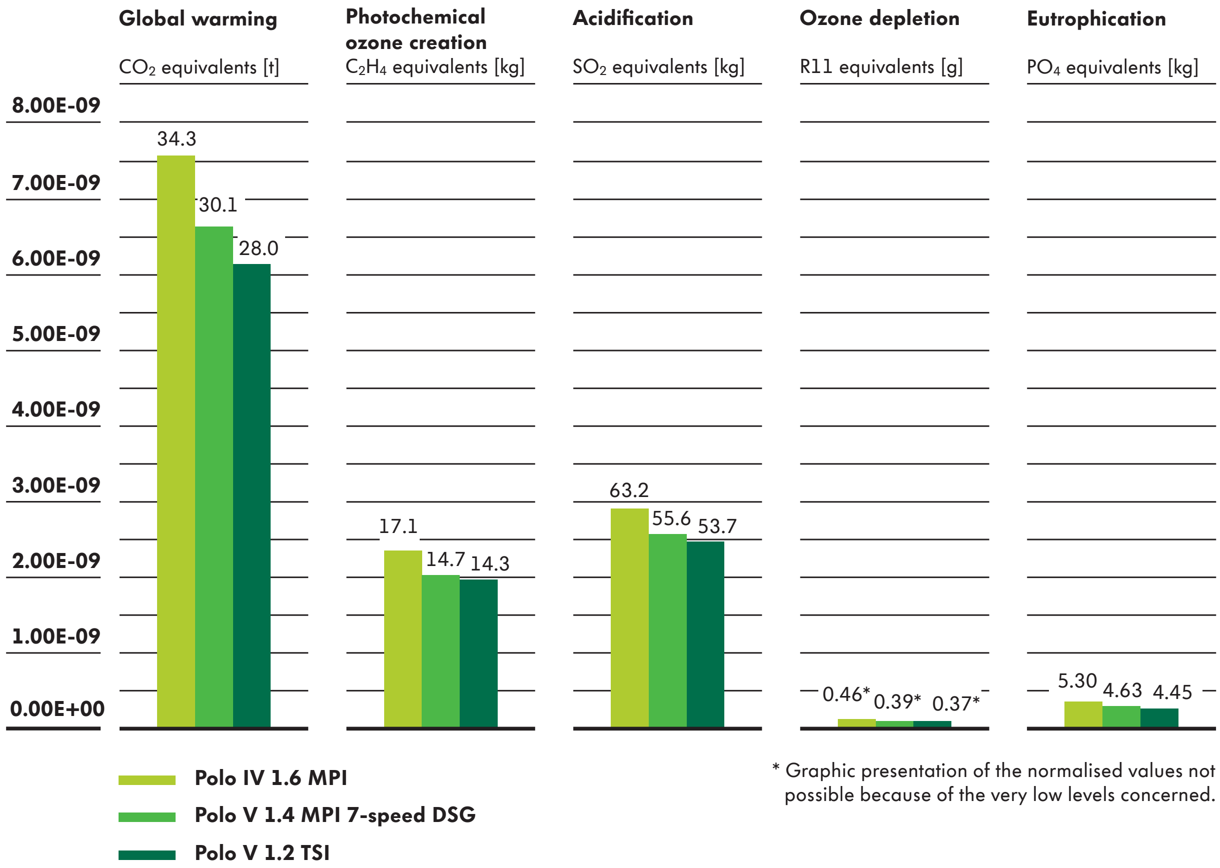

Fig. 12: Environmental impacts of the Polo IV 1.6 MPI and its successors, the Polo V 1.4 MPI DSG® and Polo V 1.2 TSI (absolute)

During its entire life cycle, the greenhouse gas emissions of the Polo 1.4 MPI DSG® are significantly lower than those of the predecessor model. In the case of the 7-speed DSG® dual-clutch gearbox, the combination with an automatic transmission, which normally results in higher fuel consumption than with a manual transmission, actually improves fuel economy. This confirms the innovative potential of the DSG® and the associated fuel saving that is possible. Overall, for the assumed distance driven of 150,000 kilometres, greenhouse gas emissions show a reduction of more than four metric tons of CO_2 equivalents per vehicle. An even greater saving of more than six metric tons of CO_2 equivalents is achieved by the new Polo with 1.2-litre TSI engine.

Fig. 13 indicates the changes in environmental impacts between the Polo 1.6 MPI and its successors, the Polo 1.4 MPI with DSG® and 1.2 TSI. The diagram clearly shows that photochemical ozone creation potential has been reduced by 14 percent and acidification potential by 12 percent for the Polo 1.4 MPI with DSG. Global warming potential is also reduced by 12 percent. With the Polo 1.2 TSI, the savings are even more pronounced, with photochemical ozone creation potential down 16 percent and acidification potential down 15 percent. In terms of global warming potential, the reduction of 6.3 metric tons of CO_2 equivalents described above corresponds to a drop of 18 percent.

Comparative environmental profiles in detail
normalised

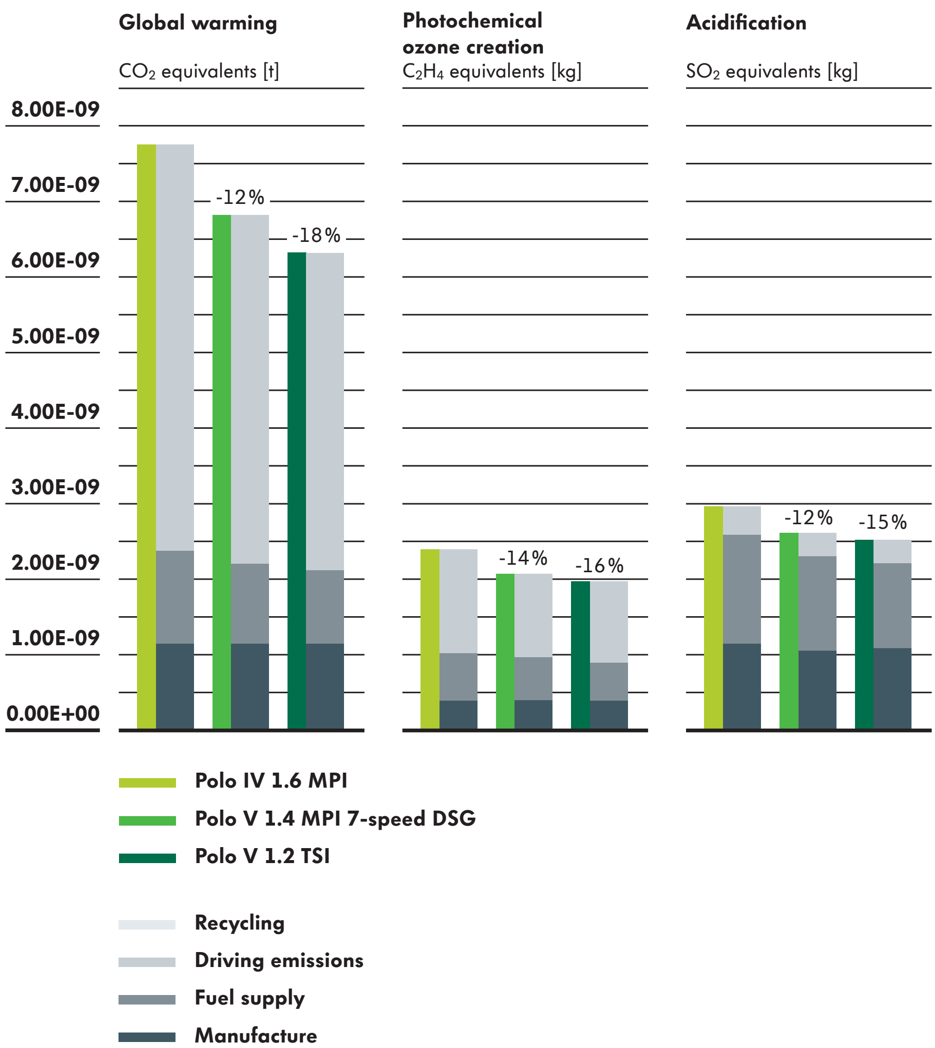

Fig. 13: Environmental impacts of the Polo IV 1.6 MPI and its successors, the Polo V 1.4 MPI DSG® and Polo V 1.2 TSI (relative)

Fig. 13 indicates the sources of these improvements in detail. As with the diesel models, the lower fuel consumption of the current Polo 1.2 TSI and Polo 1.4 MPI with DSG® is the main factor in reducing the environmental impact. It can clearly be seen that the driving emissions and the contribution to emissions associated with fuel supply are both lower in the case of the current models. The manufacture of the current models results in a slightly higher environmental impact. However, improvements in the service life emissions and fuel production process easily outweigh this increase. In the case of the petrol models too, the recycling phase has only a negligible environmental impact.

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. 14). The lower values for the Polo 1.4 MPI with DSG® and the Polo 1.2 TSI 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 fuel production for the current models, as well as to their more stringent exhaust emission standard.

Comparison of environmental impacts over the full life cycle
normalised

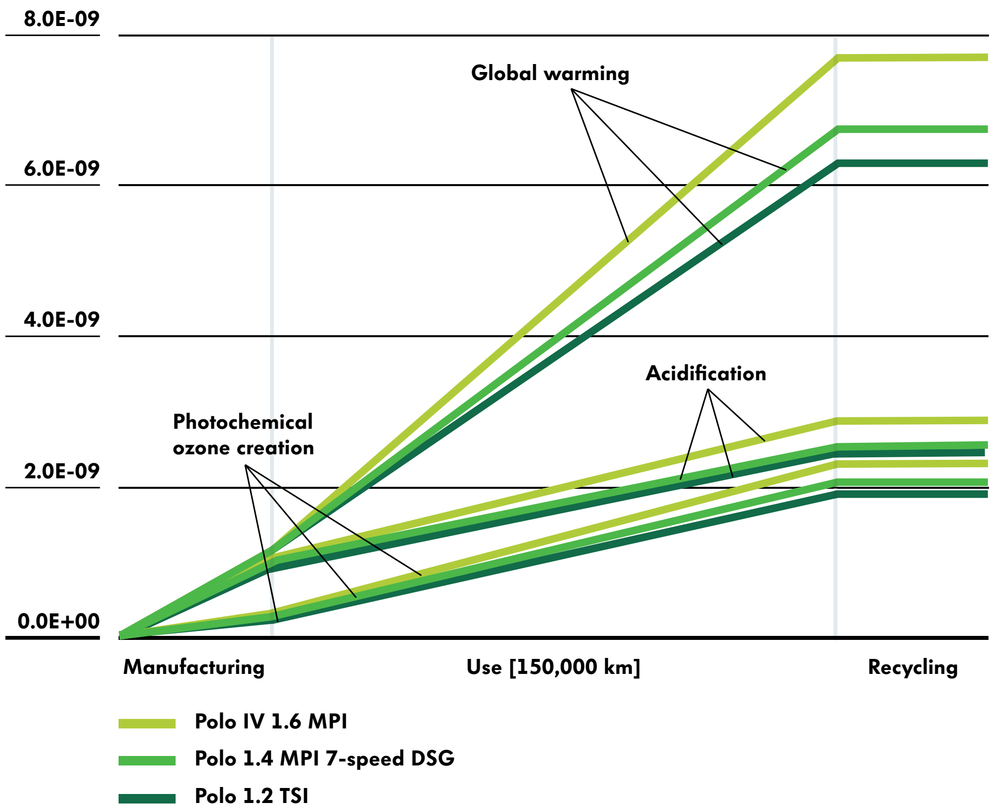

Fig. 14: Comparison of environmental impacts over the full life cycle – petrol models

Certification

The statements made for the Polo Environmental Commendation are supported by the Life Cycle Assessment of the Polo. 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 Polo (Model Year 2011)

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. 3505 5777

Certification office of the TÜV NORD CERT GmbH

Essen, dated 2010-11-12

Dr. Winfried Hirtz
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.

Bibliography and list of sources

[ISO 2006] International Organization for Standardization: ISO 14040: Environmental Management – Life Cycle Assessment – Principles and Framework. 2. Aufl. Genf: International Organization for Standardization.

[EU 1992] 92/21/EWG Europäische Union: Richtlinie des Rates der Europäischen Union über Massen und Abmessungen von Kraftfahrzeugen der Klasse M1

[EU 2001] 80/268/EWG Europäische Union: Richtlinie des Rates der Europäischen Union über Maßnahmen gegen die Verunreinigung der Luft durch Emissionen. Brüssel: Europäische Union.

[EU 2004] 70/220/EWG Europäische Union: Richtlinie des Rates über die Kohlendioxidemissionen und den Kraftstoffverbrauch von Kraftfahrzeugen. Brüssel: Europäische Union.

[EU 2008] Verordnung (EG) Nr. 692/2008 der Kommission vom 18. Juli 2008 zur Durchführung und Änderung der Verordnung (EG) Nr. 715/2007 des Europäischen Parlaments und des Rates über die Typgenehmigung von Kraftfahrzeugen hinsichtlich der Emissionen von leichten Personenkraftwagen und Nutzfahrzeugen (Euro 5 und Euro 6) und über den Zugang zu Reparatur- und Wartungsinformationen für Fahrzeuge

[Guinée und Lindeijer 2002] Guinée, J. B.; Lindeijer, E.: Handbook on Life Cycle Assessment: Operational guide to the ISO standards. Dordrecht [u.a.]: Kluwer Academic Publishers.

[Koffler et al. 2007] Koffler, C.; Krinke, S.; Schebek, L.; Buchgeister, J.: Volkswagen slimLCI – a procedure for streamlined inventory modelling within Life Cycle Assessment (LCA) of vehicles. In: International Journal of Vehicle Design (Special Issue on Sustainable Mobility, Vehicle Design and Development). Olney: Inderscience Publishers (in press).

[Krinke et al. 2005a] Krinke, S.; Bossdorf-Zimmer, B.; Goldmann, D.: Ökobilanz Altfahrzeugrecycling – Vergleich des VW-SiCon-Verfahrens und der Demontage von Kunststoffbauteilen mit nachfolgender werkstofflicher Verwertung. Wolfsburg: Volkswagen AG. Im Internet unter www.volkswagen-umwelt.de.

[Krinke et al. 2005b] Krinke, S.; Nannen, H.; Degen, W.; Hoffmann, R.; Rudloff, M.; Baitz, M.: SunDiesel – a new promising biofuel for sustainable mobility. Vortrag auf der 2nd Life-Cycle Management Conference Barcelona. Im Internet unter www.etseq.urv.es/aga/lcm2005/99_pdf/Documentos/AE12-2.pdf.

[PE International 2003] PE International GmbH: GaBi 4.2 Datenbank-Dokumentation. Leinfelden-Echterdingen: PE International GmbH.

[Schmidt et al. 2004] Schmidt, W. P.; Dahlquist, E.; Finkbeiner, M.; Krinke, S.; Lazzari, S.; Oschmann, D.; Pichon, S.; Thiel, C.: Life Cycle Assessent of Lightweight and End-Of-Life Scenarios for Generic Compact Class Vehicles. In: International Journal of Life Cycle Assessment (6), S. 405-416.

[Schweimer und Levin 2000] Schweimer, G. W.; Levin, M.: Sachbilanz des Golf A4. Wolfsburg: Volkswagen AG.

[Schweimer und Roßberg 2001] Schweimer, G. W.; Roßberg, A.: Sachbilanz des SEAT Leon. Wolfsburg: Volkswagen AG.

[Volkswagen AG 2009a] Volkswagen AG: Der Polo Umweltprädikat, Wolfsburg: Volkswagen AG. Im Internet unter www.umweltprädikat.de

[Volkswagen AG 2009b] Volkswagen AG: Der Passat Umweltprädikat, Wolfsburg: Volkswagen AG. Im Internet unter www.umweltpraedikat.de

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

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Appendix

Hanover, 12.11.2010
TNC Umweltgutachter-H

Report

Critical Review of Life Cycle Assessment

Polo - Environmental Commendation, Model Year 2011

Report No.:	8000376883/1200
Client:	Volkswagen AG 38436 Wolfsburg
Author of Life Cycle : Assessment	Volkswagen AG K-EFUP Dr. Warsen
External reviewers :	Dr. Winfried Hirtz
Length of report:	9 pages

TÜV NORD CERT Umweltgutachter GmbH
Geschäftsstelle Hannover
Am TÜV 1, 30519 Hannover, Germany, Tel.: +49(0)511/986-2420
Fax.: +49(0)511/986-2899 9287, E-Mail: whirtz@tuev-nord.de

1 General

1.1 Object and Terms of Reference

Volkswagen AG, Department K-EFUP, Environment Affairs Product, has drawn up a comparative Life Cycle Assessment " Polo - Environmental Commendation" .

Volkswagen AG, Department K-EFUP Environment Affairs Product, commissioned TÜV NORD CERT Umweltgutachter GmbH to carry out a critical review of the Life Cycle Assessment as an independent body in accordance with DIN ISO 14040 and DIN ISO14044.

The review was carried out for TÜV NORD Umweltgutachter GmbH by Dr.-Ing. Winfried Hirtz, Environmental Verifiers licensed under the Environmental Audit Act

Under the terms of reference, the objective of the critical review was to verify the reliability, transparency, relevance and representative nature of the methods used for Life Cycle Assessment with respect to

- Objective and scope of assessment
- Life Cycle Inventory
- Life Cycle Impact Assessment and
- Evaluation of assessment

1.2 Procedure

Taking into account the general quality criteria (chiefly transparency, reproducibility, quality of the computer programs and data used, and information on the sources of data), the procedure used for the critical review was as follows:

- Review of the objective and scope of the assessment, especially the function and functional equivalence of system boundaries and cut-off criteria (space, time, technology), allocation procedures together with the allocation and distribution rules adopted, and the selection of significant parameters and materials.

- Review of the Life Cycle Inventory drawn up, especially with regard to the input/output analyses (major process chains), the input and output data used and the reliability of such data, the systematic nature, completeness and plausibility of the input/output analysis, the sensitivity analysis and the assessment of errors, the plausibility and reliability of computer programs, and the consideration of upstream process chains, by-products and secondary post-use effects

- Review of the Life Cycle Impact Assessment, concentrating on the selection of impact categories (with respect to subject areas and problems) and the concentration of data with reference to impact categories

- Review of the evaluation and the comparative statements made on the basis of the evaluation

System representations, data files and other representative documents were inspected and compared on a random sample basis and some data collection and calculation procedures were reproduced on the computer, in some cases with targeted variation. For example, data regarding the previous model were viewed with respect to limit values, consumption and the utilisation phase. In the case of the current models, the overall vehicle assessment of various modelsin comparison to the previous model were considered, e.g. Blue Motion, Blue Motion Technology and 7-gear transmission DSG. In general, duplication of effort was avoided during the critical review. Relevant literature concerning life cycle assessment techniques was taken into consideration.

2 Result of Critical Review

2.1 Objective of Assessment

The objectives of the Life Cycle Assessment are defined clearly and unambiguously; external and internal target groups for the assessment are also stated. The presentation adopted for the Environmental Commendation for the Polo provides sufficient appropriate information to make the intended environmentally holistic approach clear and comprehensible.

2.2 Scope of Assessment

The Life Cycle Assessment considers the manufacture, use and disposal of a VW Polo motor vehicle. model year 2011. Various variants were considered. The scope and system boundaries of the assessment are clearly and unambiguously defined in relation to the entire system with respect to space, time and technology. The boundaries are compatible with the selected function unit and are defined over the life cycle. Environmental impact is presented and assessed in the categories greenhouse gas emissions (CO_2 equivalent), photochemical ozone creation potential (POCP), acidification potential (AP), eutrophication potential (EP) and ozone depletion potential (ODP). As the impacts in this particular assessment are generally concerned with the greenhouse effect and POCP, these are described in more detail.

Within the scope of the assessment, all relevant materials, components and processes were logged, analysed and finally grouped together for the subsequent Life Cycle Inventory into four main modules appropriate for the object of the assessment :

- Manufacture and raw material production
- Fuel provision and transport
- Utilisation phase / Driving emissions
- Recycling (VW-SiCon)

In the case of the Polo, the kerb weight should be seen in terms of the admission value and can have a different effect on the overall assessment depending on different equipment levels. In the calculation, the basis of comparison was always the previous model with the same level of equipment.

The wide variety of components and processes brought together in the computer program modules, which is a result of the technology, have been transformed into standard components of today's technological generation without changing any other aspects. In our opinion this is a useful procedure which serves the aims of the assessment. The graphs and tables in the assessment confirm the systematic nature and completeness of the procedure selected.

The effects and factors considered negligible for the definition of the Life Cycle Assessment system are explained and, where appropriate, listed. In particular, the post-use segment is mentioned and reference is made to Volkswagen's VW-SiCon recycling system. The procedure describes the recycling of the materials contained in the various components and the effects of recycling on emissions.

In summary it can be stated that all relevant factors have been identified and taken into consideration within the area investigated in accordance with the state of the art of Life Cycle Assessments.

2.3 Life Cycle Inventory

The input/output analyses for the main modules mentioned above were carried out and the Life cycle Inventory for the Life Cycle Assessment was documented using a computer system. The calculations themselves were performed using the internationally recognized software package "GaBi".

2.3.1 Data sources

The main processes in the individual areas have been modelled realistically. The data sources are based on generally accepted files, they are comprehensible and representative as regards this Life Cycle Assessment. The data basis of the "GaBi" system is extremely comprehensive. The data can be understood and traced.

2.3.2 Plausibility and completeness review

The computer system reflects the system boundaries systematically and is consistent with the assessment area defined. Boundaries are drawn at points where no (significant) impact on the results of the individual areas or the overall assessment is expected (see also the sensitivity analyses conducted). The data are of high quality and are highly symmetrical. The data used is drawn from databases (IMDS) into which the available information regarding the individual components and parts lists which are used is entered. This information is regularly verified by means of information requested from manufacturers.

All four Life Cycle Inventory areas (raw material production, fuel provision, vehicle utilisation and recycling/disposal) were verified on the basis of random samples. The correctness and plausibility of the calculations and the results were verified by reviewing selected parameters (e.g. GWP (global warming potential), POCP, AP, material input transportation, recyclability etc.) In this way, the links between the various areas and the hierarchy of data used for the assessment calculations were verified with respect to the process plans, the inclusion of partial assessments and the data basis.

Different data are new or adapted in GaBi or are made by Volkswagen. So the new data like the glass panes old/new are compared, the introduction of vulcanisation in GaBi, the change of procedures like deep-drawing insted of blanking are considered. The data for painting are new and come from Volkswagen. Remark: Therefore the results of Polo IV in this study can be lightly different in comparison with the previous environmental commodation.

For the Blue Motion (new model) are checked especially the production of wheel rim (steel and aluminium), spoiler included parts lists, electrical system "voltage transformer D/C", and use phase. For the Blue Motion Technology (new model) are checked especialle the use phase and the process overview to the production. Key aspects for the TDI 1,2 were verified with the calculations to the environmental effects.

The data for final assembly are the data from Wolfsburg 2005, it should be checked, if an actualisation of data could be made.

Furthermore, the data to the exhaust system and noble metals are checked, the same was done for the data to the car bottoms in the front and at the end.

In order to ensure that the data used could be traced back to the original data sources, both the calculations and the documentation were investigated and found to be very clear and transparent.

The environmental auditor made suggestions concerning supplements to the documentation, which was then changed on site (e.g. landfilling, data links between the different variants, descriptions as a basis for further calculations). By the completion of the project, the derivation of all the data was entirely comprehensible and traceable.

All significant parameters are available and representative and have been systematically derived and duly assessed. The assessments and the underlying data collection and calculation procedures are transparent and traceable.

2.3.3 Allocations

Allocations arise in connection with vehicle production; they are included in a database and it was possible to represent them appropriately. They are represented in the computer system completely, clearly and plausibly.

To the extent that allocations are imported to the process plan from databases, the data basis is adequate. Allocations from the databases have already been taken into consideration in the process plan.

2.3.4 Error assessments

Separate error assessments were drawn up for the manufacturing phase. In view of the numeric stability and proven quality of the data used, there is no need to include the separate error assessments (see also 2.3.5). The error assessment for the manufacturing phase amounts to approximately 2% over the life cycle regarding CO_2 emissions and use of primary energy.

2.3.5 Sensitivity Analysis

Sensitivity analyses were not carried out because the variants had the same level of equipment. In addition, the same calculated and therefore lesser values result for the equipment variants

In order to verify this statement, calculations regarding sensitivities and the associated parametering were performed at the client's premises. There were no indications that special sensitivity calculations were needed. This also has a basis in the experience of VW AG from the many studies that have been drawn up.

2.4. Life Cycle Impact Assessment

The Life Cycle Impact Assessment is based on the results of the Life Cycle Inventory and is an integral part of the process plans.
In order to carry out a Life Cycle Impact Assessment on the basis of data and information derived from the Life Cycle Inventory, it is necessary to compress the data for defined impact categories.
Taking into consideration the objectives of the assessment, the functional unit selected and the (standard) technologies used in the assessment area, the following impact categories were defined:

- GWP global warming potential
- ODP ozone depletion potential
- AP acidification potential
- NP nutrification potential
- POCP photochemical ozone creation potential

The impact categories were therefore selected in accordance with the objectives and scope of the Life Cycle Assessment.

These quantifiable impact categories represent the system assessed and the technologies used in terms of key local, regional and global categories. Individual data were properly allocated to the various categories. Data was aggregated in accordance with the environmental impact concerned; this approach is already defined in the computer program used in accordance with the scientific dose-effect relationship.

The calculations were checked. The factors stored in the computer program are internationally recognized. With reference to the objectives of the assessment, other impact categories are of secondary importance.

Data compression within these categories has been carried out on the basis of generally accepted equivalence factors in a way which is clear, reliable and easy to follow. The presentation and discussion of the results for the case of the Polo examined in the Life Cycle Assessment and covered by the Environmental Commendation is balanced and consistent.

2.5 Evaluation

The evaluation section of the Life Cycle Assessment includes specific recommendations for users and target groups.

The evaluation of the results of the Life Cycle Inventory and Life Cycle Impact Assessment which was submitted to us is based consistently and appropriately on the objectives defined for the Life Cycle Assessment.
Further statements and recommendations are strictly separated from the Life Cycle Assessment itself.

3 Summary of the critical review

The critical review of the Life Cycle Assessment "Polo - Environmental Commendation" conducted by the undersigned in accordance with the requirements of international standards DIN EN ISO 14040:2006 and DIN EN ISO 14044:2006 may be summarised as follows:

- The methods used for drawing up the Life Cycle Assessment are in accordance with the requirements of DIN EN ISO 14040:2006 / DIN EN ISO 14044:2006. The methods are scientifically well-founded and are in accordance with the state of the art of Life Cycle Assessments.
- The data used are adequate, appropriate and well-founded with reference to the objective of the assessment.
- The evaluations take into consideration the objective of the assessment and the limitations which were identified.
- The Life Cycle Assessment is consistent and transparent.

A certificate of validity has been issued concerning the critical review which was conducted (cf. Appendix). The report of the critical review will become part of the detailed version of the Life Cycle Assessment.

Dr. Winfried Hirtz

Environmental Verifier
DE-V-0151

Group Research
Environment Affairs Product
P.O. Box 011/1774
38436 Wolfsburg
Germany

December 2010