The Volkswagen Environmental Report 1997

Key figures at a glance

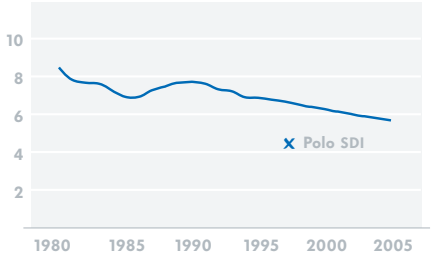
This is Volkswagen's second Environmental Report. It provides information about the environmentally related activities of the Volkswagen marque in Germany and gives examples of what is happening on the environmental front at our production plants around the world. The report covers the entire 1996 financial year and the period up to the onset of the new model year in August 1997. This report has been examined by KPMG Certification.

Recycling at Volkswagen

The amount of residual waste from scrap car disposal which has to be dumped in landfills will be reduced to 15 percent by 2002 and to 5 percent by 2015.

Fuel consumption for Volkswagen passenger cars sold in Germany

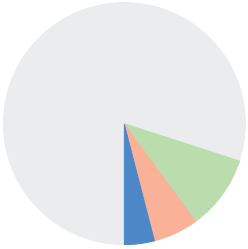
(in litres per 100 km, combined cycle)



Source: VOLKSWAGEN AG

Volkswagen has successfully cut the average fleet fuel economy figure for its products to below 7 litres per 100 kilometres. Individual models, such as the Polo SDI, outperform this figure by far. In all, our product range includes 14 models which can return fuel consumption figures of 5 litres or less per 100 kilometres in everyday use. A large proportion of our models already meet the projected Euro D3 standard which will bring exhaust emissions subject to statutory limitation down to a minimum. Certification of our Technical Development department to ISO 14001 also documents the high level of environmental awareness in the product development process at Volkswagen.

The primary energy requirement of a Golf



The total primary energy requirement of a Golf amounts to 540 GJ = 150 MWh. This assumes a distance covered of 150,000 km over a 10-year period and fuel consumption of 8.1 litres per 100 kilometres (MVEG-A cycle).

80 % Service life
10 % Petrol production
6 % Materials
4 % Production at VW

Source: VOLKSWAGEN AG

Volkswagen was the world's first car manufacturer to draw up an environmental life cycle analysis for a vehicle, in this case a Golf A3. One significant finding was that petrol production and consumption together account for 90 percent of the primary energy requirement during the vehicle's life cycle. This goes to underline the importance of all measures currently aimed at cutting fuel consumption.

Waste, emissions, water and energy consumption at all VOLKSWAGEN production plants in Germany

Industrial waste (t/a)	1994	1995	1996
recycling	24,317	22,825	38,194
disposal	32,261	30,311	23,595
Hazardous waste (t/a)			
recycling	30,523	33,222	37,521
disposal	17,684	16,748	16,469
Non-process-related waste (t/a) (1)			
recycling	5,536	4,103	3,561
disposal	978	1,120	6,037
Emissions (t/a)			
organic substances (2)	5,182	4,317	4,411
CO_2 from in-house heat/power generation	223,685	236,259	265,403
Water und waste water (million m^3/a)			
drinking water (3)	5.6	5.9	5.6
waste water (4)	7.3	7.3	(5) 6.6
Energy (MWh/a)			
total energy consumption	4,889,432	5,204,941	5,779,776

t/a = tonnes per annum
(1) building rubble, excavated soil, etc.
(2) VOC (volatile organic compounds)
(3) not incl. surface water used
(4) incl. rainwater used
(5) reduction at Wolfsburg plant owing to modernization of drainage system, reducing the amount of external waste water entering the system
Source: VOLKSWAGEN AG

This is the first time that our process-oriented environmental information system has included all key environmental data for Volkswagen's German production plants. The data for our facilities outside Germany will be progressively integrated in future. To date, five German plants have obtained certification in line with the EC Eco-audit Regulation. Our aim is to have all Volkswagen's European production facilities audited in line with this Regulation by 1999. The remaining plants outside Europe are to be certified in accordance with the ISO 14001 standard.

The Volkswagen Environmental Report 1997

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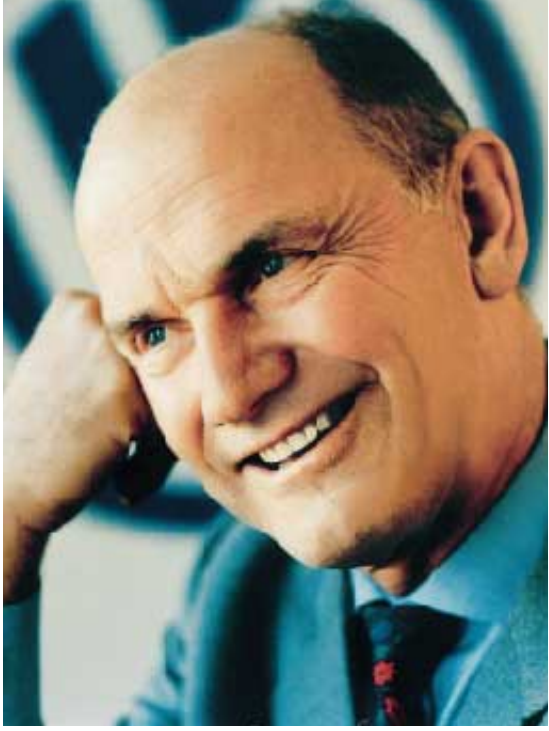
Foreword

On the Threshold of the 21st Century



Dr. techn. h. c. Dipl. Ing. ETH Ferdinand Piëch, Chairman of the Board of Management

These are no small challenges that we face: safeguarding peace and prosperity for a global population that continues to grow apace, while at the same time conserving an intact natural habitat for future generations. One avenue of approach proposed in 1992 at the United Nations Conference on the Environment and Development in Rio de Janeiro was the precept of sustainable development.

Volkswagen has made an express commitment to the contents of this precept. Accordingly, when we as a company reach a decision, we take account of the social and ecological implications of our actions – for our staff, for our customers and for society at large. For Volkswagen this is not so much a new approach as an element of our corporate culture which has evolved over the years. In this, our second Environmental Report, we have set out to describe the fruits of our efforts to date. The Report provides information about activities in the 1996 financial year and up to the onset of the new model year in August 1997.

We have achieved a continuous improvement in the environmental compatibility of our products; we have met the targets set out in our last Environmental Report, and we have reached important milestones in environmental protection both within and beyond the bounds of our company. We have succeeded in compiling a life cycle analysis of the Golf – a move which has enabled us to access fundamental findings on a car's environmental impact, from the extraction of the raw materials to recycling and disposal. Today, the average fleet fuel economy figure for our models stands at less than 7 litres per 100 kilometres. We have a total of 14 models in our range which can achieve fuel economy levels of 5 litres or less over 100 kilometres. Moreover, not only did we meet all the exhaust emission levels laid down in the Euro 2 standard two years in advance of the legal requirement, we have also ensured that a large proportion of our models already fulfil the stringent demands of the Euro d3 standard. Five Volkswagen plants have now successfully completed the ec Eco-audit certification process, while our Technical Development department has obtained certification in line with the international iso 14001 standard, providing twofold documentary proof that our products are developed and manufactured in line with the latest findings in environmental technology and demonstrating Volkswagen's extensive – and in many respects voluntary – commitment to the protection of the environment.

Our next Environmental Report will be published in the autumn of 1999. By then we are aiming to have reached many new goals, one of which is particularly close to our hearts; namely the launch of a Volkswagen that can cover 100 kilometres on just 3 litres of fuel.

Wolfsburg, November 1997

Dr. techn. h.c. Dipl. Ing. ETH Ferdinand Piëch

Safeguarding jobs and protecting the environment go hand in hand. For the Works Council that means helping to chart a course and shouldering our share of responsibility

In our efforts to safeguard the future of our production plants and jobs - and indeed our common future – protecting the environment is simply essential. Our customers want greener products; society expects our company to act in an environmentally responsible manner. In short, we have every reason to continue making an active contribution to the long-term conservation of our natural environment.

However, for a company to be able to act in an environmentally responsible way, each and every employee must be actively involved. To put it another way, Volkswagen means us – all of us together. We are the ones who live out our corporate culture. The number of voluntary environmental projects undertaken by colleagues with a commitment to the environment provide impressive proof of our responsible approach. Several such projects are described by way of example in this Report. To all those involved, I would like to say "Thank you for your commitment – let's continue down this road together."

In the future we shall not let up in our efforts to ensure that the objectives agreed between the General Works Council and Management and anchored in the factory agreement on *Environmental Protection at VOLKSWAGEN AG* are reached. This is in the best interests of each and every one of us. More environmentally compatible production processes also mean healthier working conditions for the workforce.

Together, the exceptional quality of Volkswagen products and our committed, responsible approach to active environmental protection will convince our customers, enabling us to safeguard levels of employment and value-added at our plants all over the world.

Wolfsburg, November 1997
Klaus Volkert

Klaus Volkert, Chairman of the General and Group Works Council

Volkswagen in Facts and Figures

A brief overview

Volkswagen is one of the largest companies and one of the largest motor vehicle manufacturers in the world. Our business operations focus on the manufacture and marketing of cars and commercial vehicles, the production of industrial engines, machines, tools, spares, components and parts for the Group's integrated production network, and the provision of financial services.

This Report documents the environmental activities of the Volkswagen marque in Germany and provides examples of activities at our production facilities abroad. In 1996, not including its non-European regional companies, the Volkswagen marque produced 1,498,341 passenger cars and 152,753 commercial vehicles.

In addition to the German production plants of volkswagen ag in Wolfsburg, Hanover, Emden, Brunswick, Salzgitter and Kassel, and those of the Volkswagen marque in Mosel and Chemnitz, the Group maintains production facilities and sales companies all over the world. On the German passenger car market, Volkswagen's model range extends from the Polo, Polo Classic and Polo Estate, via the Golf, Golf Estate, Golf Convertible, Vento, Passat and Passat Estate to the Sharan and Caravelle; in the commercial vehicle sector our range extends from the Caddy and Transporter via the 1t, all the way to the 1 80. Volkswagen maintains business relations with more than 12,500 suppliers. In more than 165 countries, over 100,000 employees at independent Volkswagen dealerships dedicate their efforts to the sale, care and maintenance of our products.

The new Golf

Key figures for 1996

	Unit sales 1,000 veh. (% change)	Production 1,000 veh. (% change)	Employees Dec. 31, 1996 (% change)	Sales DM mill. (% change)	Capital investments DM mill. (% change)
Volkswagen cars	1,758 (+5.0 %)	1,498 (+5.8 %)	104,733 (-4.6 %)	53,776 (+11.7 %)	3,410 (+48.3 %)
Volkswagen com. vehicles	200 (+21.9 %)	153 (-5.6 %)	14,623 (-4.0 %)	6,403 (+14.4 %)	324 (+56.5 %)
North American region	301 (+24.3 %)	231 (+20.7 %)	14,088 (+5.6 %)	7,504 (+34.0 %)	487 (+43.3 %)
South American/ African region	752 (+13.6 %)	696 (+4.8 %)	39,919 (-1.4 %)	13,564 (+21.3 %)	798 (-55.7 %)
Asian/Pacific region	295 (+27.0 %)	236 (+28.0 %)	14,825 (+9.9 %)	2,042 (+8.7 %)	7 (-76.1 %)

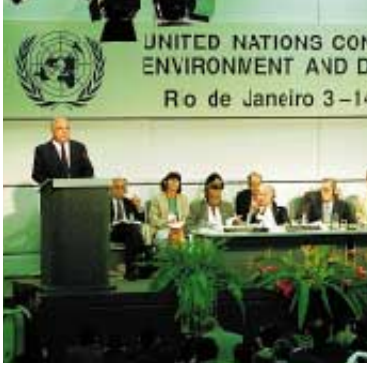
Figures are adjusted for marque- and region-specific factors.
Source: VOLKSWAGEN AG

Volkswagen and Sustainability

Global challenges

Society and the business sector are constantly changing and the motor manufacturing industry is no exception. Today, Volkswagen is exposed to fierce global competition. To hold our own, we need a consistently customer-driven approach, efficient and lean production methods and an attractive range of products. To date, we have successfully mastered the required changes. The company has developed from the North German manufacturer of the legendary VW Beetle into an international group whose products can be found in virtually every market in the world. The rapid rate at which industrialized countries consume natural resources, the dynamic pace of global population growth and the fast-moving industrialization process in Asia and South America constitute new challenges. More and more people are claiming a share of the Earth's finite resources. It is up to our generation to redress the balance between the central social, ecological and economic objectives.

The vision of sustainable development: There are no ready-made solutions. The precept of sustainable development comprises the vision of a development process which ensures that the natural foundations of human life are sustained in the long-term. The aim is to combine the conservation of natural resources, protection of the environment and the realization of social values and justice for the benefit of both current and future generations, with a process of healthy economic development. Back in 1992, the perspectives for sustainable development were set out at the un Conference on Environment and Development (unced) in Rio de Janeiro. Volkswagen was the



At the UN Conference on Environment and Development in 1992 in Rio, the precept of sustainable development was laid down as a UN objective.

Rapid growth in motorization on emerging markets will pose one of the major ecological challenges of the future.

Conference's main mobility sponsor. As a member of the group of non-governmental organizations, Volkswagen had already demonstrated its commitment to the ethos of sustainable development before the Conference began.

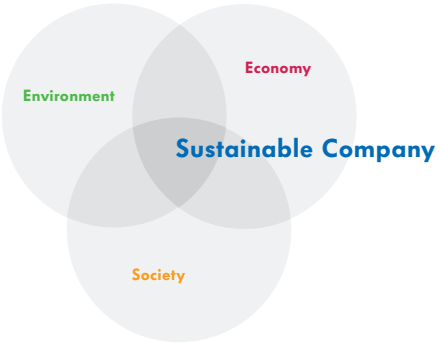
Volkswagen's contribution: In an industrial context, sustainable environmental protection can only function when both economic and social objectives are taken into account. At many of our corporate locations, Volkswagen is the largest employer, which implies a considerable responsibility for the employment situation in the surrounding region. Innovative employment models such as the four-day working week are indicative of our awareness of this responsibility. Volkswagen's interpretation of sustainability is documented not least in the company's environmental policy. We are committed to making our products more environmentally compatible over their entire life cycle, and this commitment expressly includes our suppliers, service providers and recycling operators.

Since Rio, we have put many of our original plans into practice, as witnessed for example by the advanced stage of development of our Environmental Management System, the reduction of our average fleet fuel economy figure and the presence in our product range of many particularly low-consumption or low-emission vehicles. We have also accomplished a great deal in the field of alternative propulsion systems.

Volkswagen has endorsed the voluntary commitment on the part of German automobile manufacturers to achieve a 25 percent reduction in the carbon dioxide emissions of their products by the year 2005, based on 1990 levels. As signatories to the Voluntary Agreement to Recycle Scrap Vehicles in an Environmentally Compatible Manner, within the framework of the Waste Management and Product Recycling Act, we are supporting the aim of the Federal Government to substantially reduce the amount and harmful potential of waste from the recycling of scrap cars.

All of these principles apply not only to our production plants in Germany but to our activities across the globe. One ongoing task lies in the successful transfer of both our expertise in environmental engineering and our accomplishments in the social sector to our corporate locations abroad.

Sustainable development – Volkswagen's objective



Organization

Environmental management geared to the future

We need to find long-term, sustainable solutions for every aspect of our corporate activities. By expanding our process-oriented Environmental Management System into a full-blown management matrix and increasingly gearing our efforts to the total life cycle of our products, we are striving to make sustainable development a reality.

Volkswagen's environmental protection specialists come from every division of the company.

The structure of the Environmental Management System: Prior to the introduction of our Environmental Management System (ems), the first step was to draw up a fundamental assessment of the status quo over a wide range of areas and covering a whole spectrum of issues. The key modules of ems include corporate environmental policy, goals and programmes, structures and responsibilities, documentation and environmental auditing procedures.

The Environmental Management System is process oriented and covers the entire life cycle of the car, focusing on the three core business processes of Researching and Developing, Procuring and Producing and Marketing and Recycling. But that is not all. ems also takes in the systematic expansion of Life Cycle Assessment as a management instrument; closer collaboration with suppliers on environmental matters; eco/safe driving courses for customers; supporting our dealerships in their customer care efforts through our environmental consultancy service; and the joint establishment of a take-back and recycling network in conjunction with Preussag Recycling GmbH – all significant factors in making ems a closed-loop process.

Volkswagen is to have its European production plants certified in line with the ec Eco-audit Regulation 1836/93 and at international level will promote the application of the international iso 14001 standard. We see in both procedures an opportunity to arrive at an integrated approach to environmental management which will lead everyone involved in the relevant business processes to identify with the environmental goals of our company.

At state and federal level, those responsible in the political sphere should respond by granting companies with eco-certification appropriate relief in respect of approvals and monitoring procedures.

Eco-certification for Technical Development: In what was a first for the motor manufacturing industry, in April 1996 the Technical Development department at Volkswagen obtained certification to iso/dis/14001 for its successful integration of environmental protection considerations into the vehicle development process. Product development activities are geared to the continuous improvement of Volkswagen products in respect of their environmental compatibility and the conservation of natural resources. Regulations with a bearing on the environment form part and parcel of technical specifications and contractual relations. Any effective environmental management system will always incorporate a quality management role, as well.

Rudolf Stobbe, Head of Environment, Transportation and Works Safety

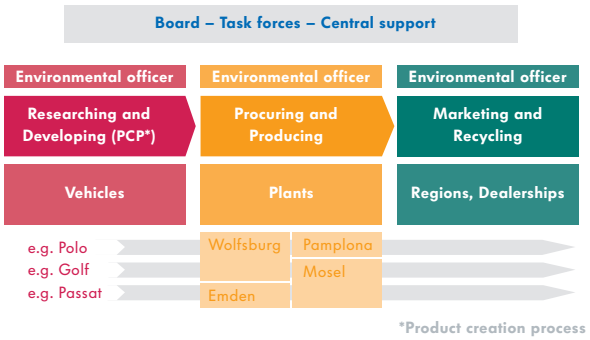
It is only through the correlation of various systems of standards, such as din/iso 9000 ff. governing quality management and iso 14001 governing environmental management that we arrive at truly integral environmental practices.

Structures and responsibilities: The member of the Board of Management with responsibility for research and development is responsible for the application of and adherence to the Environmental Management System, as well as for the definition of Volkswagen's environmental policy and its objectives. His responsibilities also include *the obligations of the operator of plant subject to licensing* in accordance with Section 52a, Federal Immission Control Act (Bundesimmissionsschutzgesetz) and Section 53, Waste Management and Product Recycling Act (Kreislaufwirtschaft- und Abfallgesetz). The environmental policy for Volkswagen's German plants is drafted by the Environmental Strategy Committee (esc) while at Group level this task is the responsibility of the Strategic Task Force for Environmental Protection (step).

The Environmental Management Officers for the three core business processes support the corporate divisions, help coordinate environmental project groups, monitor adherence to environmental goals and contribute to decision-making processes. Management and workforce are responsible for achieving the environmental goals in practice. Their efforts are supported by the specialist environmental functions within the Research, Environment and Transportation division and in Marketing/Customer Services.

Environmental management – by product and plant

(Management matrix)



Workshops

In 1996, within the framework of the continuous improvement process the Volkswagen marque held a total of 2,066 workshops. In the divisions assessed, there was an improvement in environmental performance (e.g. waste generated, energy and paper consumption).

Environmental Policy

Volkswagen has a long tradition of protecting the environment. Our environmental roots go back to the post-war years when resources were scarce and to an early awareness of the company's social responsibility towards the structurally disadvantaged regions in which the first Volkswagen plants were located.

Throughout the Nineties, Volkswagen has remained true to this tradition: in 1992 the company was one of the original signatories to the Business Charter for Sustainable Development drawn up by the International Chamber of Commerce (icc). As a member of the German Society for Environmental Management (b.a.u.m.) and through our involvement in the work of the icc and the World Business Council for Sustainable Development (wbcsd), we have continually taken a proactive corporate stance on environmental issues. In 1995, on the basis of Group-wide Basic Principles, the current version of Volkswagen's environmental policy was formulated. A factory agreement between Management and Works Council defines these Basic Principles as the foundations upon which the activities of all Volkswagen employees are based. Also in 1995, the protection of the environment was expressly anchored in Volkswagen's quality management policy.

At the Volkswagen plant in Anting/Shanghai, China, a board displays the company's environmental policy in German and Chinese

Volkswagen's Environmental Policy

Preamble

Volkswagen develops, manufactures and markets motor vehicles worldwide with the aim of safeguarding personal mobility. The company accepts responsibility for the continuous improvement of the environmental compatibility of its products and for the increasingly conservative use of natural resources, with due regard to economic aspects. Accordingly, the company makes environmentally efficient, advanced technology available worldwide and brings this technology to bear over the full life cycle of its products. At all its corporate locations, Volkswagen works hand-in-hand with society and policy-makers to shape a development process that will bring sustainable social and ecological benefits.

Basic Principles

1. *It is the declared aim of Volkswagen in all its activities to restrict the environmental impact to a minimum and to make its own contribution to resolving environmental problems at regional and global level.*

2. *It is Volkswagen's aim to offer high-quality automobiles which take equal account of the expectations of its customers with regard to environmental compatibility, economy, safety, quality and comfort.*

3. *In order to safeguard the long term future of the company and enhance its competitive position, Volkswagen is researching into and developing ecologically efficient products, processes and concepts for personal mobility.*

4. *Those responsible for environmental management at Volkswagen shall, on the basis of the company's environmental policy, ensure that in conjunction with suppliers, service providers, retailers and recycling companies, the environmental com-patibility of its vehicles and production plants is subject to a process of continuous improvement.*

5. *The Volkswagen Board of Management shall, at regular intervals, check that the company's environmental policy and objectives are being observed and that the Environmental Management System is working properly. This shall include evaluation of the recorded environmentally relevant data.*

6. *Providing frank and clear information and entering into dialogue with customers, dealers and the public is a matter of course for Volkswagen. Cooperation with policy-makers and the authorities is based on a fundamentally proactive approach founded on mutual trust and includes provision for emergencies at each production site.*

7. *In keeping with their duties, all Volkswagen employees are informed, trained and motivated in respect of environmental protection. They are under obligation to implement these principles and to comply with statutory provisions and official regulations as these apply to their respective activities.*

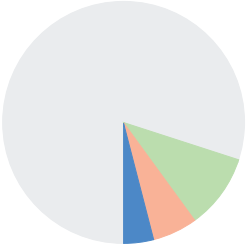
Life Cycle Analysis: the Golf

In recent years, Volkswagen has been working hard to develop methods of improving the environmental compatibility of its products. One result of these efforts has been the generation of a life cycle analysis for our most popular model, a Golf A3, with a typical level of equipment. Life cycle analysis provides us with the documented data required to put the environmental debate on an objective footing.

The overall Life Cycle Assessment of any given product consists of three parts: life cycle analysis, impact analysis and evaluation. Volkswagen drew up the life cycle analysis of the Golf in conjunction with external partners. It enables specific characteristics of the car during its production and subsequent service life to be identified. These include energy and raw material requirements and emissions. Life cycle analysis also provides good factual foundations for open discussions on the subject of traffic and the environment. A car's primary energy requirement results largely from fuel consumption during its assumed 10-year service life.

Fuel production and consumption together make up 90 percent of a car's primary energy requirement. This provides a clear indication of how important measures aimed at cutting fuel consumption really are. The amount of energy required to manufacture a passenger car is comparable to that required to produce the fuel it will consume. Each of these production processes accounts for roughly 10 percent of the total energy requirement. The energy needed to

Primary energy requirement of a Golf



The total primary energy requirement of a Golf is 540 GJ = 150 MWh. Assumed mileage is 150,000 km over 10 years, assumed consumption (MVEG-A) is 8.1 litres per 100 km.

80 % Service life
10 % Petrol production
6 % Materials
4 % Production at VW
(rounded figures)

Source: VOLKSWAGEN AG

Groups of materials in the Golf

(Kerb weight 1,025 kg including full tank)

64.0 % Steel and iron (250 kinds)
16.0 % Plastics (150 kinds)
5.5 % Petrol, oil, grease
4.0 % Rubber
3.1 % Glass
2.5 % Light metals
1.6 % Non-ferrous metals
1.3 % Electrics, wiring
1.1 % Insulating material
0.9 % Paint
0.2 % Others
(rounded figures)

Source: VOLKSWAGEN AG

produce the materials required in a car is slightly higher than the energy used in the assembly of the vehicle.

If we sort the individual components of a car by weight, it emerges that some eighty components are required to make up one half of the car's weight, including three heavyweight items: 41 kilograms of petrol, 34 kilograms of engine block and 26 kilograms of tyres. The final 3 percent of its weight is made up of several thousand parts. No single type of material predominates, neither for the major components nor the small parts.

Steel and iron are prevalent, not least because of the high degree of specialization they permit. Among the plastics there is a problem on the definition front: most plastics are compounds made up of organic and inorganic substances. For the purpose of weight classification, we have not segregated the plastic components. Wiring, electric motors, switches, fuses, etc. are grouped together under *electrical materials*. Care and maintenance during the car's service life consume additional materials and generate waste. Some of this waste, including used oil, batteries, tyres, bumpers and wax, is recycled.

The diagram shows selected airborne or waterborne emissions in the form of a bar chart. Each bar shows the data for the three phases: vehicle production, fuel production and service life. Carbon dioxide which is a product of the combustion process in the car engine is the emission mostly generated during the service life. For the remaining emissions it is the fuel production phase which dominates the picture.

A life cycle analysis of this kind can provide a useful aid to decision-making when it comes to optimizing the ecological impact of the vehicle, always assuming that:

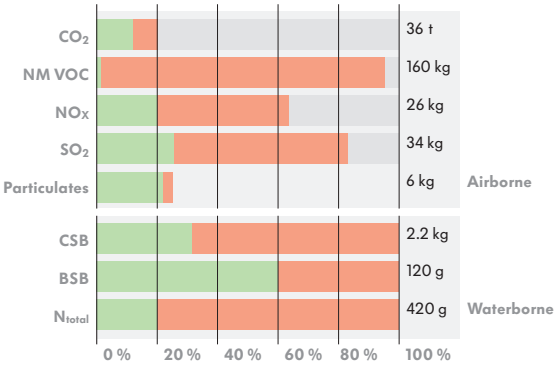
- firstly, the systematic errors in the data can be substantially reduced;
- secondly, the data structure actually reflects the structure of the manufacturing process;
- thirdly, the data is already available when the individual components are being designed.

Our investigations have shown that it is indeed possible to draw up an ecological balance-sheet for a product as complex as a car. However, the primary benefit of life cycle analyses will not be realized in full until agreement is reached on the necessary framework, namely the inclusion or exclusion of such factors as factory facilities or infrastructure.

How does the life cycle analysis for the Golf help? It enables us to make clear statements about the life cycle of the car as a product and of its operating fluids. It does not include production plant and equipment or the necessary infrastructure, i.e. primarily the roads. Trying to draw up a separate cradle-to-grave life cycle analysis for every part of a car is a hopeless venture. Quite apart from problems with methodology, it would simply take up too much time. Drawing up such analyses in individual cases by way of example, however, can promote learning by doing and may also provide the manufacturer with important data.

In our evaluation of the acquired data, we are dependent on the benchmarks set down by society. Business operations always have a positive or negative impact on the environment. To what extent and in what form such impacts are accepted and what price is deemed acceptable for their reduction or elimination, cannot be decided by an industrial enterprise alone. With the advent of this holistic approach to compiling a Life Cycle Assessment for the car as a product, we at Volkswagen have opened up new horizons in environmentally-oriented management. Now we are working towards a computer-assisted system of data acquisition and processing which will enable us to call up information on the environmental impact of a car with the vehicle still at the development stage. The next step will involve asking our suppliers to draw up life cycle analyses of their products.

Selected emissions
(per car)



Service life
Petrol production
Car production

Source: VOLKSWAGEN AG

Volkswagen's Dr. Georg Schweimer presented the results of the life cycle analysis of a Golf A3 at the joint VDI/VW conference »Integrated Views of Automobile Production« in Wolfsburg in November 1996.

Framework for the life cycle analysis of a car

	Tools Factories	**Product** Car	**Operating fluids** Petrol/Oil	**Infrastructure** Roads
Administration				
Planning				
R & D				
Prospecting			Extraction	
Raw materials		Materials	Crude oil	
Production		Suppliers VW-Plants	Refinery Distribution	
Service life		Maintenance	Petrol Combustion	
End of life		Shredder	Waste oil	
Landfill				

Source: VOLKSWAGEN AG

Employee Initiatives

Lifelong learning – getting people involved

Staff from the final assembly sector at the Wolfsburg plant have founded their own "Green Team" to ensure that as much waste material as possible gets recycled.

You cannot impose environmental protection from above, it has to be lived out by all concerned. It was with this in mind that we drew up our Factory Agreement on Environmental Protection. To ensure that the relevant duties and responsibilities are clearly laid down in black and white, we have compiled an Environmental Management Manual. Between 1990 and 1995, the number of environmental protection specialists at Volkswagen increased fivefold to approximately 130. These are Volkswagen employees at junior management level who play a supervisory, informative and advisory role. By integrating environmental management into the leadership process, we are able to draw on the existing environmental commitment of each and every member of staff and build on these assets.

The following examples are typical of the many activities initiated by Volkswagen employees. Together they illustrate how the notion of protecting the environment comes to transcend our environmental policy and the Factory Agreement and forms part of everyday life at the company.

The final assembly sector's Green Team: Avoiding waste is better than reducing it; reducing better than recycling; recycling better than disposal – thus runs one of the rules of Good Environmental Practice from the Factory Agreement on Environmental Protection. Many parts and components arrive at the Wolfsburg plant in containers, are fitted out with plastic protective caps, wrapped in plastic film or foam and protected against shifting around during transport by cardboard fillers. Employees in the final assembly sector have formed an

The members of the joint project team were drawn from all divisions of the company.

environmental team to ensure that as much of this packaging material as possible is re-used or recycled. The *Green Team* now numbers some fifty staff, all helping to save energy and raw materials and the number of different paper, cardboard, polyethylene film, foam or plastic parts they return to the materials cycle has now risen to over 160. The initiative has come to involve not only other Volkswagen plants but also some 50 external suppliers who are now re-utilizing the material collected. Consequently, the *Green Team* is also ensuring that the provisions of the Waste Management and Product Recycling Act are put into practice in Wolfsburg.

Recycling PVC underseal: Paintshop staff at the Wolfsburg plant came up with the idea of recycling PVC underseal. What they envisaged was a piece of equipment that would remove substantial contaminants from the waste generated during the underseal process and filter it. Back in 1990, acting on their own initiative they designed the equipment they needed and commissioned it. As a result, the underseal can now be returned to the manufacturer for reconditioning. The equipment was largely devised using existing components, modified for their new role and even includes scrap parts. Since 1990 the separating efficiency of the system has been continuously upgraded; today it stands at 96 percent, with an annual capacity of 400 tonnes. Our aim is to achieve a substantial reduction in volumes of waste. When the latest paintshop in Hall 9 at Wolfsburg was designed, the undersealing concept was extensively revised, leading to a 50 percent reduction in the volume of waste.

»Joining forces for ecological efficiency« – a joint project: This project which was initiated in conjunction with the IG Metall and IG Chemie trade unions under the heading of *The environmentally and socially compatible development of materials in the automotive industry, including the supplier and recycling sectors* has been successfully concluded.

Staff at the paintshop in Wolfsburg initiated the PVC underseal recycling project.

The special aspect of this project was that working groups at company and cross-company level tried out processes designed to increase employee involvement, improve cross-functional environmental management and examine potential applications for the instruments used in Life Cycle Assessment. The companies and organizations involved were Solvay, Teroson, Gurrit Essex, Preussag Recycling AG, Institute for Polymer Science and Polymer Testing (ikp) in Stuttgart, the Social Research Office in Dortmund and the Ecological Economics Research Institute (iöw) in Berlin. The contributions of the various institutes were funded by the Federal Foundation for the Environment.

Documentation on the project can be obtained (in German only) from: VOLKSWAGEN AG, Research, Environment and Transportation, Brieffach 1774, D-38436 Wolfsburg, Germany.

Volkswagen Group Manifesto

We in the Volkswagen World, with our 5 brands, dedicate ourselves to developing, manufacturing and marketing the world's best quality and most attractive vehicles, at reasonable prices. We aim to achieve the greatest possible success in global markets with our available resources. The people of the Volkswagen World are striving to secure stable and stimulating working, learning and living conditions for the long term. We want our children and grandchildren to inherit an environmentally-safe planet.
This is our commitment.

The Car and the Environment

Along with private households, industry, power stations and agro-industries, road traffic is one of the main sources of atmospheric pollutants, most of which enter the environment in the form of exhaust emissions. As market leader in Germany, Volkswagen bears a special responsibility for ensuring that airborne pollutants are kept to a minimum.

Emissions of individual exhaust gas components are expressed in grams per kilometre travelled. The limits are constantly being tightened – most recently in 1996 – and by the end of the current decade the limit for carbon monoxide (co) is expected to be no more than around 8 percent of the 1984 limit value. For hydrocarbons (hc) and oxides of nitrogen (no_x) the targeted figure is as low as 6 percent or thereabouts. Two years ahead of the statutory obligation to do so, Volkswagen has already met all of the exhaust emission limits of the Euro 2 standard, primarily as a result of the ongoing development of the three-way catalytic converter in the case of petrol-engined vehicles, and the consistent implementation of engine improvements in the case of diesels. Even the stringent terms of the Euro 3 standard, currently under discussion, are already met by a large proportion of our models.

The exhaust emission characteristics of a vehicle are influenced by the physical properties and chemical composition of fuels. Broad-based improvements in fuel quality immediately make themselves felt over the entire vehicle population in the form of reduced emissions, and thus represent an important step in achieving a lasting improvement in the quality of the air. For example, the significant reduction in benzene emissions that resulted from the introduction of the closed-loop three-way catalytic converter was followed by a further marked drop due to the use of fuels containing a reduced level of aromatic hydrocarbons.

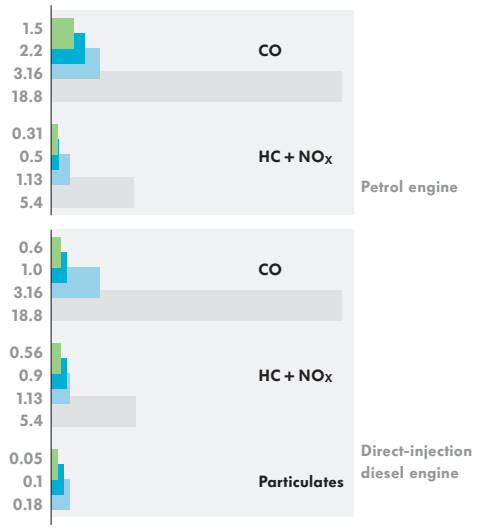
Generally speaking it can be said that where statutory limited gaseous exhaust components are concerned (co, no_x, hc) the quality of the fuel can give rise to differences in emission characteristics of up to 30 percent, while for particulates the differences can be as great as 50 percent. In the case of other exhaust components, it is frequently the composition of the fuel alone which dictates the presence or absence of substances such as lead or sulphur in the exhaust.

The effects of exhaust emissions

Local	Regional	Global
Carbon monoxide (CO) = Toxic gas *Particulates = Enter the lungs as fine dust, component of diesel emissions* *Oxides of nitrogen (NO_X) = Irritant gases affecting the mucous membranes* *Benzene = A carcinogen* *Polycyclic aromatic hydrocarbons (PAH), e.g. benzo(a)pyrene (a carcinogen) as reference substance*	*Oxides of nitrogen (NO_X), hydrocarbons (HC) = Precursors of ozone* *Sulphur dioxide (SO_2) = Cause of acid rain*	*Carbon dioxide (CO_2), Methane (CH_4) = Greenhouse gases*

Reduction of emission limit values for passenger cars in the EU

(in g/km)

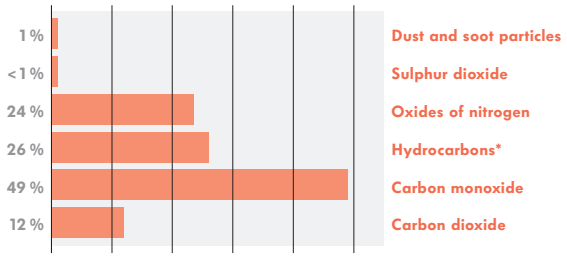


2000: Proposed limit 12/95, change of cycle – exhaust values converted to MVEG cycle.
1996: 94/12/EEC, MVEG cycle
1992: 91/441/EEC, MVEG cycle
1984: 83/351/EEC, ECE cycle, weight class 1,250 kg

Source: EU

Proportion of air pollution attributable to the passenger car

(in Germany, reference year 1994)



*Hydrocarbons excluding methane
Source: Federal Environmental Agency

The European driving cycle

(the MVEG cycle)

Compliance with the exhaust emission limit values is tested on a rolling road. This permits the actual conditions of driving on the roads to be simulated using a special driving cycle, and exhaust emissions to be measured. Since 1996, a new European driving cycle has been in use which also applies to fuel consumption regulations.

Previously, consumption was measured over three modes: urban driving, at a constant 90 km/h and at 120 km/h. This was known as the combined cycle. In the new mveg *cycle some two-thirds are made up of urban driving and one-third of non-urban driving. The constant speed modes, which led to lower overall consumption figures, are no longer applicable. The higher proportion of acceleration phases increases the significance of vehicle weight as a contributory factor to higher fuel consumption.*

Furthermore, in another decisive change in the test procedure, measurements are no longer carried out with the engine already at operating temperature. Instead, they start with the engine cold at an ambient temperature of 20 degrees Celsius. Compared with the former method, this produces fuel consumption figures some 5 to 15 percent higher, which approximates much more closely to actual consumption in everyday use.

According to an emissions forecast model developed at the Technical University of Vienna (see page 23), despite the fact that the vehicle population of Germany is expected to more or less double between 1980 and 2010, with a corresponding increase in total vehicle operation, the NO_x emission level for passenger cars in 2010 will be less than 20 percent of the 1980 figure. The CO and HC emissions caused by cars in 2010 will be only 5 and 10 percent respectively of the levels recorded in 1980. Emissions of diesel particulates from passenger cars will also be cut to less than 50 percent of their 1995 peak level by 2010.

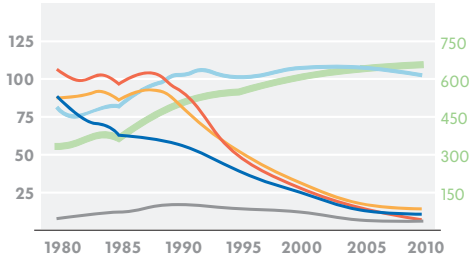
The global impact of air pollution from motor vehicles: In the early Eighties an intense debate arose on whether trace gases such as CO_2, methane (CH_4), dinitrogen monoxide (N_2O) and halogenated hydrocarbons (HHCs), in themselves harmless, can exert an influence on the earth's atmosphere. Certain effects, collectively referred to as the greenhouse effect, have focused particular attention on these components. According to scientists on the Intergovernmental Panel on Climate Change (IPCC), the measurable increase in trace gases in the atmosphere is thought to have the potential to cause additional atmospheric warming, over and above the natural greenhouse effect. The increased concentration of greenhouse gases in the atmosphere is attributed to human activity, and here in particular to the use of fossil fuels (CO_2) and to the agro-industry (CH_4 and N_2O).

For some years now, Volkswagen has been paying serious attention to the debate on climatic change. Consequently we are endeavouring to contribute to the reduction of emissions of greenhouse gases by engaging in a preventive form of environmental protection. As early as mid-1991, we began to phase out the use of HHCs. Since April 1993, no chlorinated hydrocarbons have been used in our production operations. Only small quantities of chlorofluorocarbons (CFCs) are still used in closed-loop room air-conditioning systems. Work to replace CFCs is under way. In vehicle production, no CFCs have been used in air-conditioning systems since mid-1992, and since early 1994 our Service Division has been offering a retrofit kit for converting older car air-conditioning systems to the more environmentally compatible refrigerant R 134 a.

Carbon dioxide is held responsible for some 50 percent of the greenhouse effect attributable to human activities. Industry, power stations, private households and small consumers are responsible for a good two-thirds of CO_2 emissions. In terms of CO_2 emissions worldwide, road traffic generates some 12 percent and the passenger car less than 6 percent.

For Volkswagen, cutting fuel consumption and thereby reducing CO_2 emissions is one of the main objectives when we develop new vehicles. We have undertaken to achieve a 25 percent reduction in the fuel consumption of our new vehicles between 1990 and 2005. By 1995 we had already achieved savings of 10 percent and the remaining 15 percent will be accomplished over the next ten years. The "3-litre car" in particular will be a significant step forward in our pursuit of a low-CO_2 vehicle.

Development of passenger car emissions in Germany

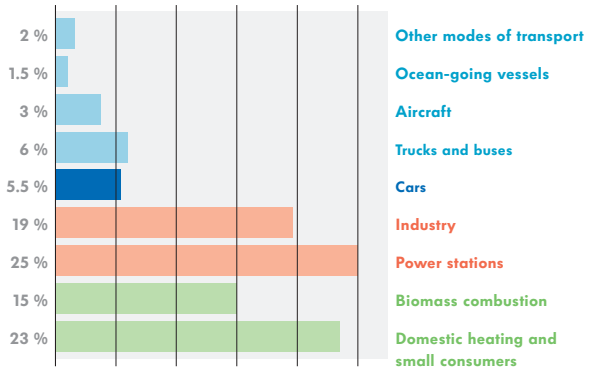


Source: TU Vienna

Vehicle operation (billion km/a)
CO emissions (100 kt/a)
CO_2 emissions (Mt/a)
NO_X emissions (10 kt/a)
HC emissions (10 kt/a)
Particulates (kt/a)

Annual global anthropogenic emissions of CO_2

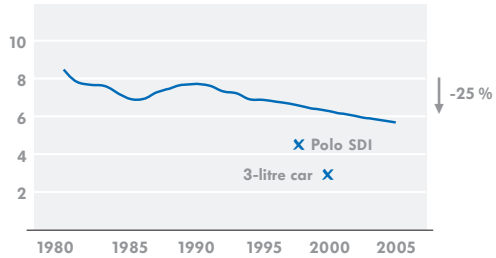
(in reference year 1995 total 28 billion tonnes)



Source: TU Vienna

Fuel consumption of Volkswagen passenger cars sold in Germany

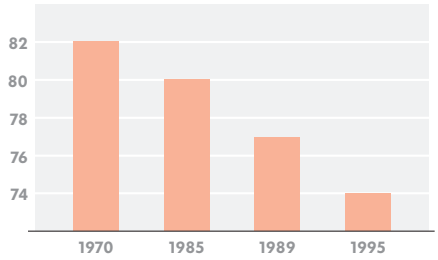
(in l/100 km for the combined cycle)



Source: VOLKSWAGEN AG

Tightening of noise emission limit values for passenger cars in the EU

(accelerated pass, in dB(A))



Source: EU

1970: 70/157/EEC, four-speed gearbox in 2nd gear only, five-speed gearbox in 3rd gear only.
1985: 84/372/EEC, high-performance car in 3rd gear only, modified measuring procedure for vehicles with automatic transmission.
1989: 84/424/EEC, direct injection vehicles = +1 dB(A)
1995: 92/97/EEC, defined surface of test track, direct injection vehicles = +1 dB(A)

Vehicle noise emissions too have seen a marked reduction over recent years.
Further reductions are possible with improvements in road surfaces and tyres.

The Polo

Volkswagen has been building the Polo, the smallest model in its range, since 1975. The car is produced at factories as far afield as Wolfsburg (Germany), Pamplona (Spain), Pacheco (Argentina), Poznan (Poland) and Uitenhage (South Africa). In 1996 a total of 459,811 Polos were manufactured, as against 379,957 in 1995.

Emissions and consumption: All Polo engines are designated low-pollution, low-consumption and low-noise. The petrol engines are equipped with a three-way catalytic converter with lambda control and all diesel engines with an oxidation catalyst. The diesel engines can run on biodiesel. The 74 kW petrol engine also has an exhaust gas recirculation system. The air-conditioning systems in the Polo contain no cfcs. The coefficient of drag (c_d) is 0.33.

Noise: The production models are up to 3 decibels (a) quieter than is required by law in Germany. This has the effect of reducing the noise perceived by the human ear by up to 50 percent.

Eco-friendly materials: On the Polo, in as far as possible Volkswagen avoids using materials that have a negative environmental impact, from the production of plastic parts to the car's lead-free paintwork. The fuel tank, for example, is made of recyclable plastic up to 40% of which comes from recycled production residues. As with all other plastic parts, the Polo's fuel tank is marked in such a way as to permit precise identification of the materials used. Within the individual assemblies – in a bumper for instance – to a very large extent we use a single type of plastic so as to ensure segregated recycling. All models have asbestos-free brake and clutch linings. A further aspect of environmental protection lies in the use of waste oil, which has been reconditioned into high-grade base oil, as an engine and gearbox

Aerodynamics

	Coefficient of drag (c_d)	**Frontal area** (A)	**Total aerodynamic drag** (c_d x A)
Polo	0.33	1.91	0.63

Source: VOLKSWAGEN AG

From the North Cape to the Straits of Gibraltar. In March 1997, a VW Polo SDI 1.9 completed a marathon economy run through ten European countries, using only 3.3 litres of fuel per 100 kilometres. The production model started out at Hammerfest on the North Cape, arriving 6,185 kilometres and 77 hours later at Tarife on the Straits of Gibraltar. Average speed: around 80 km/h. On the Spanish stage, from Taragona to Tarife, the Polo SDI actually made do with only 2.71 litres of diesel per 100 kilometres.

lubricant. The engine block of the 37 kW unit is made entirely of recycled aluminium. Renewable raw materials, such as natural fibre composites, are used in every Polo. Altogether we use 4 kilograms of moulded wood-fibre material in the doors and side panel trims.

Consumption and emission figures

	37 kW 50 bhp EC stnrd.*	**44 kW** 60 bhp EC stnrd.*	**55 kW** 75 bhp EC stnrd.	**74 kW** 100 bhp EC stnrd.	**44 kW** 60 bhp EC stnrd.*	**47 kW** 64 bhp EC stnrd.	**47 kW** 64 bhp EC stnrd.
Engine type (1)	petrol 4-cylinder	petrol 4-cylinder	petrol 4-cylinder	petrol 4-cylinder	SDI 4-cylinder	diesel 4-cylinder	SDI 4-cylinder
Cub. capacity l/cm^3	1.0/999	1.4/1390	1.6/1598	1.4/1390	1.7/1716	1.9/1896	1.9/1896
Max. output kW at rpm	37/5000	44/4700	55/4800	74/6000	44/4200	47/4400	47/4200
Max. torque Nm at rpm	86/3000 to 3600	116/3000	135/2800 to 3600	128/4400	115/2200 to 3000	124/2000 to 3000	124/2200 to 2800
Fuel consumption l/100 km (2)							
urban cycle	7.7	8.5	9.8	9.6	5.9	7.7	6.2
non-urban	4.9	5.0	5.2	5.4	3.6	4.4	3.8
overall consumpt.	**5.9**	**6.3**	**6.9**	**6.9**	**4.4**	**5.6**	**4.7**
Emissions							
CO_2 (g/km)	142	151	166	166	119	151	127
CO (g/km)	0.61	0.188	0.395	1.103	0.194	0.285	0.495
NO_X + HC (g/km)	0.311	0.078	0.174	0.348	0.370	0.51	0.597
Particulates (g/km)(3)					0.018	0.055	0.056
Driving noise dB(A)	72.5	72.5	74	73.5	73	71.5	73

(1) Emission control for petrol engines via closed-loop three-way catalytic converter, for diesel engines via oxidation catalyst.
(2) In accordance with 93/116/EC
(3) Particulates (diesel engines only)
All data relate to vehicles with manual gearboxes.
*** These models comply with the Euro D3 standard (as at 10/97). Information on the current Euro D3 range can be obtained from Volkswagen dealerships.**
Source: VOLKSWAGEN AG

The Golf and the Vento

Volkswagen has been building the Golf since 1974 and the fourth generation of this model has recently been launched in Germany. The Golf is built at the Wolfsburg and Mosel factories in Germany, in Bratislava (Slovak Republic), Brussels (Belgium), Puebla (Mexico) and Uitenhage (South Africa). In 1996 a total of 701,475 third-generation Golfs were manufactured, as against 717,873 in 1995. Of the Vento, the notchback version, 57,609 units were built in 1996 and 65,250 in 1995.

Aerodynamics

	Coefficient of drag (c_d)	**Frontal area** (A)	**Total aerodynamic drag** (c_d x A)
Golf	0.31	2.10	0.65
Vento	0.30	1.98	0.59

Source: VOLKSWAGEN AG

The Golf is the first in its class to offer a high-quality navigation system.

Emissions and consumption: All Golf and Vento engines are designated low-pollution, low-consumption and low-noise. A shortening of the warm-up phase has helped to cut consumption and emissions. All petrol engines are equipped with a three-way catalytic converter with lambda control. An activated carbon filter cuts refuelling emissions by 45 to 60 grams per fill-up. All diesel engines have an oxidation catalyst, which reduces hydrocarbon and carbon monoxide (hc and co) emissions by 60 percent. By using an exhaust gas recirculation system we have been able to lower combustion temperatures, leading to a marked reduction in oxides of nitrogen (no_x). The diesel engines can also run on biodiesel, and the air-conditioning systems in the Golf are cfc-free. Since the autumn of 1997, Volkswagen has been offering a special feature on the new Golf in the form of a satel-lite-assisted navigation system. This makes Volkswagen the first motor manufacturer in Germany to offer a highly-efficient naviga-tion system to a broad customer base. Navigation systems can not only save a considerable amount of time, but also help eliminate detours and wrong turnings, thereby reducing fuel consumption as well. The Golf's coefficient of drag (c_d) is 0.31.

Noise: The production models are up to 3 decibels (a) quieter than is required by law in Germany. This has the effect of reducing the noise perceived by the human ear by up to 50 percent.

Environment-friendly materials: The fully-galvanized body of the Golf prolongs its service life by a good 30 percent and makes it possible to offer a 12-year warranty against perforation rusting.

Volkswagen is also the first motor manufacturer to take account of growing environmental awareness and health-consciousness in its selection of textiles for vehicle interiors. Without exception, the materials and leather used in the manufacture of seats and trim on the Golf are selected for their eco-friendliness. Customers can rest assured that neither fabrics nor leather contain harmful dyes or concentrations of chemicals and that the statutory limits have been outperformed by substantial margins.

The engine block of the 74 kW engine is made of recycled aluminium. The 55 kW engine achieves a reduction in fuel consumption through the use of roller rocker arms and its engine block too is made entirely of recycled aluminium. The rolling resistance of the tyres has also been reduced. Every Golf features low-weight magnesium parts, including the steering wheel rim. All models have asbestos-free brake and clutch linings, and coolant which contains no amines, nitrite or phosphate. Renewable raw materials, such as natural fibre composites, are used in every Golf. Altogether we use 1.5 kilograms of moulded wood-fibre material (in the door trims) and 1 kilogram of moulded flax-fibre material.

Good aero-dynamics help to save fuel.

Consumption and emission figures (Golf)

	55 kW 75 bhp EC stnrd.*	**74 kW** 100 bhp EC stnrd.*	**92 kW** 125 bhp EC stnrd.*	**110 kW** 150 bhp EC stnrd.*	**110 kW** 150 bhp EC stnrd.*	**50 kW** 68 bhp EC stnrd.	**66 kW** 90 bhp EC stnrd.*	**81 kW** 110 bhp EC stnrd.
Engine type (1)	petrol 4-cylinder	petrol 4-cylinder	petrol 4-cylinder	petrol 5-cylinder	petrol 4-cylinder	SDI 4-cylinder	TDI 4-cylinder	TDI 4-cylinder
Cub. capacity l/cm³	1.4/1390	1.6/1595	1.8/1781	1.8/1781	2.3/2327	1.9/1896	1.9/1896	1.9/1896
Max. output kW at rpm	55/5000	74/5300	92/5800	110/5700	110/6000	50/4200	66/4000	81/4150
Max. torque Nm at rpm	131/3000	140/3800	168/3500	210/1750 to 4600	205/3200	129/2200	210/1900	235/1900
Fuel consumption l/100 km (2)								
urban cycle	8.4	10.5	11.7	10.8	13.2	6.9	6.6	6.5
non-urban	5.3	5.9	6.3	6.1	7.2	4.2	4.1	4.0
overall consumpt.	**6.4**	**7.6**	**8.3**	**7.8**	**9.3**	**5.1**	**5.0**	**4.9**
Emissions								
CO_2 (g/km)	154	182	199	187	223	138	135	132
CO (g/km)	0.476	0.587	0.698	0.338	0.407	0.451	0.329	0.305
NOx + HC (g/km)	0.186	0.180	0.139	0.110	0.098	0.573	0.519	0.604
Particulates (g/km)(3)						0.061	0.062	0.061
Driving noise dB(A)	73	72.5	73.5	70.5	73.5	75	72	72

The Vento TDI (66 kW) complies with the Euro D3 standard, and like all Volkswagen's diesel engines is approved to run on biodiesel.

Consumption and emission figures (Vento)

	55 kW 75 bhp EC stnrd.*	**66 kW** 90 bhp EC stnrd.*	**74 kW** 100 bhp EC stnrd.*	**85 kW** 115 bhp EC stnrd.*	**128 kW** 174 bhp EC stnrd.	**47 kW** 64 bhp EC stnrd.	**47 kW** 64 bhp EC stnrd.	**55 kW** 75 bhp EC stnrd.	**66 kW** 90 bhp EC stnrd.*	**81 kW** 110 bhp EC stnrd.
Engine type (1)	petrol 4-cylinder	petrol 4-cylinder	petrol 4-cylinder	petrol 5-cylinder	petrol 6-cylinder	diesel 4-cylinder	SDI 4-cylinder	diesel 4-cylinder	TDI 4-cylinder	TDI 4-cylinder
Cub. capacity l/cm³	1.8/1781	1.8/1781	1.6/1595	2.0/1984	2.8/2792	1.9 / 1896	1.9 / 1896	1.9 / 1896	1.9 / 1896	1.9 / 1896
Max. output kW at rpm	55 / 5000	66 / 5500	74 / 5800	85 / 5400	128 / 5800	47 / 4400	47/ 4200	55/ 4200	66 / 4000	81 / 4150
Max. torque Nm at rpm	140 / 2500	145 / 2500	140 / 3500	166 / 3200	235 / 4200	124/2000 to 3000	124/2200 to 2800	150/2200 to 3200	202/1900	235/1900
Fuel consumption l/100 km (2)										
urban cycle	10.8	10.8	10.9	11.2	15.0	7.9	6.8	8.1	6.4	6.6
non-urban	5.8	5.8	6.1	6.3	7.9	4.7	4.1	5.0	4.2	4.1
overall consumpt.	**7.6**	**7.6**	**7.9**	**8.1**	**10.5**	**5.9**	**5.1**	**6.1**	**5.0**	**5.0**
Emissions										
CO_2 (g/km)	182	182	190	194	252	159	138	165	135	135
CO (g/km)	0.396	0.871	0.947	1.140	1.080	0.055	0.293	0.197	0.449	0.402
NO_X + HC (g/km)	0.095	0.059	0.186	0.224	0.408	0.444	0.594	0.624	0.387	0.648
Particulates (g/km)(3)						0.050	0.079	0.066	0.039	0.063
Driving noise dB(A)	74	73	72.5	72	72.5	71	73.5	73	74	73.5

(1) Emission control for petrol engines via closed-loop three-way catalytic converter, for diesel engines via oxidation catalyst.
(2) In accordance with 93/116/EC
(3) Particulates (diesel engines only)
All data relate to vehicles with manual gearboxes.
*** These models comply with the Euro D3 standard (as at 10/97). Information on the current Euro D3 range can be obtained from Volkswagen dealerships.**
Source: VOLKSWAGEN AG

Euro D3 standard

A new motor vehicle taxation system came into force in Germany on July 1, 1997. Owners of cars which already comply with the pollutant limit values laid down in the new Euro D3 standard receive a non-recurring tax credit of between DM 250 (petrol engines) and DM 500 (diesels). They also benefit from a lower rate of tax. In the case of petrol engines, for example, the motor vehicle tax is reduced from DM 13.20 to DM 10 per hundred cubic centimetres of engine displacement. Many Volkswagen engines already comply with the Euro D3 standard.

The Passat

Volkswagen has been building the Passat, now in its fifth generation, since 1973. The Passat is manufactured at the Emden and Mosel factories in Germany and in Brussels (Belgium). In 1996 a total of 205,625 Passats were manufactured, compared to 214,254 in 1995.

In the wind tunnel the Passat reveals its exceptional aerodynamics, returning a c_d of 0.27.

Emissions and consumption: All Passat engines are designated low-pollution, low-consumption and low-noise. The petrol engines comply with the Euro D3 standard, and are equipped with a three-way catalytic converter and lambda control. By using catalyst coatings which take effect even at low temperatures, we have been able to reduce emissions in the warm-up phase. All diesel engines have an oxidation catalyst which reduces hydrocarbon and carbon monoxide (hc and co) emissions by 60 percent. By using an exhaust gas recirculation system we have been able to lower combustion temperatures, leading to a marked reduction in no_x. The diesel engines can run on biodiesel. Air-conditioning systems in the Passat are cfc-free. The Passat's virtually seamless bodywork makes for optimum aerodynamics, resulting in an improved c_d of 0.27. Since the autumn of 1996, Volkswagen has been offering a satellite-assisted navigation system on the new Passat. This makes Volkswagen the first German manufacturer to offer a high-quality navigation system on mid-range models for a broad customer base at under dm 3,000. Navigation systems can not only save a considerable amount of time, but also help eliminate detours and wrong turnings, thereby reducing fuel consumption as well.

Noise: The production models are up to 3 decibels (a) quieter than is required by law in Germany. This has the effect of reducing the noise perceived by the human ear by up to 50 percent.

Environment-friendly materials: Despite its increased comfort and safety, the entry-level Passat weighs 20 kilograms less than its predecessor. This is achieved through the use of light alloys such as aluminium instead of cast iron (the new engine block of the 1.6-litre engine is 16.9 kilograms lighter) and magnesium for the gearbox housing, saving 4.5 kilograms. All models have asbestos-free brake and clutch linings. A further aspect of environmental protection lies in the use of waste oil which has been reconditioned into high-grade base oil, as

Aerodynamics

	Coefficient of drag (c_d)	Frontal area (A)	Total aerodynamic drag (c_d x A)
Passat	0.27	2.15	0.58

Source: VOLKSWAGEN AG

Magnesium gearbox housing. This lightweight material has a strategic significance for Volkswagen in the reduction of vehicle weight.

an engine and gearbox lubricant.

The fully-galvanised body of the Passat prolongs its service life by a good 30 percent and saves some 5 kilograms of pvc underseal. Volkswagen is also the first motor manufacturer to take account of growing environmental awareness and health-consciousness in its selection of textiles for vehicle interiors. Without exception, the materials and leather used in the manufacture of seats and trim on the Passat are selected for their eco-friendliness. Customers can rest assured that neither fabrics nor leather contain harmful dyes or concentrations of chemicals and that the statutory limits have been outperformed by considerable margins. Renewable raw materials such as cotton-fibre felt insulating mats and luggage boot covers are used in every Passat. Altogether we install 2 kilograms of moulded flax-fibre material in each vehicle.

Consumption and emission figures

	74 kW 100 bhp EC stnrd.*		**92 kW** 125 bhp EC stnrd.*		**110 kW** 150 bhp EC stnrd.*		**110 kW** 150 bhp EC stnrd.*		**142 kW** 193 bhp, Syncro EC stnrd.*		**66 kW** 90 bhp EC stnrd.		**81 kW** 110 bhp EC stnrd.	
Engine type (1)	petrol 4-cylinder		petrol 4-cylinder		petrol 4-cylinder		petrol 5-cylinder		petrol 6-cylinder		TDI 4-cylinder		TDI 4-cylinder	
Cub. capacity l/cm³	1.6/1595		1.8/1781		1.8/1781		2.3/2327		2.8/2771		1.9/1896		1.9/1896	
Max. output kW at 1/min	74/5300		92/5800		110/5700		110/6000		142/6000		66/4000		81/4150	
Max. torque Nm at 1/min	140/3800		168/3500		210/1750 to 4600		205/3200		280/3200		202/1900		235/1900	
Fuel consumption l/100 km (2)	Passat	Estate	Passat	Estate	Passat	Estate	Passat	Estate	Passat	Estate	Passat	Estate	Passat	Estate
urban cycle	11.4	11.8	12.4	12.5	10.7	10.9	13.5	13.5	15.0	15.2	7.1	7.2	7.1	7.2
non-urban	6.0	6.2	6.4	6.6	6.3	6.5	7.3	7.5	7.9	8.5	4.3	4.5	4.3	4.5
overall consumpt.	**8.0**	**8.4**	**8.6**	**8.8**	**7.9**	**8.1**	**9.5**	**9.7**	**10.5**	**10.7**	**5.4**	**5.6**	**5.3**	**5.5**
Emissions														
CO_2 (g/km)	192	199	206	211	190	194	228	233	252	257	146	151	143	149
CO (g/km)	1.460	1.460	0.936	0.936	0.568	0.568	1.370	1.370	0.972	0.972	0.523	0.523	0.395	0.395
NO_X + HC (g/km)	0.240	0.240	0.925	0.925	0.260	0.260	0.374	0.374	0.303	0.303	0.497	0.497	0.646	0.646
Particulates (g/km)(3)											0.076	0.076	0.085	0.085
Driving noise dB(A)	74	74	73.5	73.5	71	71	72	72	70.5	70.5	73.5	73.5	72	72

(1) Emission control for petrol engines via closed-loop three-way catalytic converter, for diesel engines via oxidation catalyst.
(2) In accordance with 93/116/EC
(3) Particulates (diesel engines only)
All data relate to vehicles with manual gearboxes.
*** These models comply with the Euro D3 standard (as at 10/97). Information on the current Euro D3 range can be obtained from Volkswagen dealerships.**
Source: VOLKSWAGEN AG

The Sharan

The Sharan is Volkswagen's multi-purpose vehicle. It has been built since 1995 at the Palmela (Portugal) factory in cooperation with the Ford Motor Company. In 1996 a total of 55,676 Sharans were produced, compared with 19,708 in 1995.

Environment-friendly materials: All Sharan models have asbestos-free brake and clutch linings, and the vehicles' appointments feature eco-friendly materials containing no asbestos, cfc or cadmium. A further aspect of environmental protection lies in the use of waste oil which has been reconditioned into high-grade base oil as an engine and gearbox lubricant.

Without exception, the materials and leather used in the manufacture of seats and trim on the Sharan are selected for their eco-friendliness. Customers can rest assured that neither fabrics nor leather contain harmful dyes or concentrations of chemicals and that the statutory limits have been outperformed by a substantial margins.

Renewable raw materials such as cotton-fibre insulating mats are used in every Sharan. Altogether we install 11 kilograms of moulded wood-fibre material in each vehicle for door and side panel trims.

Emissions and consumption: All petrol engines are equipped with a three-way catalytic converter and lambda control, whereas the diesels have an oxidation catalyst and exhaust gas recirculation (egr) to reduce emissions of oxides of nitrogen (no_x). All the diesel versions can be run on biodiesel, and the air-conditioning systems are cfc-free. This Volkswagen mpv has a c_d of 0.31, which is low for this class of vehicle.

Noise: The production models are up to 3 decibels (a) quieter than is required by law in Germany. This has the effect of reducing the noise perceived by the human ear by up to 50 percent.

The Sharan in the wind tunnel.

Consumption and emission figures

	85 kW 115 bhp EC stnrd.*	**128 kW** 174 bhp EC stnrd.	**66 kW** 90 bhp EC stnrd.	**81 kW** 110 bhp EC stnrd.
Engine type (1)	petrol 4-cylinder	petrol 6-cylinder	TDI 4-cylinder	TDI 4-cylinder
Cub. capacity l/cm³	2.0/1984	2.8/2792	1.9/1896	1.9/1896
Max. output kW at rpm	85/5000	128/5800	66/4000	81/4150
Max. torque Nm at rpm	170/2400	235/4200	202/1900	235/1900
Fuel consumption l/100 km (2)				
urban cycle	13.9	16.5	8.5	8.5
non-urban	7.7	8.8	5.3	5.2
overall consumpt.	**9.9**	**11.6**	**6.5**	**6.4**
Emissions				
CO_2 (g/km)	238	278	176	173
CO (g/km)	0.62	0.913	0.444	0.349
NO_X + HC (g/km)	0.148	0.311	0.865	0.660
Particulates (g/km)(3)			0.073	0.077
Driving noise dB(A)	74	74	75	74

(1) Emission control for petrol engines via closed-loop three-way catalytic converter, for diesel engines via oxidation catalyst.
(2) In accordance with 93/116/EC
(3) Particulates (diesel engines only)
All data relate to vehicles with manual gearboxes.
*** These models comply with the Euro D3 standard (as at 10/97). Information on the current Euro D3 range can be obtained from Volkswagen dealerships.**
Source: VOLKSWAGEN AG

Aerodynamics

	Coefficient of drag (c_d)	**Frontal area** (A)	**Total aerodynamic drag** (c_d x A)
Sharan	0.31	2.68	0.83

Source: VOLKSWAGEN AG

The Caravelle, Transporter and LT

The Caravelle, the Transporter and the LT are Volkswagen's commercial vehicles. Now in its fourth generation, the Transporter has been built in Germany since 1950. Around the world, the Transporter, the Caravelle mpv, the LT light truck series (2.8 to 4.6 t gvw) and the L 80 (up to 7.5 t gvw) are manufactured at the Volkswagen plants in Hanover (Germany), Anchieta (Brazil), Poznan (Poland), Taipeh (Taiwan) and Uitenhage (South Africa). In 1996 a total of 72,777 Caravelles were built as against 71,362 in 1995. Transporter production totalled 68,677 units in 1996 compared with 69,993 in 1995, while 11,229 units of the new LT model were built in 1996 and 15,474 units of its predecessor in 1995.

Emissions and consumption: All petrol engines are equipped with a three-way catalytic converter and lambda control. The diesels are equipped with an oxidation catalyst and, with the exception of the 55 kW engine, also feature exhaust gas recirculation. The tdi engines can be run on biodiesel. The Caravelle and Transporter return a c_d of 0.37 and the LT 0.36.

Noise: The production models are up to 3 decibels (a) quieter than is required by law in Germany. This has the effect of reducing the noise perceived by the human ear by up to 50 percent.

Environment-friendly materials: A further aspect of environmental protection lies in the use of waste oil which has been reconditioned into high-grade base oil as an engine and gearbox lubricant. On the Caravelle and Transporter the entire bumper system (outer skin and foam element for impact absorption) is made of polypropylene and the mounting brackets of recycled polypropylene. In every Caravelle and Transporter, 19 kilograms of moulded wood-fibre material is installed in the side panel trims. Renewable raw materials are used in all Volkswagen cars and commercial vehicles. Natural fibre composites (nf composites) which are mixtures of natural fibres and a binding agent can be adapted to all kinds of applications and functions by altering their composition (fibre type, length and positioning). The advantages of using NF composites include low emissions, a positive CO_2 balance, their weight-saving potential, their anti-splinter properties in the required temperature and humidity range, their ability to accept trim materials, for example decorative fabrics, without the need for adhesives (*one-shot trim*) and the recyclability of any production residues. In addition to moulded flax-fibre material, which is particularly suitable for parts which have a bearing on safety, such as door trims and backrest covers, some 8 kilograms of moulded cotton-fibre material, derived from recycled textile residues, are used in these Volkswagen vehicles. We are currently looking into additional applications for natural fibre composites and natural binding agents.

Top: The Transporter in different guises
Bottom: the LT delivery van

Aerodynamic values

	Coefficient of drag (c_d)	**Frontal area** (A)	**Total aerodynamic drag** (c_d x A)
Caravelle	0.37	3.08	1.14
LT (Kombi)	0.36	4.00	1.44

Source: VOLKSWAGEN AG

The Caravelle and Multivan

Consumption and emission figures

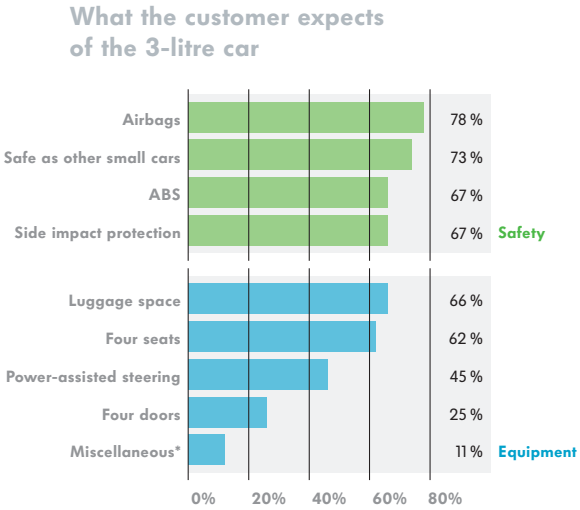
	Caravelle and Transporter						LT (Kombi)		
	62 kW 84 bhp EC stnrd.	**85 kW** 115 bhp EC stnrd.*	**103 kW** 140 bhp EC stnrd.*	**50 kW** 68 bhp EC stnrd.	**55 kW** 75 bhp EC stnrd.	**75 kW** 102 bhp EC stnrd.	**105 kW** 143 bhp EC stnrd.	**55 kW** 75 bhp EC stnrd.	**75 kW** 102 bhp EC stnrd.
Engine type (1)	petrol 4-cylinder	petrol 5-cylinder	petrol 6-cylinder	diesel 4-cylinder	diesel 5-cylinder	TDI 5-cylinder	petrol 4-cylinder	SDI 5-cylinder	TDI 5-cylinder
Cub. capacity l/cm^3	2.0/1968	2.5/2461	2.8/2792	1.9/1896	2.4/2370	2.5/2461	2.3/2295	2.5/2461	2.5/2461
Max. output kW at rpm	62/4300	85/4500	103/4500	50/3700	55/3700	75/3500	105/5000	55/3800	75/3500
Max. torque Nm at rpm	159/2200	200/2200	240/3000 to 3400	140/2000 to 3000	160/1900 to 2900	250/1900 to 2300	210/4000	160/2200	250/1900
Fuel consumption l/100 km (2)									
urban cycle	14.4	16.4	15.4	9.8	12.0	9.5	17.6	12.1	10.9
non-urban	9.0	9.3	9.0	7.0	7.4	6.4	10.4	6.9	7.0
overall consumption	**11.0**	**11.9**	**11.4**	**8.1**	**9.1**	**7.5**	**13.1**	**9.0**	**8.5**
Emissions									
CO_2 (g/km)	264	286	274	219	246	203	299	243	236
CO (g/km)	0.892	0.989	1.013	0.139	0.211	0.399	1.660	0.106	0.340
NO_X + HC (g/km)	0.437	0.367	0.401	0.904	1.052	0.863	0.301	1.206	0.921
Particulates (g/km)(3)				0.057	0.124	0.083		0.067	0.096
Driving noise dB(A)	73.5	73.5	72	74	72	73.5	74	73.5	74.5

(1) Emission control for petrol engines via closed-loop three-way catalytic converter, for diesel engines via oxidation catalyst.
(2) In accordance with 93/116/EC
(3) Particulates (diesel engines only)
All data relate to vehicles with manual gearboxes.
*** Information on the Euro D3 performance of the current range can be obtained from Volkswagen dealerships.**
Source: VOLKSWAGEN AG

The 3-litre Car

A challenge for the millennium

The 3-litre car at the Wolfsburg Research and Development headquarters. The wraps will be coming off within the next two years.



***The feature most frequently mentioned was air conditioning (1.5%).**
Source: auto, motor und sport

In recent years, people's sensitivity to questions and problems concerning the environment has increased enormously. The call for cars featuring extremely low fuel consumption is no more than a logical extension of this heightened awareness. The whole debate is now focused on the "3-litre car" – a car that needs only 3 litres of fuel to cover 100 kilometres. And our customers' expectations of such a car are not exactly modest: it must be a fully-fledged model, combining all the normal standards of safety and comfort, plus a high degree of flexibility and variability in terms of transportation needs and interior appointments, with low fuel consumption and emissions.

Magnesium from Israel for the vehicles of the future.

Resistance to motion: Next to its propulsion concept, the most important factor influencing the fuel economy of a vehicle is its resistance to motion. This is made up of a number of different factors (see table below).

Vehicle weight: One key element in the realization of a 3-litre car is vehicle weight. The palette of lightweight automotive design currently includes solutions brought to readiness for series production that involve aluminium, magnesium, titanium, plastics and materials derived from thin-sheet-metal technology. The traditional material for car manufacturing, namely steel, has also been through a long and positive development process. New steel composites can save up to 15 percent in weight – innovative seaming processes make thin sheet parts stronger than heavier-gauge materials. The solution in terms of all-steel construction lies in what are called tailored blanks. These are sheet-metal blanks of various grades and gauges. However, the fact that a weight reduction of 100 kilograms only cuts average fuel consumption by some 0.2 litres per 100 kilometres (urban, non-urban and motorway driving in the mveg cycle with a diesel engine) illustrates the dimensions of the challenge facing Volkswagen's research and development engineers.

New prospects – magnesium: Extremely light and extremely stable, magnesium is a beacon of hope in the battle to minimize fuel consumption and vehicle weight. With a density of only 1.8 grams per cubic centimetre, magnesium is one of the lightest metallic construction materials – a good 35 percent lighter than aluminium. Compared with fibre-reinforced plastics, magnesium has the advantages of a metal in that it can be cast and sintered, and more easily recycled. Since very high concentrations of magnesium are found in the Dead Sea in Israel, in 1996 Volkswagen set up a joint venture with the Dead Sea Works to produce magnesium in industrial quantities. Once the start-up phase is complete, the factory will produce some 30,000 tonnes of magnesium a year. In addition to the factory, Volkswagen, Dead Sea Magnesium and the neighboring Ben Gurion University have together set up a magnesium research institute.

Outlook: As a niche product, a 3-litre car could never make a tangible contribution to relieving the pressure on the environment. Only a 3-litre car that offers a sensible price/performance ratio will serve the needs of the environment and also be accepted by a wider market. Accordingly, in our 3-litre car we are aiming to offer a fully-fledged four-seater or in other words a perfectly normal Volkswagen with very high fuel economy and which makes highly efficient use of the required resources. Moreover, the technological advances that go into the 3-litre car will also find their way into other classes of vehicle, helping to reduce the Volkswagen average fleet fuel economy figure.

Resistance to motion

Aerodynamic drag	Frontal area, vehicle shape, speed
Rolling resistance	Tyres, weight
Residual braking moment	Brakes
Acceleration resistance	Driven mass, weight
Internal resistance	Friction in engine and gearbox
Gradient resistance	Weight

Alternative Propulsion Systems

The Volkswagen life cycle analysis of a Golf has shown that the biggest energy consumer in the life cycle of a motor vehicle is its propulsion system. Consequently, the Volkswagen Research Division sets great store by optimizing existing propulsion technologies from an environmental point of view and developing pioneering and pro-environmental propulsion systems and fuels for the motor vehicle of the future.

Biodiesel

Fuels produced from renewable raw materials feature a far more favourable carbon dioxide cycle than traditional fuels. In some cases the carbon dioxide cycle is a closed loop. Accordingly, these "alternative" fuels contribute far less to total carbon dioxide (CO_2) emissions than their traditional counterparts. As of model year 1996 (model year 1997 for the Sharan), practically all Volkswagens with diesel engines are approved to run on normal diesel fuel, biodiesel (DIN V 51606), or any combination of the two. For older Golf A3, Vento A3, Passat B4 and Transporter T4 models, Volkswagen offers retrofit packages to enable them to run on biodiesel. Conversion involves the replacement of the fuel lines, seals and die-cast parts made of elastomers which come into contact with biodiesel. The exhaust gas of engines run on biodiesel contains up to 10 percent less carbon monoxide, up to 20 percent less hydrocarbons, up to 50 percent less particulates and up to 50 percent less polycyclic aromatic hydrocarbons (PAH) – although it does contain more oxides of nitrogen and aldehydes than when conven- tional diesel fuel is used. Biodiesel is virtually sulphur-free, easily biodegradable, and can be mixed in any proportion with conventional diesel fuel. Performance drops slightly; fuel consumption increases slightly. Using biodiesel produced from rapeseed leads to a drop of at least 30 percent in emissions of greenhouse gases by comparison with normal diesel fuel. In Germany, biodiesel will never be able to replace more than 5 percent of conventional diesel fuel and, not least on account of its high agricultural production costs, is set to remain a niche fuel here.

All new diesel-engined models from Volkswagen are approved to run on biodiesel. A retrofit package is available for older vehicles.

A natural-gas-powered engine on the test bench at Group Research in Wolfsburg. The emissions subject to statutory limits are substantially lower than for petrol and diesel fuels.

Natural gas

Natural gas engines can be installed on production models as an alternative to petrol and diesel engines. Both the technical characteristics and environmental potential of natural gas – reduction of emissions, husbanding of resources, positive climate balance-sheet – have already established it as a fuel for commercial vehicles and passenger cars, although to a limited extent. To date, Volkswagen has sold over six hundred vehicles running on compressed natural gas (cng). Natural gas vehicles make a significantly lower contribution to the formation of low-level ozone and smog. Emissions of pollutants subject to statutory limits are clearly lower than with conventional fuels, while emissions of non-limited exhaust components (e.g. polyaromatic hydrocarbons) show a very strong decrease. Currently, natural gas propulsion is offered as a dual-mode concept for selected variants of the Polo, Golf, Passat and Transporter/Caravelle series. These are modified production models which can be switched over from natural gas to petrol and vice-versa. On account of the increased fuel tank volume required and the lack of an adequate filling station network, cng is a typical fleet fuel for local transport operators. The downside of the technology is reflected in a slight loss of power, a reduced range and an increase in fuel tank weight and volume.

City STROMer

Although electric propulsion systems are entirely non-pollutant at the point of operation, the energy they require – in the form of electricity – has to be generated some-where. Up to a point, therefore, the emissions are not eliminated but simply transferred elsewhere. To date, the biggest problem with electric vehicles has been how to store the energy required to drive them. Even though enormous strides have been made in battery technology, the range of electric vehicles in everyday use will remain very limited. Consequently electric propulsion is best suited to urban zones, holiday resorts and spas.
In the shape of the Golf CitySTROMer, Volkswagen now has a production model which incorporates over twenty years of research and experience. There is potential for further development above all in terms of motor technology and of the energy storage medium, the battery.

For the research engineers the biggest challenge is still the problem of how to store the electricity required to power the Golf CitySTROMer.

Alcohols

Among the alcohols, methanol in particular and, with certain reservations, ethanol too represent interesting supplements or alternatives to conventional fuels. These are outstanding fuels for both diesel and spark-ignition engines, in part producing higher levels of efficiency while at the same time emitting less pollutants. Many different raw materials can be used to produce methanol, and promising propulsion systems for the future already exist – for example in the shape of multi-fuel vehicles which run on m 85 (a commercially available mixture of 85 percent methanol and 15 percent petrol) or any combination of m 85 and petrol. Methanol can be produced not only from fossil resources but also from agricultural or forestry-based biomass products, and even from organic waste. On account of their favourable climate balance-sheet and their relatively minor contribution to the smog and ozone problem, methanol-powered vehicles are ideal for urban areas. Research projects are currently looking for ways of producing methanol from hydrogen and enriched CO_2 derived from industrial flue gases. Apart from its use in multi-fuel concepts, methanol could be used to power specially-adapted direct-injection engines, and also as a method of storing hydrogen for fuel cell propulsion systems. Because of the relative scarcity of raw materials in Central Europe, ethanol produced from renewable crops containing sugar and starch will play only a subsidiary role here. This does not however apply in countries such as Brazil, where Volkswagen has to date sold in the region of two million ethanol-powered vehicles.

A Golf Estate as an electro-diesel hybrid vehicle. A universally applicable concept in the context of European traffic conditions.

Electro-diesel hybrid

A hybrid propulsion system is actually two propulsion systems in one (e.g. internal combustion engine and electric motor) and, ideally, combines the best of both worlds. The electro-diesel hybrid has been the subject of extensive research. While the internal combustion engine handles acceleration, speeds over 60 km/h and longer distances, the electric motor deals with the lower speed range. The Volkswagen Research electro-diesel hybrid features a 66 kW tdi engine with oxidation catalyst and a 19 kW asynchronous electric motor, arranged on a common shaft with the gearbox. Over the mveg cycle, the hybrid Golf consumed 2.8 litres of diesel fuel and 9.8 kilowatt-hours of electricity per 100 kilometres. By comparison, the so-called "advanced hybrids", featuring fuel cells, gas turbines or Stirling motors, for example, are still very much research vehicles and a long way from a cost/benefit ratio that would make them an economic proposition.

The Fuel Cell

From vision to reality

Supplies of petroleum as an energy medium for internal combustion propulsion systems in road vehicles are not inexhaustible. Accordingly, we are working towards the development of pollutant-free propulsion concepts based on systems such as the fuel cell and the electric motor which do not require petroleum.

A working model of the fuel cell, displayed on the Volkswagen stand at the 1997 Hanover Industrial Trade Fair.

Electric propulsion systems based on the fuel cell have a number of advantages: a high efficiency factor, zero-emission operation with hydrogen, no energy consumption when the vehicle is stationary, no vibration, low noise levels and independence of fossil fuel supplies.

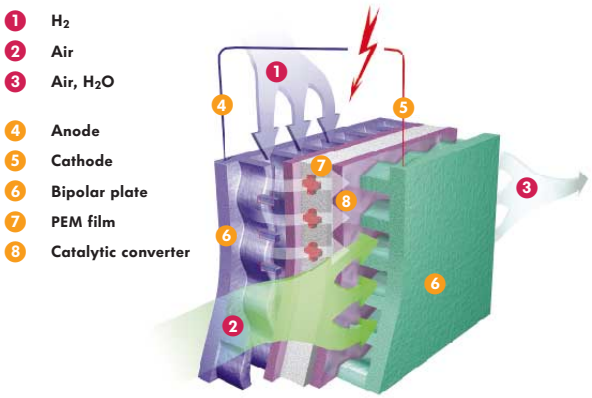
The fuel cell reverses the process of electrolysis, since it generates electricity by transforming hydrogen and oxygen into water. Fuel cell vehicles powered by hydrogen are thus rated as zero-emission vehicles – and that with an efficiency factor averaging between 60 and 70 percent.

Hydrogen in the car: There are various alternative methods of supplying the fuel cell with the hydrogen it needs to generate electricity. The hydrogen, for instance, could be carried on board the vehicle in pressurised tanks. Whilst this system is of a relatively simple design, it does entail considerable disadvantages, such as the technical difficulties presented by the refuelling process, the concomitant hazards and the lack of an adequate network of filling stations. Volkswagen research favours obtaining hydrogen from liquid methanol (CH_3OH) by means of a process of reformation on board the vehicle. The benefits of this system outweigh the drawbacks of its complicated design, since only minor technical modifications would be required in order to incorporate methanol into the existing filling station infrastructure. In the fuel cell, methanol combines with air and water in the reformer to produce carbon dioxide (CO_2) and hydrogen.

Our decision to forge ahead with fuel cell technology makes one thing quite clear: from today's viewpoint, the large-scale application of fuel cell technology within the space of a decade appears well within the realms of the feasible. The main question now concerns the production of the methanol required. An overwhelming advantage of this fuel, rich in hydrogen, is the broad range of raw materials which can be used for its manufacture. Until

The principle of the fuel cell

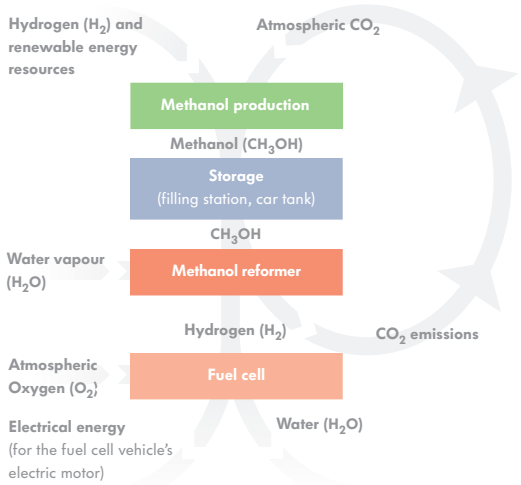
Reaction equation
Anode: $H_2 \rightarrow 2H^+ + 2e^-$
Cathode: $\frac{1}{2} O_2 + 2H^+ + 2e^- \rightarrow H_2O$



now, the industrial production of methanol has been based exclusively on fossil carbon sources, natural gas, petroleum and coal, so the overall energy and emission balance still leaves room for improvement. One promising option would be to generate methanol from CO_2, organic or non-organic waste and hydrogen, using renewable energy resources.

A particularly attractive prospect would be to arrive at a process of methanol synthesis which presents a closed CO_2 cycle. In other words, the amount of CO_2 produced downstream of the reformer and released into the atmosphere is extracted from the air again for the renewed production of methanol. This is the basis of the CO_2 recycling process presented at the World Hydrogen Conference in June 1996 in Stuttgart together with the Centre for Solar Energy and Hydrogen Research (ZSW). The result is a closed cycle which presents a neutral CO_2 balance and does not burden the atmosphere. Volkswagen is currently supporting the analysis of the ecological and economic implications of this far-reaching concept for the automotive sector. Over the next few years, Volkswagen and its partners will be developing a hybrid fuel cell vehicle incorporating methanol reformation in a project subsidized by the European Union. In addition to the extremely low emission levels of the proposed vehicle, amounting to between one-tenth and one-hundredth of those of an ultra-low emission vehicle (ULEV), the greatest challenge facing this project is the achievement of a high overall efficiency factor.

The vision of a closed CO_2 cycle



Production and the Environment

When assessing the overall environmental impact of a product it is important to include the manufacturing process itself. For many years now Volkswagen and its suppliers have been developing an approach to this central aspect of their activities which guarantees effective protection of the environment. We work to the principle that, where waste is concerned, avoidance is better than reduction, reduction better than recycling and recycling better than disposal.

Technical solutions alone will never bring about sustainable development. Any attempt to achieve more environmentally friendly production processes has to involve other factors, such as the creation of an appropriate environmental management system. It is also important to ensure that any environmental measures taken in production plants are economically justifiable. Our plants in Germany are mostly situated in regions which are not well developed in structural terms and have relatively high rates of unemployment. Volkswagen is often the most important employer in the region, and our responsibility for safeguarding jobs therefore goes beyond our own employees and covers the entire region, including all the other companies which are directly or indirectly dependent upon us.

Volkswagen has decided that its European plants will undergo certification in line with the EC Eco-audit Regulation. By the end of 1996 five factories had achieved certification, and those that remain will do so progressively by 1999. We regard the EC Eco-audit as an important milestone on the road towards achieving optimised and more eco-friendly production processes. The audit consists essentially of four elements:

- *description of the Environmental Management System*
- *determination and assessment of the environmental impact of the company's activities*
- *environmental tests and audits*
- *external certification and publishing of Environmental Statements for each plant*

As part of the preparation for certification we examine how environmental protection is organized at our plants and check that each plant is operating in conformity with the relevant laws and regulations.

We also carry out a risk analysis. For this purpose we have developed our own checklists and risk identification software. The results are used to analyse our strengths and weaknesses and draw up recommendations for action. The process constantly identifies new ways of improving the environmental situation in our factories, thus enabling us to reduce the liability risks for our company at the same time.

The tests and audits help us to identify environmental goals and ways of achieving them, and the results are then published in the form of an Environmental Statement. Simplified Environmental Statements are then drawn up annually, announcing any significant changes in the factory's operations and providing a summary of the latest environmental data. The eco-audit is repeated on a regular basis.

Assembly line operatives working on the Passat in our Mosel plant in Saxony. The plant has obtained certification under the EC Eco-audit Regulation.

Capital investments and operating costs for environmental protection
(in DM millions, excl. Mosel and Chemnitz plants)

	1994	1995	1996
Capital investments	50	51	67
Operating costs	175	158	161

Source: VOLKSWAGEN AG

Waste, emissions, water and energy consumption of all VW production plants in Germany

Industrial waste (t/a)	1994	1995	1996
recycling	24,317	22,825	38,194
disposal	32,261	30,311	23,595
Hazardous waste (t/a)			
recycling	30,523	33,222	37,521
disposal	17,684	16,748	16,469
Non process-related waste (t/a) (1)			
recycling	5,536	4,103	3,561
disposal	978	1,120	6,037
Emissions (t/a)			
organic substances (2)	5,182	4,317	4,411
CO_2 from in-house heat/power generation	223,685	236,259	265,403
Water und waste water (million m^3/a)			
drinking water (3)	5.6	5.9	5.6
waste water (4)	7.3	7.3	(5) 6.6
Energy (MWh/a)			
total energy consumption	4,889,432	5,204,941	5,779,776

t/a = tonnes per annum
(1) Building rubble, excavated soil etc.
(2) VOC (volatile organic compounds)
(3) Not incl. surface water used
(4) Incl. rainwater used
(5) Reduction at Wolfsburg plant owing to modernisation of drainage system, reducing the amount of external waste water entering the system

Source: VOLKSWAGEN AG

Capital investments: Acquiring and operating environmental plant and equipment inevitably involves both capital investments and expenditure on ongoing running costs. Investments have been made not only in order to conform with statutory requirements and regulations but also to cut costs and equip our plants with progressive technologies. Thus, investment in environmental protection can actually save money, as well as proving an effective means of avoiding future environmental hazards and the expense of subsequent remediation.

The actual levels of investment are considerably higher than those indicated in the table. This is partly because plant and equipment increasingly have in-built environmental protection elements, the cost of which is difficult to identify separately and is therefore not included in the statistics on environmental investment.

Operating costs: These are the ongoing costs of running environ-mental plant and equipment. Nowadays they are recorded on the basis of a system of report-ing by cost-centre managers. The data acquired is therefore liable to a degree of variation and is used to respond to statistical enquiries. It is not an integral element of our accounting system and therefore not used directly as a control variable.

Waste, emissions, water and energy consumption at all German plants: The figures fail to reveal a clear trend in this field. The considerable efforts which we have made to protect the environ-ment – and the positive effects of these efforts – are often masked by increases in production output, the growing volume of packaging and changes in the definitions laid down in environmental legislation.

Suppliers

Working together as partners

Dr. Martin Winterkorn, Member of the Board of the Volkswagen Marque responsible for Technical Development, and Francisco Javier Garciá Sanz, Member of the Board of the Volkswagen Marque responsible for Procurement, presenting a Volkswagen Environmental Award to Dr. Franz Wressnigg, Chairman of the Board of Siemens Automotive Engineering Division.

Environmental protection cannot and must not stop at the factory gates. More than 75 percent of all raw materials, components and systems for Volkswagen products are manufactured by partner companies. Volkswagen's environmental policy contains a commitment to bring pressure to bear on its suppliers to behave in an environmentally responsible manner. We expect our suppliers to continuously improve the environmental aspects of their products and manufacturing processes – and this means we have to work closely together on an ongoing basis and in a spirit of partnership, from the initial development phase onwards and throughout the production planning process. We insist on their identifying and documenting the chemical composition of any materials they supply to us and require them to make a clear commitment to environmental protection as part of their corporate philosophy. We also expect suppliers to come up with ideas for recycling and disposal of the products they supply to us and to reflect on how our joint environmental goals can be achieved. Volkswagen regards a visible commitment to protecting the environment as part and parcel of the service our suppliers are expected to provide – and we judge their performance accordingly.

1997 Environmental Symposium: In February 1997, over nine hundred representatives of more than four hundred of our suppliers came to Wolfsburg from Germany, Europe and North America to attend the 1997 Environmental Symposium *Top Priority – Partners for the Environment* and demonstrate the close alliance which Volkswagen and its suppliers practise on environmental issues. The symposium focused on the topics of environmental management, product development and environmental protection, and environmental aspects of the production, use and recycling or disposal of products. Experts from Volkswagen, other com-panies and industry associations discussed the most important aspects of environmental protection with reference to the automobile. Regular workshops are to be organized in the future by Volkswagen and its suppliers to ensure that this cooperation is systematically deepened.

PRIORITÄT A
Partner für die Umwelt

1996 Procurement volume
(in DM billions)

Volkswagen cars	25.2
North American region	2.6
South American/African region	6.8
Asian/Pacific region	3.8

Source: VOLKSWAGEN AG

The Volkswagen Environmental Awards

The 1997 Environment Symposium witnessed the first ever presentation of the Volkswagen Environmental Awards. Six of our partner companies were honoured for their all-embracing approach to environmental protection and their contribution to ensuring that Volkswagen vehicles are as eco-friendly as possible:

Continental AG and its Korbach plant for producing tyres with a low rolling resistance, a high proportion of renewable raw materials and a longer service life – and for introducing particularly environmentally friendly production processes.

Fichtel & Sachs GmbH in Möllersdorf, Austria, for the refurbishment and recycling of clutch systems.

Fichtel & Sachs AG in Schweinfurt for their environmental management system and their support for workshops and dealers in environmental matters.

KKP Hölzer & Wulf OHG in Mellrichstadt for their easy-to-dismantle mountings and their general commitment to environmental protection beyond the everyday requirements of their operations, for example through their involvement with the German *Young Researcher of the Year* competition.

Mann & Hummel in Ludwigsburg for the manufacture of non-metallic filter elements using highly segregated materials for easy recycling, and a pronounced emphasis on environmental protection in their management systems.

Siemens AG Automotive Engineering, Würzburg, for manufacturing the electric propulsion system for the Golf CitySTROMer.

Further Volkswagen Environmental Awards will be awarded in future for pioneering corporate achievements in the field of environmental protection.

Early in 1997, Volkswagen presented the company's first Environmental Awards to six of its suppliers for their exemplary commitment to environmental protection.

Logistics

Ensuring a smooth flow of goods and materials and meeting the transport requirements of the Volkswagen Group are the task of Volkswagen Transport GmbH and Co. OHG (VWT). At its Wolfsburg site, Volkswagen operates the biggest industrial railway terminal anywhere in Europe, with more than 90 percent of new vehicles being loaded onto trains at the Wolfsburg plant and dispatched to stations and ports elsewhere for distribution.

Using AMES-T to improve vehicle routing and scheduling and reduce transport mileage:
The ames-t (Advanced Mobility Engineering and Services for Transportation) project is an attempt to optimise vehicle routing and scheduling in collaboration with freight carriers, customers and suppliers. In conjunction with material tracking systems and simplified incoming goods procedures, this project has boosted the efficiency of Volkswagen's transport operations. ames-t links customers, suppliers and freight carriers through a shared database and enables them to benefit from improved vehicle routing and scheduling, intelligent transport systems and communications/systems integration.

The freight terminal at the Wolfsburg plant. New vehicles are sent out by rail to join their new owners.

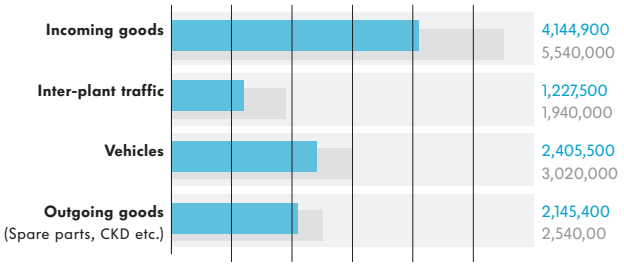
Freight centre: The declared aim of volkswagen is integrate truck and rail transport and thus transfer more freight than ever on to the railways. The key concept here is intermodal transport: goods are carried over long distances by rail and then transferred to trucks that are more flexible for local distribution to their final destination. To this end, the rail freight terminal at the Wolfsburg plant is being further upgraded. Since the autumn of 1997 it has been home to a new freight centre for industrial logistics under the auspices of the Regional Association of Greater Brunswick. Some dm 25 million has already been invested in the first stage of constructing this new intermodal transport centre, the main element of which is a trans-shipment terminal with a special crane for transferring special *swap-body* containers between railway wagons and trucks.

A further advantage of the new freight centre will be that many of the truck movements between the station at nearby Brunswick and the Wolfsburg plant can be dispensed with in future. At the moment a total of 60 special containers are sent by rail each day, which means a saving of around 350,000 road kilometres per year. And with plans to expand this by a further 100-120 containers a day, the potential savings could total between 6 and 7.5 million truck kilometres per year.

Environmental assessment of logistical processes: In order to be able to assess the environmental impact of logistical processes, Volkswagen and a number of partners have founded an organization known by its German acronym of inpro (Innovation Company for Advanced Production Systems in the Automotive Industry). The aim is for inpro to provide a planning instrument to support the process of assessing the environmental impact of alternative delivery concepts. There is an urgent need to take action in the transport sector, where the focus of environmental protection to date has been largely on hazardous goods. There is also a lack of appropriate instruments for making a thorough evaluation of logistical alternatives. Other important issues include the planning of container movements (reusable versus disposable packaging) and related aspects of resource cycle management.

1996 transport volume

(VWT as a whole, in t/a)



1996 freight volume
Projected freight volume for the year 2000
Source: VOLKSWAGEN AG

The Wolfsburg Plant

The headquarters of Volkswagen

Volkswagen's Wolfsburg plant is home to the Board of Management, Central Administration and Research and Development. With an area of 8 square kilometres, the plant is the world's largest single automobile factory "under one roof" and currently employs some 45,000 staff.

The plant itself is divided into two production divisions – automobile production and component production – and six service divisions. The town of Wolfsburg lies immediately to the south of the plant.

Products: In 1996, the Wolfsburg plant manufactured the Golf, Golf Estate, Vento and Polo models at a rate of approximately 2,700 vehicles per day, together with vehicle components and parts for the Group's integrated production network.

Environmental protection highlights

Emissions: Solvent emissions are being reduced, despite increased production output, by means of new painting systems and modifications to existing equipment. The authorization for these changes is complete. No chlorinated hydrocarbons (chcs) have been used in the production sector since April 1993. Only small quantities of chlorofluorocarbons (cfcs) are still used in closed-loop room air-conditioning systems. Work to replace cfcs is under way.

Waste management: Since February 1997, Volkswagen has been remediating a licensed landfill site which was in operation from 1958 until 1977. Over this period, this 38,000 square metre, company-owned landfill site was used for disposal of building rubble, sludges from phosphate coating, waste water treatment and painting operations, and the harmful substances present in this waste are seeping into the groundwater and soil. In order to purify the ground-water which has already been polluted and to prevent further seepage of the pollutants, the entire landfill is being enclosed within a retaining wall. At a maximum depth of 18 metres, the retaining wall reaches a virtually impermeable soil stratum. The aim is to dry out the land-filled waste and to remove the pollutants from the underlying sand. This remediation work on the landfill site is expected to cost DM 18 million. In 1996, a total of 4,140 tons of paper, cardboard, plastic films, material residues and artificial leather from the waste sorting plant was recycled. Just under 3,000 tons of household-type industrial waste was sent directly for external recycling. Overall, 9,700 tons of industrial waste still had to be landfilled. Various projects are currently under way to ensure more thorough waste segregation with the aim of further increasing the recycling rate for industrial waste.

Water management: Wolfsburg's thirteen waste water treatment plants with separate circuits for sanitary and industrial waste water ensure a recycling rate of 98.4 percent.

Noise control: A research project with external partners has brought about a reduction in workplace noise emissions. In Wolfsburg, the project covered the press shop together with the old and new machining shops.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection is achieved by means of specific environmental goals and programmes. The Wolfsburg plant is currently being audited in line with the ec Eco-audit Regulation; certification by an external auditor is expected by the end of 1997.

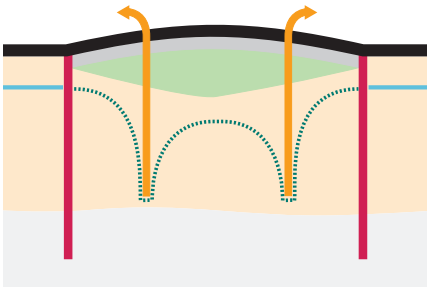
Paint residue recycling

Thanks to water-based paints, Wolfsburg has for the first time been able to recycle paint residues from an automotive paintshop on a large scale in an environmentally friendly manner, instead of disposing of them as hazardous waste. The overspray is washed out of the booth air and the paint is coagulated with additives in a multi-stage process and left to settle. Once the water has been separated from the settled residues, the recovered water is recirculated to the painting booths.

The residual paint sludge is pelletised in the Wolfsburg West combined heat and power plant and the pellets used to supplement fuel for the plant's boilers. Output of pelletised paint totalled some 2,000 tons.

Detailed information can be obtained from VOLKSWAGEN AG, Environmental Officer, Gebäudemanagement und Umweltschutz, Brieffach 1470, D-38436 Wolfsburg.

Schematic diagram of remediation of the sludge landfill at the Wolfsburg plant



DM 18 million is being invested in the remediation of a disused landfill.

VW Kraftwerk GmbH

VW Kraftwerk GmbH (VWK), a wholly-owned subsidiary of VOLKSWAGEN AG, operates two combined heat and power plants at the Wolfsburg plant to generate electricity and heat. At 59.6 percent, their efficiency is distinctly higher than that of power plants without cogeneration which generally operate at around 40 percent efficiency.

Products: vwk's principal task is to supply Volkswagen's Wolfsburg plant and its 45,000 staff with electricity, heat and natural gas. Deionised water is also supplied to the Volkswagen plant for use in the paintshop. In addition, heat and power are fed into Wolfsburg's municipal networks and power into the national grid.

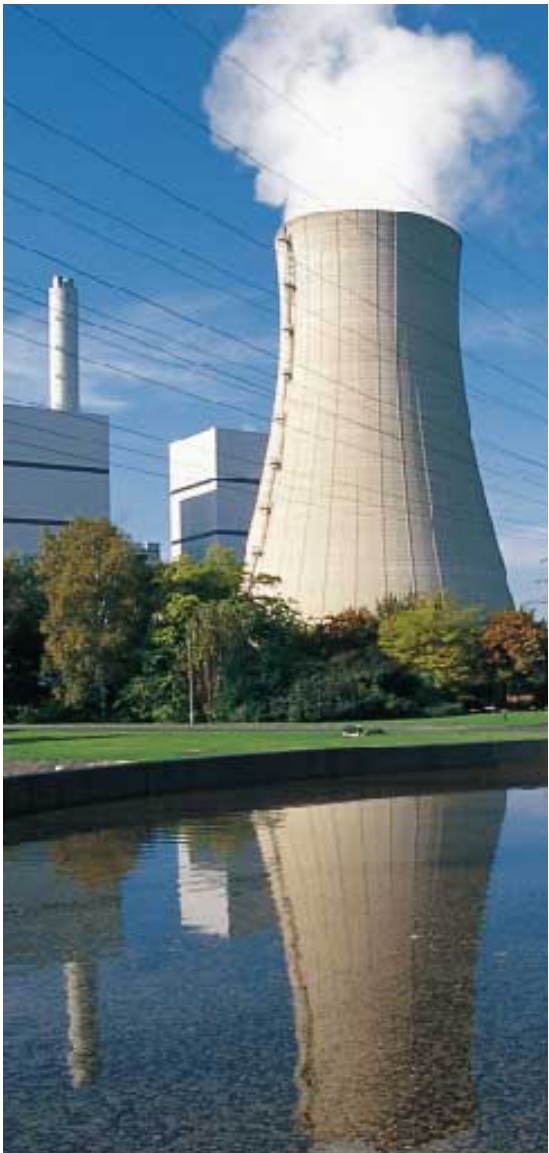
Certified in line with the EC-Eco-audit Scheme

Environmental protection highlights

In August 1996, VW Kraftwerk GmbH's Wolfsburg facility was the first German industrial power plant to obtain certification in line with the voluntary ec Eco-audit Regulation.

Energy input/output balance and emissions: In 1996, VWK's Wolfsburg site had an electrical power output of 2,050 million kilowatt-hours and a district heating output of 2,167 million kilowatt-hours. These 4,217 million kilowatt-hours of energy were generated using 7,072 million kilowatt-hours of fuel, 95 percent of which was coal (700,000 tonnes) with the remainder being primarily natural gas (170 million cubic metres) together with waste oil (10,000 tonnes) and pelletized paint (2,400 tonnes).The figures reflect comparatively high energy consumption, partly caused by the extended period of cold winter weather. There was accordingly a slight increase in emissions of carbon monoxide, oxides of nitrogen, sulphur dioxide and particulates. The Wolfsburg power plants remained well within their voluntary, self-imposed commitment to restrict heavy metal emissions to no more than 45 percent of the statutory limit values as an annual mean.

Environmental goals and programme: The environmental policy of VW Kraftwerk GmbH applies. Continuous improvement in vwk's process-oriented environmental protection is achieved by means of specific environmental goals and programmes. The measures to be implemented are based on the results of the first environmental audit



The combined heat and power stations at Wolfsburg supply electricity and heat to the Volkswagen plant and households in Wolfsburg. Heavy metal emissions in 1996 were only 1.3 percent of the statutory limit values.

and on the evaluation of environmental impacts using the u-risk software package. Energy-related goals include reducing carbon dioxide (CO_2) emissions by some 40,000 tonnes per annum* by means of efficiency improvements, a reduction in VWK's own power consumption by approximately 3 MW* and in CO_2 emissions by approximately 100,000 tons per year* by means of fuel substitution. One noise-related goal is to reduce the immission contribution as measured in the centre of Wolfsburg by 1-2 decibels (a). Monitoring goals include more broad-based measurement methods, while further goals include improving employee awareness and transferring know-how by consultancy activities.

Implementation of the environmental programme, with eleven individual measures still outstanding, is regularly monitored by the staff responsible. The environmental programme is documented in detail in VW Kraftwerk GmbH's Environmental Statement.

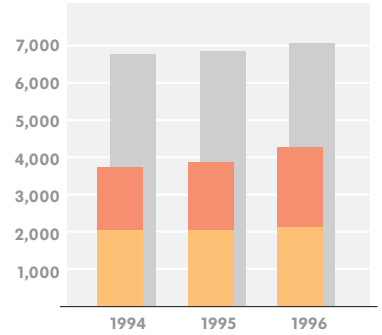
VWK and open dialogue: The possible environmental impact of recycling residues in the Wolfsburg power plants was one controversial topic of discussions between power station operators and concerned local residents. In addition to coal, natural gas and ultra-light fuel oil, power is also generated from residues with a high energy content, such as waste oil, pelletized paint from the production sector and sewage sludge. A permanent license allows the company to burn 30,000 tonnes of waste oil per year. This helps to conserve natural oil resources. It is also planned to recover the energy content of used tyres, industrial rubber and plastics, leading to savings of up to 100,000 tonnes of coal per year. The safety of this process was confirmed by TÜV experts as long ago as 1993.

*** in comparison with 1995 energy input.**

Aware that only a readiness to talk and an open approach can create trust, representatives of the power utility have taken part in discussions with environmental and public interest groups and organized information events of their own. Press conferences and background discussions lent greater depth to the debate on residue recycling. As a result of these discussions, in 1996 VWK obtained certification in line with the EC Eco-audit Regulation. The resultant Environmental Statement and the local newsletter *Kraftwerk aktuell* provide information on environmental activities as they relate to the utility's operations. VWK also publishes an annual report about emissions and compliance with limit values.

Detailed information can be found in VW Kraftwerk GmbH's Environmental Statement. This is available (in German only) from: VW Kraftwerk GmbH, D-38436 Wolfsburg.

Energy input/output balance
(in million kWh)



	1994	1995	1996
Energy input	6,703	6,842	7,072
Thermal output	1,725	1,822	2,167
Electrical output	2,006	2,017	2,050
Efficiency (%)	**55.7**	**56.1**	**59.6**

Source: VOLKSWAGEN AG

The Brunswick Plant

Of all Volkswagen's plants, this one to the north of the city of Brunswick boasts the longest traditions. The plant covers an area of almost 50 hectares, some 70 percent of which is developed, and provides work for 5,600 staff. The plastic part manufacturing operation also belonging to the plant is located roughly 800 metres to the north of the main plant on an industrial estate.

Products: The Brunswick plant manufactures running gear components, plastic parts, vehicle components, machinery and tools for Volkswagen Group marques, as well as for external customers.

Environmental protection highlights

In September 1996, Volkswagen's Brunswick plant obtained certification in line with the voluntary EC Eco-audit Regulation. The main items of environmental significance are the facilities that are subject to authorization in accordance with the German Federal Immission Control Act. Certification documented the fact that these and other equipment of environmental significance, such as the thermal emulsion and rinsing water separation plant, the waste water treatment plant and the dip coating plants, are operated in accordance with the relevant regulations.

Emissions: Running gear components are painted on modern high-build coating lines with low-solvent, water-based paints. The energy content of the solvent residues which escape during drying is recovered. The heating plant at the main site generates process heat with low-emission natural gas. Additional heat is supplied by the district heating network of the local municipal power utility. No chlorinated hydrocarbons (CHCs) have been used in the production sector since August 1992. Only small quantities of chlorofluorocarbons (CFCs) are still used in industrial plant and equipment. Work to replace CFCs is under way.

Waste management: The metal and plastic production residue streams are virtually completely recycled. Cutting compounds for machining are continuously reconditioned and recirculated.

Water management: Since the main plant is located in a water protection zone, particular care is taken when handling substances hazardous to water quality. Retaining bunds have thus been installed for the environmentally significant emulsion filters. There are two instances of groundwater contamination on the site which were caused by CHC spills in the past. Licensed, continuous groundwater remediation prevents this contamination from spreading. CHCs have moreover been banned from production processes since 1992.

Noise control: The environs of the Brunswick plant are somewhat problematic, with housing close to the plant. Noise control measures for any new projects planned in the plant are optimized using special software. Since the

Products from the Brunswick plant include running gear components for the Group's integrated production network.

Input/Output balance sheet for the Brunswick plant

1996 Material and Energy Inputs

Materials used (t)	
Iron/steel/ non-ferrous metals	188,567
Plastics	5,260
Assembled parts	35,221
Oils and greases	1,600
Other auxiliary substances such as chemicals, paints, acids, alkalis, adhesives	1,486
Industrial gases	
Oxygen (Nm^3)	40,881
Acetylene (Nm^3)	3,114
Protective gas, CO_2 (kg)	611,861
Argon (kg)	1,323,878
Quantity of drinking water (m^3)	304,701
Energy (MWh)	
Electrical energy	141,101
District heating (bought in)	55,576
Heating oil	6,987
Natural gas	112,867
Environmentally significant plants	Heating plants, Dip coating plants, Cutting compound handling plants

1996 Product Output

Running gear components (pcs.)	
Rear axles, semi-trailing arms and axle casings	2,331,730
Steering gear	165,665
Front axles (swivel bearings)	1,983,510
Plastic parts	107,554,489
Machinery, tools, for example casting dies, shaping dies, assembly lines	
Waste	
Recycling (t)	
Household waste and household-type industrial waste	889
Hazardous waste (process-related)	1,992
Ferrous, non-ferrous waste	42,615
Disposal (t)	
Household waste and household-type industrial waste	905
Hazardous waste (process-related)	749
Waste air (t)	
Particulates	1.3
Carbon monoxide (CO)	18.0
Hydrocarbons (HC)	49.0
Oxides of nitrogen (NO_X)	22.1
Carbon dioxide (CO_2)	23,332.0
Waste water (m^3)	
Sanitary waste water	69,969
Industrial waste water	122,755
in kg	
Adsorbable organic halogen compounds (AOX)	11.4
Hydrocarbons (HC)	119.0
Zinc (Zn)	6.6
Nickel (Ni)	11.1
Copper (Cu)	4.7
Others	

Source: Simplified Environmental Statement for the Brunswick plant, 1997

noise situation at the site has not yet been fully documented, a noise emission map is being drawn up.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Brunswick plant is achieved by means of specific environmental goals and programmes. The measures to be implemented are based on the results of the first environmental audit and on the evaluation of environmental impacts using the u-risk software package. Our goals include improving the baseline environmental data, remediation of underground contamination, improvement of environmental protection systems and improvement of training in environmental matters.

Implementation of the environmental programme comprising twelve individual measures is regularly monitored by the staff responsible. The environmental programme is documented in detail in the Brunswick plant's Environmental Statement.

Plastics recycling

Waste from plastic bumper production is completely recycled at the Brunswick plant. Pellets made from reject painted plastic bumpers are supplied from the Wolfsburg plant. The plastic part production unit at Brunswick converts these pellets into components which are used in non-visible applications, primarily the fan belt guard on the engine, the tool pouch and vehicle interior ventilation components. On average, 135 tonnes of repelletized polypropylene from painted bumpers is recycled in this way each year.

Detailed information can be found in the Brunswick plant's Environmental Statement. This is available (in German only) from: VOLKSWAGEN AG, Service Center Werktechnik, Brieffach 3400, D-38037 Braunschweig.

The Kassel Plant

The Volkswagen plant in Baunatal, 5 kilometres to the south of the city of Kassel, produces components for the Volkswagen integrated production network. The plant currently employs 15,500 staff. The site has a total area of some 2.4 million square metres, approximately 0.85 million of which are developed.

Products: The Kassel plant manufactures manual and automatic gearboxes, differentials, exhaust systems including catalytic converters, bodywork components for the Passat and spare parts. It also reconditions engines and gearboxes. The plant is also the spare parts centre for over 12,500 customer service workshops in more than 165 countries.

Environmental protection highlights

Emissions: Reducing thermal energy and room heating requirements is one way of cutting carbon dioxide (CO_2) emissions. We have achieved such reductions by setting up a central building services management system which allows precise control of energy streams. In the winter months, further energy is saved by using some of the thermal energy in waste air to heat incoming fresh air via heat exchangers. No chlorinated hydrocarbons (CHCs) have been used in the production sector since April 1993. Only small quantities of chlorofluorocarbons (CFCs) are still used in closed-loop refrigeration and room air-conditioning systems. Work to replace CHCs is under way.

Waste management: The site's 5.6-hectare hazardous waste landfill has been completely rehabilitated in recent years. The site has been brought into line with current best practice at a cost of approximately DM 32 million. The landfill, which has been filled to half its capacity, has been planted with vegetation and the quantity of waste landfilled (currently 6,000 tonnes per year) is being reduced continuously.

Water management: The central waste water treatment plant and several decentralized pre-treatment plants ensure that the effluent discharged into the river Bauna is of a quality comparable with that of normal river water. The stated goal of achieving water quality level 2 has now been achieved. Water quality is continuously monitored in our in-house laboratory. The plant has its own water supply: five groundwater wells provide the water for production and sanitary purposes. Specific water consumption per gearbox produced has been continuously reduced over recent years.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Kassel plant is achieved by means of specific environmental goals and programs. The Kassel Volkswagen plant is preparing for certification in line with the EC Eco-audit Regulation in 1998.

The new magnesium gearbox casing produced in Kassel is 4.5 kilograms lighter than its aluminium counterpart.

Volkswagen can draw on extensive experience with magnesium, the material of the future.

Magnesium

Kassel has been casting six hundred magnesium gearbox casings per day since August 1996. Each of these gearbox casings is 4.5 kilograms lighter than its aluminium equivalent. Magnesium is vital to Volkswagen's strategy of cutting fuel consumption by reducing the weight of new models. As with aluminium, considerable quantities of energy are consumed in primary magnesium production and Volkswagen is therefore establishing an internal recycling system for secondary magnesium. The energy input and associated CO_2 emissions amount to between just 5 and 12 percent of the energy input for primary material.

The Kassel plant's brochure "Umweltschutz – heute und morgen" contains further information. This is available (in German only) from: VOLKSWAGEN AG, Werktechnik, Postfach 1451, D-34219 Baunatal.

The Emden Plant

The Emden plant, which employs 9,900 staff, is located to the south west of the city of Emden. Of the total site area of some 4 million square metres, only 38 percent have been developed. A proportion of the remainder is used agriculturally and the site also includes biotopes which merit special protection.

Certified in line with the EC-Eco-audit Scheme

Products: Emden is a vehicle production plant. The plant builds the Passat and Passat Estate and has a capacity of 1,400 vehicles per day.

Environmental protection highlights

In September 1995, the Volkswagen plant in Emden became the first German automobile plant to obtain certification in line with the voluntary EC Eco-audit Regulation. The main items of environmental significance are the facilities that are subject to authorization in accordance with the German Federal Immission Control Act, namely the paintshop and heating plant. Certification documented the fact that these and other equipment of environmental significance, such as the waste water treatment plant, waste collection and waste oil storage facilities, are operated in accordance with the relevant regulations.

Emissions: In general, the plant is supplied with electricity and district heating by local utility companies. No chlorinated hydrocarbons (CHCs) have been used in the production sector since April 1993. Only small quantities of chlorofluorocarbons (CFCs) are still used in closed-loop room air-conditioning systems. Work to replace CFCs is under way.

Waste management: In the Seventies, the plant operated a licensed landfill site which now no longer satisfies current best safety practice. The contamination is therefore being contained and the site remediated. Waste management is also being centralized.

Water management: Commissioning of a new dip coating line in 1996 substantially reduced waste water loadings and achieved 20 percent economies in treatment chemicals. Plant and equipment using substances hazardous to water quality is being adapted to current best practice. After trials at the Emden plant, a waste water register developed by Volkswagen will be used at all the Group's plants in Germany.

Noise control: Control measures meet or exceed the requirements of the German Noise Prevention Code.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Emden plant is achieved by means of specific environmental goals and programme. The measures to be implemented are based upon the results of the first environment audit and on the evaluation of environmental impacts using the U-RISK software package. Our goals include improvement of the baseline environmental data and waste management, as well as remediation and/or containment of under-ground contamination and improvement of environmental protection systems and environ-mental training and information schemes.

Implementation of the environmental programme, with thirteen individual measures still outstanding, is regularly monitored by the staff responsible. The environmental programme is documented in detail in the Emden plant's Environmental Statement.

Sufficient electricity is generated by the wind farm on the site of the Emden plant to cover some 8 percent of the City of Emden's electricity needs.

Input/Output balance sheet for the Emden plant

1996 Material and Energy Inputs

Materials used (t)	
Iron/steel	111,982
Plastics, elastomers	23,799
Light metals	3,010
Non-ferrous metals	767
Assembled parts (without specifying individual parts, some bought-in)	51,470
Car seats	8,203
Gearboxes	4,518
Glass	6,169
Natural materials	78
Auxiliary substances/ chemicals	15,591
Quantity of fuel (l)	2,792,767
Industrial gases (m^3)	
Oxygen	41,396
Acetylene	5,787
Protective gas	125,298
Drinking water (m^3)	551,933
Energy (MWh)	
Electrical energy	182,115
District heating	171,815
Natural gas	170,456
Environmentally significant plants	Paintshop, Heating plant, Waste water treatment plant

In comparison with the 1995 Environmental Statement and the 1996 simplified Environmental Statement, the baseline data for materials used (inputs) were further improved with the current model change from the Passat B 4 to the Passat B 5. In the new Passat, the multi-component items, for example gearboxes, can be broken down and calculated in greater detail. Improved data acquisition has also allowed the addition of further material groups. The details relating to car seats and gearboxes thus relate only to the old model, Passat B 4, while natural materials, in contrast, relate only to the new model, Passat B 5.

1996 Product Output

Vehicles (units)	
Total vehicles	180,944
Passat Estate	116,741
Passat Saloon	56,763
Taro / Hilux	7,440
Waste	
Recycling (t)	
Total waste recycling	9,093.0
Household waste and household-type industrial waste	3,209.8
Hazardous waste	1,304.9
Metals	4,579.2
Disposal (t)	
Total waste disposal	2,579.5
Household waste and household-type industrial waste	1,563.4
Hazardous waste	1,016.1
Waste air (t)	
Particulates	12.2
Carbon monoxide (CO)	64.5
Organic solvents (VOC)	456.2
Oxides of nitrogene (NO_X)	46.2
Carbon dioxide (CO_2)	32.386.6
Waste water (m^3)	
Quantity	458,446
In kg/a	
Adsorbable organic halogen compounds (AOX)	7.9
Chemical oxygen demand (COD)	19,101.9
Hydrocarbons	103.2
Phosphorus (P)	328.6
Nitrogen (N)	4,278.8
Nickel (Ni)	15.3
Zinc (Zn)	31.0
Chromium (Cr)	13.8
Lead (Pb)	1.5

Source: Simplified Environmental Statement for the Emden plant, 1997

Wind power

The Emden municipal power utility has installed a wind farm on the agricultural section of the Volkswagen site. Wind turbines can convert the wind's energy into electricity at an efficiency of approximately 40 percent. So far, ten wind turbines with a rated output of 5 megawatts have been installed on the wind farm which came on line in 1994 and cover some 8 percent of the City of Emden's electricity needs. Moreover, the prototype of what, at the time, was the world's largest wind turbine, the tw 1500 with a rated output of 1,500 kilowatts, was installed in April 1996. This turbine alone can meet the electricity needs of up to 1,300 households. Once trials have been successfully completed, the turbine is scheduled to go into series production.

Detailed information can be found in the Emden plant's Environmental Statement. This is available (in German only) from: VOLKSWAGEN AG, Werk Emden, D-26703 Emden.

The Emden plant builds the Passat and Passat Estate.

The Salzgitter Plant

Volkswagen's Salzgitter plant is located in the south eastern region of Lower Saxony and is the City of Salzgitter's most important employer with 7,200 staff. Some 30 percent of the site, which covers approximately 280 hectares, has been developed.

Products: The Salzgitter plant has become the Group's centre of competence for engine production, with a daily capacity of some 7,500 petrol and diesel engines. These are destined for all of the Volkswagen Group's vehicle assembly plants, as well as for other automobile manufacturers. 55 percent of the engines are dispatched by train.

Environmental protection highlights

Certified in line with the EC-Eco-audit Scheme

In December 1996, the site obtained certification in line with the voluntary EC Eco-audit Regulation. The main items of environmental significance are the facilities that are subject to authorization in accordance with the German Federal Immission Control Act. Certification documented the fact that these and other equipment of environmental significance, such as the waste water treatment plant, intermediate waste storage facilities, waste collection points or demulsification units, are operated in accordance with the relevant regulations.

Emissions: Thermal energy is produced with low-emission natural gas in the plant's own heating plant (173 megawatt-hours). Targeted energy management systems have allowed peak electrical power consumption to be reduced from 53 megawatts in 1991 to a current 47 mega-watts. Emissions from engine test benches are treated with catalytic converters. No chlorinated hydrocarbons (CHCs) have been used in the production sector since 1990. Only small quantities of chlorofluorocarbons (CFCs) are still used in closed-loop room air-conditioning systems. Work to replace CFCs is under way.

Waste management: Coolant emulsions for machining are recycled and waste collection is segregated. This waste is largely reprocessed in neighbouring industrial operations. The Thiederhall underground landfill, at which production sludges were deposite 1977 until 1987, is located nearby. The necessary shutdown procedure is currently being implemented in agreement with all the relevant authorities. The site has been recultivated and was returned to agricultural use in 1993.

Water management: The waste water treatment plant treats industrial waste water from the Salzgitter plant and municipal waste water from more than 2,500 households in the Thiede and Steterburg districts. Addition of a further biological treatment stage in 1994 reduced nitrogen levels by 75 percent.

Noise control: Measurements made in the vicinity revealed that noise emissions from the Salzgitter plant are below the guide values laid down in the German Noise Prevention Code.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Salzgitter plant is achieved by means of specific environmental goals and programme. The measures to be implemented are based upon the results of the first environmental audit and on the evaluation of environmental impacts using the U-RISK software package.

Our goals include improvements to environmental protection systems, to the baseline environmental data and to environmental training measures.

Implementation of the environmental programme, with seventeen individual measures still outstanding, is regularly monitored by the staff responsible. The environmental programme is documented in detail in the Salzgitter plant's Environmental Statement.

Input/Output balance sheet for the Salzgitter plant

1995 Material and Energy Inputs

Materials used (t)	
Iron/steel	189,848
Light metals	27,256
Plastics/elastomers	4,174
Assembled parts	17,906
Chemicals, oils and greases	4,908
Quantity of fuel	1,188
Industrial gases (m^3)	
Nitrogen	1,000,370
Argon	356,600
Oxygen	9,154
Propane	5,645
CO_2	2,534
Acetylene	928
Drinking water (m^3)	392,924
Municipal waste water	
from City of Salzgitter (m^3)	569,186
Energy (MWh)	
Electrical energy	239,830
Natural gas	186,292
Environmentally significant plants	Heating plant, engine test benches, cutting compound handling plant, waste water treatment plant

1995 Product Output

Units manufactured	
Engines	1,320,564
Engine blocks	23,558
Cylinder heads	45,918
Crankshafts	15,600
Exhaust manifolds	299,937
Intake manifolds	61,748
Miscellaneous components	14,386,887
Waste	
Recycling (t)	
Household waste and household-type industrial waste	1,610
Hazardous waste	5,022
Ferrous, non-ferrous waste	37,130
Non-process-related waste	573
Disposal (t)	
Household waste and household-type industrial waste	628
Hazardous waste	16
Non-process-related waste	1,958
Waste air (t)	
Carbon dioxide (CO_2)	36,421
Carbon monoxide (CO)	120
Oxides of nitrogen as NO_2 (NO_X)	33
Sulphur dioxide (SO_2)	6
Organic substances	34
Waste water (m^3)	
Total quantity	799,018
Proportion from Salzgitter plant	229,832
in kg	
Chemical oxygen demand (COD)	29,963
Biological oxygen demand (BOD)	3.196
Hydrocarbons	220
Adsorbable organic halogene compounds (AOX)	22
Total phosphorus (P)	86
Total inorganic nitrogen (N)	11,430
Ammonium	1,978
Cyanide	16
Iron (Fe)	354
Zinc (Zn)	62
Lead (Pb)	2.4

Source: Environmental Statement for the Salzgitter plant, 1996

Car pooling

Volkswagen supports car pooling in order to reduce the number of staff travelling to work in their own cars. There is a car pool notice board within the internal mail system and buses are more frequent at shift change times to encourage the use of public transport.

Detailed information can be found in the Salzgitter plant's Environmental Statement. This is available (in German only) from: VOLKSWAGEN AG, Werk Salzgitter, D-38231 Salzgitter.

With a daily output of 7,500 units, the Salzgitter plant is the world's largest engine manufacturing facility.

The Hanover Plant

The Stöcken district in the north of Hanover, the state capital of Lower Saxony, has been home to the headquarters of Volkswagen's commercial vehicle operations since 1956. Covering an area of some 1.1 million square metres, the plant employs 14,000 staff.

The new LT won the 1996/97 German Commercial Vehicle Award. With the TDI engine installed, fuel consumption is particularly low.

Products: Every day, the Hanover plant turns out some 700 Transporter, Caravelle and lt (1 to 2.5 tonnes payload) models, together with sheet steel pressings, light metal castings and components for the Group's integrated production network.

Environmental protection highlights

Emissions: Preparations have been made for drawing up a register of odour nuisances and atmospheric pollutants. No chlorinated hydrocarbons (chcs) have been used in the production sector since April 1993. Only small quantities of chlorofluorocarbons (cfcs) are still used in closed-loop room air-conditioning systems. Work to replace cfcs is under way.

Water management: A new plant for treating waste water from the bodyshell pretreatment process was commissioned in hall 17 of the Hanover plant in June 1996. The plant cost dm 2.2 million and a further dm 900,000 was spent on infrastructural measures. The plant can treat waste water containing chromium, paint and acids/alkalis arising from the pretreatment process separately to a standard at which it can be discharged into the sanitary waste water system.

Noise control: The environs of the plant are somewhat problematic, with housing close to the plant. In an in-depth expert study, the entire plant's contribution to local noise levels has been mapped out. On the basis of these findings, our noise reduction measures are now being implemented more efficiently.

Environmental goals and programs: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Hanover plant is achieved by means of specific environmental goals and programme. Our goal for Hanover, as for all our European plants, is to obtain certification for the plant in line with the ec Eco-audit Regulation.

Plant register

New German regulations pertaining to plant and equipment that handle substances hazardous to water quality (vaws) require that a plant register be established. Volkswagen is preparing this register using software we have developed in-house. The process involves recording, classifying and rating the plant and equipment concerned. The register will support the efforts of planning departments, plant operators, environment officers and the authorities. The computerised plant and equipment register is now being used successfully at Volkswagen and in other companies.

Expert network: Amendments to the Federal Water Act (whg) mean that stricter requirements will in future be applied to production plant and equipment in which substances hazardous to water quality are used. The extended scope of the Act means that additional licensing is required and technical measures must be implemented. A further requirement is that the initial and recurrent inspections of this equipment be performed by approved experts. Volkswagen has thus established its own network of experts and appointed suitable staff to act in this capacity. In this way, important water protection measures can be planned in good time and implemented without excessive cost.

Detailed information may be obtained from: Volkswagen Commercial Vehicle Division, Umweltschutz, Brieffach 2399, Postfach 210580, D-30405 Hannover.

The Mosel Plant

Volkswagen Sachsen GmbH's Mosel vehicle production plant was established in 1990 on a 1.8 million squaremetre site in western Saxony. Located near Zwickau, the Mosel plant employs 3,800 staff.

The latest environmental protection systems were implemented at the Mosel plant from the outset. Wetland biotopes and meadows were established on the site to offset the impact of the plant and formerly channelled water courses were renaturalized.

Products: The plant manufactures the Golf and Passat saloon and currently has a production capacity of 432 vehicles per day.

Environmental protection highlights

In March 1996, Volkswagen's Mosel plant obtained certification in line with the voluntary ec Eco-audit Regulation. The main items of environmental significance are the facilities that are subject to authorization in accordance with the German Federal Immission Control Act, namely the paintshop and the heating plant. Certification documented the fact that these and other equipment of environmental significance, such as the waste water treatment centre and the oil, paint and tank storage facilities, are operated in accordance with the relevant regulations.

Emissions: In 1993, the lignite-fired power station was shut down and a modern natural-gas-fired power station commissioned, thereby dramatically reducing regional emissions of oxides of nitrogen, sulphur dioxide and particulates. In addition, a modern paintshop using water-based paints was commissioned in March 1997.

Car production at the Mosel plant in Saxony. Volkswagen was the first and remains the largest private-sector investor in Germany's new federal states.

Waste management and disposal: Over 90 percent of all residues are sent to regional recycling companies for reprocessing.

Noise control: The area around the plant is classed as a mixed industrial/residential area. From the planning stage onwards, noise emissions were computer modelled and noise abatement measures implemented, including a landscaped soil mound noise barrier on the eastern side of the plant. Press shop plant and equipment was installed on a suspended foundation and provided with soundproofing enclosures.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Mosel plant is achieved by means of specific environmental goals and programmes. The measures to be implemented are based on the results of the first environmental audit and on the evaluation of environmental impacts using the u-risk software package. Our goals include improving the baseline environmental data and

Input/Output balance sheet for the Mosel plant

1996 Material and Energy Inputs

Materials used (t)	
Iron/steel	116,250
Light, heavy and non-ferrous metals	5,510
Plastics	5,510
Textiles, laminates	2,500
Elastomers (rubber, PVC and bitumen)	7,010
Glass	3,710
Paint (complete multi-layer coating)	2,510
Other material	2,800
Quantity of fuel (l)	589,230
Industrial gases (m^3)	
Acetylene	250.89
Oxygen	1,000.96
Argon	9,875.30
Nitrogen	42.05
Quantity of drinking water (m^3)	121,973
Energy (MWh)	
Electrical energy	75,596
Natural gas	143,707
Environmentally significant plants	Paintshop, waste water treatment centre and natural-gas-fired heating plant

1996 Product Output

Vehicle units	
Golf A3	84,351
Passat	3,521
Pressings (t)	20,347
Waste	
Recycling (t)	
Household waste and household-type industrial waste	1,299.00
Hazardous waste	1,391.00
Disposal (t)	
Household waste and household-type industrial waste	498.00
Scrap (t)	
Pressing scrap	18,176.00
Mixed scrap	674.00
Waste air (t)	
Particulates	2.00
Organic solvents	536.90
Oxides of nitrogen as NO_2 (NO_X)	46.10
Carbon monoxide (CO)	97.00
Carbon dioxide (CO_2)	27,304.33
Waste water (m^3)	
Total quantity	215,490.00
of which municipal	32,056.00
of which GKN propshaft factory	15,663.00
in kg	
Adsorbable organic halogene compounds (AOX)	16.25
Chemical oxygen demand (COD)	13,885.00
Hydrocarbons	34.05
Phosphorus (P)	149.06
Nitrogen (N)	1,228.13
Nickel (Ni)	4.09
Zinc (Zn)	13.86
Lead (Pb)	1.75
Copper (Cu)	2.00
Chromium (Cr)	1.72

Source: Simplified Environmental Statement for the Mosel plant, 1997

environmental protection systems. Implementation of the environmental programme, with six individual measures still outstanding, is regularly monitored by the staff responsible.

Integrated environmental protection: Water management for the plant and the surrounding region

The waste water treatment centre includes a biological treatment plant for waste water from the town of Mosel, the neighboring propshaft factory and the Volkswagen plant, together with central treatment facilities for partial streams of production waste water from the plant. Agreements have also been concluded with regional waste water treatment associations governing the treatment of sewage sludge. The waste water treatment centre has improved the quality of the effluent flowing into the Zwickau section of the river Mulde, raising the prevailing water quality here to 2-3 from its 1991 level of 4.

Detailed information can be found in the Mosel plant's Environmental Statement. This is available (in German only) from: Volkswagen Sachsen GmbH, Sächsische Automobilbau GmbH, Fahrzeugfertigung Mosel, Postfach 200, D-08125 Mosel.

The Chemnitz Plant

Volkswagen's commitment in Chemnitz dates back to 1984. Since 1988, when a new assembly shop was completed, the plant has been supplying engines to the Group's integrated production network. In June 1992, a new engine production facility was added to the existing plant.

The plant employs five hundred staff. The Chemnitz site now covers a total area of 230,000 square metres, some 60,000 square metre of which have been greenscaped.

Products: In 1996, the Chemnitz plant built some 500,000 engines for Volkswagen's integrated production network.

Environmental protection highlights

Waste management: When Volkswagen took over the Chemnitz site, which already had a long history of industrial use, it was found that the soil and groundwater were so severely contaminated that remediation work had to start immediately. Once the situation had been analysed, the groundwater was purified and contaminated rubble and soil placed in temporary storage, biologically remediated and then reused. A total of seven lightweight buildings had to be erected as temporary storage facilities to accommodate approximately 80,000 tonnes of contaminated soil and rubble.

Environmental goals and programme: The environmental policy of the Volkswagen marque applies. Continuous improvement in process-oriented environmental protection at the Chemnitz plant is achieved by means of specific environmental goals and programmes. Our goal is for the Chemnitz plant to obtain certification in line with the ec Eco-audit Regulation in 1999.

Since being taken over by VOLKSWAGEN AG, the Chemnitz site has been comprehensively remediatated.

Integrated environmental protection: Machining

Automobile production is inconceivable without machining operations. The environmental significance of machining primarily arises from the use of coolant emulsions. These coolant emulsions generally consist of mineral oil-in-water emulsions or mineral machining oils. The use of these substances causes contamination in the workplace and entails complicated treatment after use. This problem can be resolved in many cases and in new processes by using coolant emulsions based on natural substances (of vegetable origin). The oils are more readily biodegradable than comparable mineral oil products and thus result in reduced workplace contamination. Moreover, since these oils fall within a lower water hazard class, the requirements in terms of the plant and equipment concerned are less stringent. The waste oil, swarf and grinding sludges can be disposed of in a more eco-friendly manner and substantially less oil is required. The overall environmental situation improves accordingly and this may also bring benefits on the cost side while achieving identical or in some cases even higher quality.

Today, Chemnitz builds engines for Volkswagen's global integrated production network.

State-of-the-art findings have often been successfully integrated into Volkswagen's customary series production methods. Completely dispensing with coolant emulsions, i.e. dry processing, is another of our objectives. Chipless or near net shaping processes are also being developed as part of our integrated approach to environmental protection.

Further information can be obtained from:
Volkswagen Sachsen GmbH, Motorenfertigung Chemnitz,
Postfach 285, D-09028 Chemnitz.

Production Plants around the World

In its early years, Volkswagen was quick to trigger the internationalization process by forging ahead with targeted export activities and setting up production facilities outside Germany. Until the mid-Seventies, these activities all centred on the Beetle which, in many countries, played the dual role of providing mobility and promoting local industrial development.

All over the world, people at Volkswagen are developing, manufacturing and marketing cars with the aim of safeguarding personal mobility.

It was back in 1947 that the first Volkswagen cars were exported to the Netherlands. Exports to the United States followed in 1949. In the course of the Fifties, Volkswagen's foreign activities came to include production projects all over the world. Today, the main production facilities of the Volkswagen Group outside Germany are located in Brazil (1953), South Africa (1956), Mexico (1964), Belgium (1970), Argentina (1980), the People's Republic of China (1985), Spain (1986), the Slovakian Republic (1991), Poland (1993), Taiwan (1994) and Portugal (1995).

The basic principles of the environmental policy of the Volkswagen Group apply equally to all production facilities outside Germany. The international coordination of environmental protection activities is handled by the Strategic Task Force for Environmental Protection (step). This is the body responsible for determining important issues related to the environment, enabling the Group to adopt a global approach based on largely uniform principles. Our aim is for the production facilities outside Europe to obtain certification to iso 14001. In addition, we plan to methodically integrate facilities outside Germany into the Environmental Information System, which will mean that their environmental activities can be documented in equal detail.

The Bratislava plant in the Slovakian Republic.

Bratislava Plant, Slovakian Republic

Volkswagen Bratislava spol. s.r.o. (Founded in 1991; wholly-owned subsidiary of volkswagen ag). Production of the Golf, Golf Estate and Golf Syncro models, as well as gearboxes and gearbox components. The plant employs 2,400 staff.

Environmental protection highlights:

- *Waste management operations brought into line with the waste management programme of the Slovakian Republic*
- *Consistent waste segregation at the point of occurence*
- *Priority assigned to waste recycling methods*
- *Construction of a new secondary treatment system to reduce paintshop emissions*
- *Operation of a monitoring system for emissions from heat/power generation and the boiler room*
- *Operation of a central waste water treatment plant and pre-treatment of waste water upstream of the plant*
- *Alterations to the bodyshell pre-treatment plant*
- *Further automation of the central waste water treatment plant*
- *Ongoing inspection of soil and groundwater to identify existing environmental hazards*
- *Revitalization of the immediate environment of the plant in collaboration with the environmental group "Association for Industry and Environment"*

Palmela Plant, Portugal

AutoEuropa-Automòveis, Lda. (Founded in 1991; volkswagen ag holds a 50 percent stake). Production of the Sharan and of models for the Seat marque and for Ford Motor Company. The plant employs 4,000 staff.

Environmental protection highlights:

- *Use of low-solvent and lead-free paints*
- *Recirculation and treatment of waste water from the paintshop*

Poznan Plant, Poland

Volkswagen-Poznan Sp. zo. o, (Founded in 1993; volkswagen ag holds a 59 percent stake). Production of the Transporter. skd assembly of the Polo as well as ckd and skd assembly of other models for Volkswagen Group marques. The plant employs 1,260 staff.

Environmental protection highlights:

- *Conversion of the combined heat and power plant from coal-fired to gas-fired*

The two other companies in the North American Region, namely volkswagen of america inc. and Volkswagen Canada Inc., which together employ a total of 969 staff, are exclusively sales companies with no production facilities of their own.

North American Region

Puebla Plant, Mexico

Volkswagen de Mexico, S.A. de C.V. (Founded in 1964; wholly-owned subsidiary of volkswagen ag). Production of the Jetta (Vento), Golf, Golf Convertible and Beetle models, as well as engines, components and spare parts. The plant employs 13,092 staff.

Environmental protection highlights:

- *Reduction of emissions in waste air from the foundry*
- *Preparation for conversion to production processes with a lower impact on the environment (e.g. use of water-based paints in the paintshop)*
- *Treatment of waste water at the factory's own waste water treatment plant*
- *Recycling of industrial waste and environmentally compatible disposal of hazardous wastes*
- *Staff training in aspects of environmental protection*

Volkswagen has been building cars in Puebla, Mexico, since 1964. Today more than 13,000 staff are employed at the plant.

South American/African Region

Volkswagen do Brasil Ltda.

São Bernardo do Campo, Brazil (Founded in 1953; wholly-owned subsidiary of volkswagen ag)

Anchieta Plant: Production of the Golf (2nd generation), Saverio (Pick up), Santana, Quantum and Kombi Van (t1 and 2) models, as well as engines, gearboxes and components. The plant employs 22,033 staff.
Environmental protection highlights:

- *Drainage system for sanitary waste water*
- *Projected measures designed to save water*

Taubaté Plant: Production of the Golf (2nd generation) and Parati models. The plant employs 7,750 staff.
Environmental protection highlights:

- *Chemical and biological waste water treatment stages*
- *Projected solar-powered test aimed at the treatment of waste water effluent*

Resende Plant: Production of trucks of between 7 and 35 tonnes and bus chassis. The plant employs 290 staff.
Environmental protection highlights:

- *Planning of waste water treatment facilities in line with the current state of the art*

São Carlos Plant: Engine production.
The plant employs 316 staff.
Environmental protection highlights:

- *Extensive greenscaping measures in the grounds of the plant*
- *Installation of a modern waste water treatment plant*
- *Installation of a high-efficiency swarf cleaning and drying plant*

Volkswagen Argentina S.A.

Buenos Aires, Argentina (Founded in 1987, wholly-owned subsidiary of volkswagen ag)

Pacheco Plant: Production of the Gol (2nd generation) and Polo Classic models. The plant employs 2,201 staff.
Environmental protection highlights:

- *Projected thermal energy recovery from paint sludge*
- *Noise abatement measures in the interest of local residents*

Cordoba Plant: Production of gearboxes and components and engine assembly.
The plant employs 1,274 staff.
Environmental protection highlights:

- *Noise abatement measures in the production sector*
- *Greenscaping programme at the initiative of employees*

Volkswagen of South Africa (Pty.) Ltd.

Uitenhage, South Africa (Founded in 1956; wholly-owned subsidiary of volkswagen ag since 1974)

Uitenhage Plant: Production of the Golf (1st and 3rd generation), Jetta (3rd generation), Golf Pick-up (1st generation), Polo Classic and Transporter (3rd generation) models, as well as models of the Audi marque, engines and components. The plant employs 6,500 staff.
Environmental protection highlights:

- *Involvement in national and regional industrial environmental forums*
- *Week-long event to mark "Environment Day"*
- *Waste management audit*
- *Preparation for ISO 14001*
- *Training of new staff on environmental matters*

Asian-Pacific Region

Anting/Shanghai Plant, China

Shanghai-Volkswagen Automotive Company Ltd. (Founded in 1985, vo1kswagen ag holds a 50 percent stake). Production of the Santana 2000, Santana (Passat notchback, 2nd generation) models and engines. The plant employs 10,222 staff.

Environmental protection highlights:

- *Reduction in fuel consumption and development of vehicles with catalytic converters to run on unleaded fuel once the distribution infrastructure is in place*
- *Orientation of (petrol-engined) vehicle exhaust and noise emissions to European and U.S. standards*
- *Natural gas propulsion project: Urban operation of a pilot fleet of fifty vehicles*
- *Conservation of resources through the use of advanced production plant and engineering, including a paintshop with a thermal waste air treatment system.*
- *CFC-free car air-conditioning systems*

The Santana 2000. Volkswagen is the market leader in China.

Changchun Plant, China

faw-Volkswagen Automotive Company, Ltd. (Founded in 1991; vo1kswagen ag holds a 30 percent stake). Production of the Jetta a2 and Jetta a2 Facelift, as well as models of the Audi marque, engines and gearboxes. The plant employs 3,800 staff.

Environmental protection highlights:

- *Reduction in fuel consumption and development of vehicles with catalytic converters to run on unleaded fuel once the distribution infrastructure is in place*
- *Use of locally-built parts made from recycled raw materials (e.g. door trims and insulating mats)*
- *Conservation of resources through the use of advanced production plant and engineering, including a paintshop with a thermal waste air treatment system.*
- *Reconditioning and recycling of process-related waste.*

Taipei Plant, Taiwan

Chinchun Motor Co., Ltd., Taipei, Taiwan (Founded in 1991; vo1kswagen ag holds a 26.5 percent stake). Production of the Caravelle (4th generation). The plant employs 665 staff.

Environmental protection highlights:

- *Orientation of (petrol-engined) vehicle exhaust and noise emissions to European and U.S. standards*

Dealers and the Environment

As independent companies contractually bound to Volkswagen, our dealers carry out maintenance and repair work in accordance with the eco-friendly principles set out in Volkswagen's "Environmental Workshop Manual". Scrap parts collected at the dealerships are returned to Volkswagen and either recycled (e.g. bumpers, wheel arch liners, radiator grilles and catalytic converters) or channelled into Volkswagen's reconditioned parts programme (e.g. starter motors, clutches, engines and gearboxes).

In the shape of special manuals and company literature, Volkswagen provides its dealers and their workshop staff with far-sighted advice on eco-friendly working practices. Moreover, Volkswagen's own specialist construction engineers can be consulted on all aspects of building a "green" workshop, from spray-booth waste-air treatment to oil separation systems. Volkswagen also provides all dealerships with a workshop eco-equipment catalogue from which they can select effective solutions for the storage, collection, disposal and recycling of waste and, in particular, operating fluids such as oil.

Waste disposal: Workshop waste (mainly batteries, tyres, plastic components and parts routinely replaced during servicing) is currently returned by each individual dealer to Volkswagen's regional distribution centres, largely making use of existing logistics arrangements and thus creating little additional traffic. Volkswagen has outsourced the disposal of operating fluids and glass to specialist recycling companies. The number of different materials returned to Volkswagen and the type of

In the workshops at Volkswagen dealerships, waste is carefully segregated. Our aim is to produce a waste inventory for each individual dealership in line with the German Waste Management and Product Recycling Act.

collection system used are currently determined at regional level, although intense efforts are currently under way to establish a uniform nationwide solution. Volkswagen is striving to set up a system whereby some 15 high-volume types of non-hazardous waste (both scrap parts and operating fluids) are transferred to collection points at the Volkswagen distribution centres via the company's own logistics links. From here, specialist waste disposal companies operating at nationwide level will be responsible for collecting and recycling the waste. We envisage using this system to provide us with accurate data on the volume of waste generated by each individual dealership, thus allowing us to draw up an individual waste inventory for each dealership, as required by the German Waste Management and Product Recycling Act.

Umweltfreundlich geführter Betrieb nach den Richtlinien von Volkswagen und Audi '96

Environmental consulting service: Volkswagen has established its own Environmental Protection Consulting Service which provides on-site advice to Volkswagen dealerships. In Germany, dekra Umwelt GmbH, lueg Umweltschutz GmbH and tüv, established names in the field of testing and certification, provide advice on environmental issues in accordance with principles laid down by Volkswagen and draw up environmental reports on the dealerships in question. Once any deficiencies have been remedied, and following a further inspection by the experts, the dealership qualifies for the Volkswagen Environmental Seal which is valid for one year. More than 500 dealerships have already made use of this environmental consulting concept and around 50 percent of them have now been awarded the Environmental Seal. Today, future-oriented dealerships are already using closed-loop water systems or waste water treatment systems or are even run as zero-waste-water operations, use water-based paints for bodywork repairs and have installed heat recovery and solar energy systems.

The Environmental Workshop Manual: A three-part manual providing a rich source of up-to-date information on environmental protection and waste disposal has been specially drawn up for Volkswagen dealerships. In addition to background information on process-oriented environmental protection, complete with illustrations and a glossary of terms, the manual also includes a special binder designed to serve as a waste register. Page by page, this binder lists general tips on how to treat individual categories of waste. It also contains information on the treatment of waste water and includes pre-printed forms which can be used to log waste water management activities.

Eco-friendly paint for bodywork repairs: Volkswagen currently offers a material for bodywork repairs which helps reduce solvent emissions by some 90 percent. Aquaplus is a water-based paint which can be applied using conventional paint-spraying equipment in conjunction with deionized water.

Environment-friendly customer service literature: Volkswagen is the first car manufacturer to produce all its customer literature on paper bleached without the use of chlorine (chlorine-free paper). Workshop documentation has been printed exclusively on recycled paper for a number of years now. Since 1992, in our binders, folders and wallets we have used polypropylene film rather than pvc. A breakdown reveals that the Volkswagen Service Division uses an annual total of some 1,100 tonnes of chlorine-free paper for customer literature in place of conventional paper, some 400 tonnes of recycled paper for workshop documentation and some 300 tonnes of polypropylene film in place of pvc.

Volkswagen wins the 1996 German Hazardous Substances Protection Award

With its programme of measures designed to help the Volkswagen/Audi dealership organization meet the requirements of the German Hazardous Substances Ordinance (GefStoffV), Volkswagen scooped the 1996 German Hazardous Substances Protection Award. The concept developed by Volkswagen provides practical support and helps reduce the burden on customer-service workshops as they implement the Hazardous Substances Ordinance.

Thus, the substitute substance studies prescribed by the Hazardous Substances Ordinance are carried out centrally in Wolfsburg. This involves checking the products used for hazardous materials and investigating the feasibility of using alternative products. In addition, Volkswagen carried out extensive measurements of pollutants at selected workshops, culminating in the production of 30 sets of instructions which provide dealers with rules for the safe handling of hazardous materials and correct disposal procedures. Volkswagen also produced material- and process-oriented guidelines for the use of original Volkswagen materials in workshops. These are made available to every Volkswagen dealer in Germany together with a brochure explaining the requirements of the Hazardous Substances Ordinance.

The DM 10,000 German Hazardous Materials Protection Award was donated by Volkswagen to the "Arche" organization based in Wolfsburg, a charitable institution which aims to act as a bridge between the world of work and the church. From left to right, Rudolf Stobbe, Head of Environment, Transportation and Works Safety, Pastor Hans Finette, Dr. Friedrich-Julius Quissek, Head of Research, Environment and Transportation, and Uwe Bartels, a member of the Works Council.

Retrofitted catalytic converters

Back in the Eighties, the very first programme designed to encourage car owners to retrofit catalytic converters saw Volkswagen sell over one million conversion kits. The revised road tax legislation which came into force in Germany on July 1, 1997 strengthens the link between the level of taxation and a car's pollutant emissions. Around 1.5 million owners of older Volkswagen models not equipped with closed-loop three-way catalytic converters have seen their road tax double as a result.

We now offer additional conversion kits for the installation of closed-loop three-way catalytic converters (C-cats). By retrofitting a catalytic converter of this kind, vehicles can be re-categorised as "low-pollution models" (Euro 1). Kits are currently available for Golf, Golf Convertible, Jetta, Passat, Santana, Transporter t4 and Beetle models, with or without open-loop catalytic converters.

The average cost of conversion of dm 1,300 can be recouped in less than three years,

For the 1.5 million or so owners of older Volkswagen models, we offer conversion kits that enable closed-loop three-way catalytic converters to be installed. Depending upon model and engine size, the cost of conversion can be recouped in less than three years.

depending upon the precise model and size of engine. Conversion is in fact rewarded with a more favorable tax rate than the one paid before the latest round of road tax changes came into force. Owners of vehicles not equipped with a catalytic converter, by contrast, face an increase in road tax of as much as dm 22.80 for each 100 cm^3 of displacement.

For a 1.6 litre Golf, for instance, this represents a two-fold increase in annual tax to dm 665.60. A Golf equipped with a C-cat, by contrast, incurs only dm 211.20 in annual road tax. In other words, owners of a Golf equipped with a closed-loop three-way catalytic converter pay less than a third of the amount otherwise due.

Greener Motoring

In the owner's manuals for Volkswagen vehicles, aspects with a bearing on the environment are clearly marked. In our view, the detailed tips on environment-friendly driving techniques are particularly important. As your style of driving and the way you use optional accessories on your vehicle can have a major impact on fuel consumption, the following basic principles are well worth studying:

- *Do not warm up the engine before setting off.*
- *Avoid accelerating at full throttle.*
- *Avoid sudden bursts of acceleration.*
- *Be aware of what is happening well ahead of you and drive accordingly.*
- *Make sure your tyres are at the correct pressure; incorrect tyre pressures increase fuel consumption and affect your safety.*
- *Do not leave unnecessary items in the boot; additional weight means additional fuel consumption.*
- *Anything carried on the car roof, such as roof racks, boxes or bicycles, adds extra weight and also increases aerodynamic drag; both factors cost you fuel, so remove all roof-top equipment after use.*
- *When you stop for a longer period, switch off the engine.*
- *Have your car serviced regularly.*
- *Equipment which consumes a lot of electricity (e.g. heated seats) should only be left on for as long as really necessary; leaving the rear window de-mister on in urban traffic, for instance, pushes up fuel consumption by around 0.4 litres per 100 kilometres.*
- *Using an air-conditioning system in urban traffic causes fuel consumption to rise by roughly 1.8 litres per 100 kilometres.*
- *An open sun-roof will increase your car's aerodynamic drag, leading to higher fuel consumption.*

Micro-video cameras help monitor driving technique.

On Volkswagen's "Safety and Economy" driving course, a team of professionals helps drivers to adopt a safer and more economical approach to motoring.

In future, customers ordering a Volkswagen will receive initial hints on the environment-friendly use their new car before the vehicle itself actually arrives – in the form of a special book about the model they have ordered (e.g. *Your New Passat*). Along with a chapter on the relationship between cars and the environment in general, the book describes the environmental impact of all aspects of a car's life cycle, from production through to recycling, and provides useful hints on driving techniques and caring for the vehicle.

Safety and Economy driving course: Anyone not content to settle for theoretical advice on economical and ecological driving techniques can sign on for Volkswagen's *Safety and Economy* driving course. Under the guidance of a team of trained professionals, participants are introduced to the subject by a series of straightforward computer graphics. What are the most common mistakes? How do you avoid them? And how does our eyesight affect our driving?

This theoretical session is followed by practical training monitored by micro-video cameras. Drivers learn how to avoid obstacles, good braking practice with and without abs, and correct cornering. Fuel consumption is monitored along selected routes, initially without supervision and later with the benefit of professional advice. Participants can then put the fuel saving tips into practice, again over selected routes and using the fleet of Volkswagen cars provided for the training course.

Noise abatement: Each and every driver can help to reduce road traffic noise levels: a car travelling at 50 km/h in second gear generates as much noise as several cars travelling at the same speed in fourth gear. Noise abatement is part and parcel of protecting the environment.

Volkswagen's "Safety and Economy driving course"

(intensive 8-hour course)

Practical introduction	Theory	Avoiding obstacles	Braking	Cornering	Ergovision	Economy on the road
Initial orientation and self-assessment	*Exercises dealing with specific situations supported by computer graphics*	*Use of micro-video cameras to record progress.* *Intensive training in keeping the car stable.*	*Correct braking with and without ABS.*	*Controlling the vehicle when cornering.*	*A test to check driver's eyesight.*	*Extensive practical test along a selected route.* *Individual professional instruction and assessment.*

Recycling

By signing the "Voluntary Agreement to Recycle Scrap Vehicles in an Environmentally Compatible Manner within the framework of the Waste Management and Product Recycling Act," (an undertaking also known by its German acronym FSV), Volkswagen is supporting the aim of the German government to achieve a substantial reduction in both the volume and environmental impact of waste generated by the disposal of scrap motor vehicles.

We have undertaken to take back scrap vehicles (i.e. vehicles which were first registered after the introduction of legislation requiring documentary proof of disposal) up to twelve years old, free of charge. The fsv undertaking includes a commitment to reduce the volume of landfilled waste from scrap vehicles from its current total of 25 percent by weight to 15 percent by 2002 and to 5 percent by 2015. Volkswagen also welcomes the pending introduction of the Scrap Car Ordinance on 1 April 1998, which complements the fsv by specifying that vehicles can only be permanently removed from the road vehicle register upon submission of documentary proof of correct disposal.

A nationwide network of vehicle disassembly centres: The use of secondary (i.e. recycled) materials in the production of new vehicles, ideally with the materials in question presenting identical characteristics to first-time raw materials, is only technically and economically feasible if the recycling operators are supplied with large volumes of correctly segregated waste. Volkswagen has commissioned Preussag Recycling GmbH (prg) to create a nationwide network of some 50 scrap vehicle disassembly centres in Germany. To this end, prg has concluded cooperation agreements with independent recycling operators, mostly small and medium-sized companies. The ultimate aim of establishing arround 70 disassembly centres looks set to be achieved by 1998/99. Of the 50 centers currently in operation, a number have already been certified as specialist waste disposal companies (KrW/AbfG § 52), in accordance with din/iso 9000 ff. and with the ec Eco-audit Regulation.

At Volkswagen, recycling activities have reached an entirely new level. Scrap vehicles are disassembled and component parts reused or recycled by a nationwide network of specialist centres.

In addition to their recycling activities, the vehicle disassembly centres also market used spare parts which account for a substantial portion of their income. Parts which are no longer fully functional are reconditioned, for instance at the Volkswagen plant in Kassel. In fact, for almost 50 years now, Volkswagen has operated its own reconditioning program involving the return by the Volkswagen Sales Organization of some 35 different assemblies, comprising around 2,500 individual components recovered from car repairs. Since 1947, some 7.1 million engines and 2.2 million gearboxes have been reconditioned, chiefly at the Kassel plant. The reconditioning of engines alone has enabled Volkswagen to cut potential emissions by 560,000 tonnes of carbon dioxide and save a total of approximately 900 gigawatt-hours of energy, 450,000 tonnes of iron ore (310,000 tonnes of steel) and 175,000 tonnes of bauxite (44,000 tonnes of aluminium).

Designing for recyclability: A key objective is to produce large parts, such as bumpers, radiator grilles, wheel arch liners or fuel tanks, using plastics of a homogeneous material structure, which can be removed quickly and easily from their metallic surrounds thanks to advances in mounting technology. Volkswagen aims to achieve a technical recyclability quota of 95 percent by 2015.

Bumper recycling in the production sector

Materials (t/a)	
New material	approx. 1,450
Production waste directly recycled	approx. 42
Painted production waste	approx. 135
Weight (kg)	
Front	approx. 3.3
Rear	approx. 4.4
Pcs.	
Daily output	approx. 2,200

Reject painted bumpers from the production process are ground down at the Volkswagen plant in Wolfsburg and shipped to Brunswick where the granulate is used to make tool pouches, V-belt guards, guides and baffles.
Source: VOLKSWAGEN AG

Recovering parts from customer service workshops: Volkswagen and Audi workshops in Germany replace approximately 1,200 tonnes of bumpers a year. The scrap bumpers are ground down, purified and sorted by a specialist plastics recycling company. The end-product is a fully processable high-quality granulate which is shipped to one of Volkswagen's suppliers and used to produce wheel arch liners for Volkswagen models.

Insulation matting made from recycled material

(used in Wolfsburg for the front footwell and transmission tunnel in the Polo)

Volume	
Sets/day	800
Tonnes/year	approx. 915
Weight (kg)	
Matting for footwell	approx. 5.0
Matting for tunnel	approx. 0.2

A Volkswagen supplier produces insulation matting for the Polo using polyurethane foam from vehicle seats, waste textiles from scrap vehicles and production waste.
Source: VOLKSWAGEN AG

Use of recycled brake fluid

Volume of input material (l/a)	
For series production	533,000
For the Kassel spares division	1,620,000
Total	2,150,000
Proportion of recycled material (%)	95
Brake fluid per vehicle (l)	0.7

(rounded figures)
Source: VOLKSWAGEN AG

Volkswagen Believes in Dialogue

Active exchange of information with interest groups

For Volkswagen, talking and listening to other parties with an interest in environmental protection is about more than just exchanging information. It is about promoting mutual understanding and entering into genuine dialogue, with journalists, environmental groups, politicians, the authorities, our customers and, last but not least, our own employees.

The Environmental Forum: As opinion leaders, representatives of the press and media are a particularly important target group. Following similar events in 1991 and 1994, the third Volkswagen Environmental Forum took place in 1996, providing an opportunity for in-depth debate and a comprehensive exchange of information. Over a period of ten days, from November 12-22, 1996, we discussed viewpoints, projects and proposals relating to environmental protection at Volkswagen with around 300 journalists and environmental experts from Germany, Europe and Asia.

A visit from Federal Minister of the Environment, Dr. Angela Merkel: One particularly important event in 1996 was the visit to the Wolfsburg plant on September 7 by Dr. Angela Merkel, accompanied by a number of Bonn-based correspondents. Together they gained an insight into material reuse and recycling at Volkswagen. The visit was prompted by the fact that Volkswagen had put into prac-tice some of the requirements of the Waste Management and Product Recycling Act before it actually came into force.

Greenpeace: To coincide with the presentation of the new Volkswagen Passat in August 1996 in Dresden, Volkswagen discussed the pros and cons of cars with representatives of Greenpeace. Greenpeace stated that the measures introduced to date to reduce fuel consumption were inadequate. Volkswagen drew attention to the success of a number of measures, including tdi technology, which has enabled the Passat, a mid-size family car, to achieve fuel consumption on the road of just 5 litres per 100 kilometres.

Trade fairs and exhibitions: The Hanover Industrial Trade Fair is one of the most important events of its kind for Volkswagen. Topics we have focused on in Hanover in recent years have included lightweight car design, diesel technology and alternative propulsion systems, such as the fuel cell. Volkswagen staff have explained our exhibits to thousands of visitors.

Sponsoring: The far-reaching consequences of human interference with natural eco-systems were illustrated by an exhibition in one of the world's most famous museums, the American Museum of Natural History in New York. The exhibition, *Endangered! Exploring a World at Risk*, was on show from March 8 to September 1, 1997, opening a window on endangered species and their habitats. Over 500,000 visitors gained some insight into the complexity of the world's eco-systems and the impact of human activity. The exhibition was sponsored by Volkswagen.

Corporate communications at Volkswagen: Volkswagen provides its staff with information on environmental issues in a variety of ways. On notice boards at the various plants, posters describe important issues. The Volkswagen staff magazine, *Autogramm*, features regular reports on environment-related projects at the company. In addition, environmental protection pages are currently being designed for the Volkswagen Intranet. Employees in key positions also receive a monthly environmental bulletin covering current trends and events in the field of environment and transportation. This information is also stored in the euris database.

The life cycle analysis of the Golf A3 was the topic of debate at the third Volkswagen Environmental Forum. On the platform were (from the left): Dr. Friedrich Hinterberger of the Wuppertal Institute for Climate, Environment and Energy; Volkswagen's Dr. Georg Schweimer; Dr. Manfred Schuckart of the Institute for Polymer Science and Polymer Testing, Stuttgart; and Volkswagen's Dr. Hartmut Heinrich and Dr. Horst Minte.

Thoughts on our mobile society

There is a conflict between our desire for mobility and the need to protect our environment. We need sophisticated, innovative solutions if we are to maintain mobility as an expression of our liberal society. Imposing bans and restrictions would not only spell an end to mobility, it would also be tantamount to abandoning our innovative capabilities and our will to shape the world around us. In the Seventies, we succeeded in severing the link between energy consumption and economic growth. Why don't we develop a vision which entails breaking the link between traffic and its undesirable side-effects? This is an area in which I expect to see solutions being advanced by forward-looking companies.

Dr. Jürgen Rüttgers, Federal Minister of Education, Science, Research and Technology

The role of the German automotive industry in the globalization process and its significance as an employer call for corporate strategies that reflect both environmental and social awareness. Companies should strive for sustainable development, a precept which has now gained wide recognition. This implies taking on a pioneering role with regard to ecological product design and stepping up the ecological efficiency of the production process. Ultimately technology and market leadership will belong to those manufacturers who are quick to offer innovative concepts for both individual vehicles and integrated transport systems.

Klaus Zwickel, Chairman of metalworkers' union IG Metall

Projects

EXPO 2000

Volkswagen will be exploring the theme of the expo 2000 exhibition in Hanover with its own project entitled *The New Car City*. One of the key objectives is to make the company more accessible and to intensify dialogue between Volkswagen and its customers. With this in mind, exhibition areas are to be created, in particular in Wolfsburg, featuring events and attractions for both customers and employees. The interests of children and young people will be addressed by a theme and adventure park. In addition to an innovative customer service centre, visitors will be able to tour a multimedia island equipped with sophisticated communications technology providing a glimpse of the future or delve into the past at our AutoGalerie car museum.

The theme of the Universal Exposition in Hanover, the capital of the State of Lower Saxony, is "Man, Nature, Technology", the idea being to provide a highly topical and lively launchpad for the new millennium – a forum for ideas, products and problems, evoking questions and providing answers for the future.

Volkswagen has approved an investment package of dm 270 million for its expo 2000 projects in which ecological concerns will be very much to the fore. The creation of the theme and adventure park, for example, will entail the greenscaping of large areas previously covered by asphalt.

Volkswagen is also developing the Rain Forest House, which will be erected in the Herrenhäuser gardens in Hanover. As a result of this project, Volkswagen is already directly involved in planning activities for expo 2000.

The reson initiative – safeguarding jobs through products made from natural fibres

As a result of profound structural change affecting south east Lower Saxony, jobs are increasingly at risk, particularly in manufacturing industry. One way of combating these risks is to promote the introduction of new products and processes.

One avenue which is being explored within the framework of a joint public and private sector project is the cultivation, processing and use of renewable raw materials. The presence of both potential producers and potential customers in the region creates a favorable backdrop for the project.

Renewable resources such as flax not only offer compelling ecological advantages, their fibres are also of a kind suitable for extremely demanding applications. They can make a major contribution to the protection of the environment by helping to conserve finite resources and moving us towards better resource cycle management.

reson, the regional development agency for south east Lower Saxony, comprises a number of organizations including Volkswagen and other leading companies from the region, local and regional authorities, trade unions and universities. *reson* has already presented a viable concept for the project, based on a study drawn up with the aid of a number of local research institutions: the Federal Institute for Biology (bba), the Federal Institute for Agriculture and Forestry (fal), Brunswick Technical University and the Wilhelm-Klauditz-Institute, affiliated to the Fraunhofer Society.

The study and the working groups behind it, with participants drawn from over 30 additional organizations, are prime examples of the kind of cooperation that can be achieved at regional level, fostering the transfer of know-how, and preparing the ground for future innovation.

The Renewable Resources project also forms a key component of the expo Association's decentralized Resource Cycle Management project which is based in Wolfsburg.

A model of the "New Car City" to be created in the eastern segment of Volkswagen's Wolfsburg site. The company is to invest a total of DM 270 million in its EXPO 2000 projects.

Partners in the Renewable Resources project: (from the left) Oliver Syring, M.A., reson; Dr. Nasir El Bassam and Dr. Katrin Jakob of the Federal Institute for Agriculture and Forestry; Prof. Dr. Klaus Lompe of Brunswick Technical University; and Dr. Gerhard Prätorius, reson.

Transportation

At Volkswagen we not only build cars, we also take a pro-active approach to tackling the impact of motorization. The company conducts research into innovative transportation concepts and scenarios and puts these concepts into practice.

The Dial-a-Bus system from Volkswagen offers door-to-door local public transport.

Dial-a-Bus

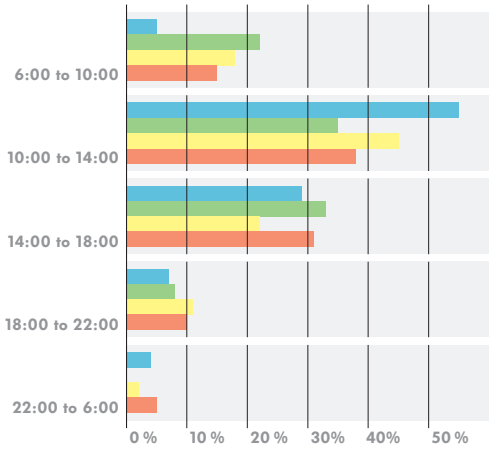
Dial-a-Bus is a mobility system developed by Volkswagen that has been up and running since 1982. As the name implies, Dial-a-Bus is a form of local public transport using mini-buses which allows passengers to travel from door to door without being restricted to fixed bus stops or timetables. All a would-be passenger has to do is call the Dial-a-Bus centre. This project has been undergoing long-term trials in the region of Leer. Only recently, the concept was enhanced to include a new pc-controlled dispatch and route-planning system with state-of-the-art communications technology which makes use of the satellite-assisted global positioning system, digital maps and data transmission to the vehicles. The summer of 1996 saw the arrival of a fleet of high-roof Volkswagen Caravelles with electrically operated sliding doors and a special step for easy access. Equipped with tdi engines which can run on biodiesel, the Caravelles have been very well received by passengers. The Dial-a-Bus service has given Volkswagen invaluable practical experience in this sector and leaves us well placed to provide customized advice for potential operators. Volkswagen can now offer complete one-stop solutions, from system design and planning right through to implementation.

Tenants of the Schlump Building in Hamburg benefit from a special mobility concept. In addition to bicycles and a pass for the local transport network, they also have access to a whole fleet of Volkswagen models suitable for a variety of transportation needs.

Wohn mobil

Wohn mobil (Stay Mobile) is a concept developed by Volkswagen in conjunction with a number of partners. This is car-sharing with a difference, designed to provide a high degree of personal mobility. In this new and, to date, unique project which has been implemented in the district of Eimsbüttel in Hamburg, when residents of the Schlump Building rent an apartment they automatically gain membership of a car pool. Accordingly, the landlord takes on a dual role, as a provider of living space and access to the car pool, thereby ensuring personal mobility. Access to the hire cars is by means of a built-in key safe and the resident's personal mobility chip card. The aim of the project is to offer users a variety of vehicles for a variety of needs. Tenants of the Schlump Building can choose from three Polos, an electric Golf, a Caravelle, a selection of bicycles and an annual pass for the local transport network. The Wohn mobil concept offers a number of advantages: the cars, which are parked right outside the door, cost just dm 5,- to dm 9,- an hour and every time they need a car, tenants can select the right vehicle for their transportation needs. The concept has created a new dimension of personal mobility with a fleet of vehicles to choose from.

Daily pattern of fleet use



In contrast to conventional car-sharing systems where peak use is between 14:00 and 18:00, demand for Wohn mobil cars is at its highest between 10:00 and 14:00. One striking feature of Wohn mobil usage patterns is that the entire fleet is used.
Source: VOLKSWAGEN AG

CityMobil

The CityMobil project is jointly operated by Volkswagen and the Wolfsburg local transport operator wvg. Five mini-buses supplied by Volkswagen ply a circular route which serves the central pedestrian zone in Wolfsburg at five-minute intervals. The buses call at 15 different stops that display the special CityMobil logo. Volkswagen provides this free service in order to make the centre of Wolfsburg more attractive, gain practical experience and investigate the feasibility of applying the system to other cities.

The CityMobil project in Wolfsburg is a pilot scheme in the public transport sector designed to increase the attractiveness of inner cities.

MOTIV

motiv is a research project involving a number of German companies and designed to investigate the practical benefits of using intelligent transport systems (telematics). The project has secured the participation of Volkswagen and other leading German car manufacturers, as well as suppliers and potential service providers. The aim is to develop marketable concepts for new telematics services within the project's four-year term. One important aspect is the combined use of the different means of transport. Specially designed information systems help users to decide which form of transport best meets their individual requirements at any given time, thereby also helping to make the best use of available transport resources.

Intelligent transport services (telematics)

Volkswagen is currently preparing to introduce new emergency and breakdown services. The gps satellite-assisted positioning system constantly monitors the vehicle's location which can then be transmitted to a call centre by means of gsm mobile communications. The system is activated automatically when the vehicle's crash sensor is triggered, saving precious time in emergency situations.

Transportation scenarios

Volkswagen carries out transportation scenario studies in order to assess the likely development of traffic and transportation systems in the future. This has enabled us to identify the following trends: As a result of growing affluence, in particular in Asia but also in South America, there will be a growing demand for (personal) mobility. Currently, even high-growth newly industrializing countries lag well behind the level of motorization found in Europe, and it is not hard to predict that they will strive to close the gap. However, these countries will in no way mimic our own development as, able to access modern technology and transportation structures, they have the opportunity to realize an increase in mobility without the same impact on the environment.

In Europe, a number of simultaneous trends can be observed: an increase in mobility due to European integration, and, in particular, the opening up of Eastern Europe; an improvement in the interfaces between the various modes of transport at national level and between the various national systems in individual modes of transport; an increasing role for telecommunications as a means of organizing transportation; and the gradual breakdown of the old barriers between personal and public transport thanks to new organizational structures and new forms of ownership. In Germany, the use of the main road transport arteries by commercial vehicles is increasing sharply as a result of the country's new role as a conduit between Western and Eastern Europe. This explains why Germany is a particularly accessible market for services which promote the efficient use of various forms of transport. The significance of mobility remains undiminished, its impact, however, (measured in t/km, pollutant emissions or consumption of resources) is falling.

Tailbacks. The main cause: racers and crawlers.
Tailbacks sometimes seem to occur for no reason at all and then vanish with equal alacrity. They also cause a sharp increase in fuel consumption and pollution. Researchers have discovered that most tailbacks have one and the same cause: an excessive difference between the speeds at which people are driving. Contrary to widespread belief, it is not the people who observe speed limits who are the main cause of tailbacks, but those who disrupt the steady flow of traffic either by speeding or by driving too slowly. Intelligent transport systems can help to keep the traffic flowing smoothly.

Passenger car density
(in selected countries)

	No. of cars per 1,000 persons
Algeria	12
Brazil	94
France	521
Germany	540
Italy	570
Japan	520
Mexico	128
The Russian Federation	160
South Africa	129
Spain	443
Thailand	49
United Kingdom	471
USA	746

Source: VDA

Goals and Activities

The third Volkswagen Environmental Report will be published in 1999. By that time, we aim to have reached and completed the following goals and activities:

Environmental Management

- In line with the continuous improvement process, cip^2, we shall optimize our process-oriented Environmental Management System and anchor it more firmly in the internal structures of corporate processes at Volkswagen.

- The data acquired within the framework of the life cycle analysis of the Golf will be continuously updated to permit further improvements in the ecological balance-sheet of our vehicles from the product development stage onwards, taking account of progress on the engineering front. Furthermore, the life cycle analysis project is to be extended to additional vehicles and components in line with VW standard 91104.

- In-house training and communications measures aimed at improving the awareness and motivation of Volkswagen's employees will be continued.

Researching and Developing

- Appropriate vehicle engineering measures will be introduced to meet our voluntary and self-imposed obligation to cut CO_2 emissions from our products by 25 percent by the year 2005, compared with 1990 levels.

- By the turn of the millennium, we will offer our customers a 3-litre car, that is, a car that requires only 3 litres of fuel to cover 100 kilometres. The technical findings that emerge from the development of this vehicle will be built into the development process of all classes of Volkswagen vehicles.

- We shall be stepping up our research into alternative propulsion systems, with particular emphasis on the fuel cell.

Procuring and Producing

- We shall agree on recycling and disposal concepts with our suppliers which take into account the provisions of the Waste Management and Product Recycling Act and the relevant ordinances.

- In line with our Environmental Principles, we will provide training for our business associates in the form of seminars, workshops and ongoing dialogue on the subject of environmental protection.

- To promote the spirit of competition in the field of environmental protection, we shall present awards for outstanding environmental achievements which benefit our customers.

- All Volkswagen's European production plants will obtain certification in line with the ec Eco-audit Regulation by 1999.

- We plan to have our production facilities outside Europe certified in line with the iso 14001 standard.

- The continuous improvement of process-oriented environmental protection at our production facilities is achieved by means of specific environmental goals and programme. The extensive individual activities undertaken at the various locations are documented in the Environmental Statements of those plants which have obtained certification in line with the ec Eco-audit Regulation.

Marketing and Recycling

- The environmental consultancy support provided for our dealerships by tüv, dekra Umwelt GmbH or lueg Umweltschutz GmbH is to be extended.

- A uniform nationwide take-back system for approximately fifteen types of high-volume waste is to be introduced. Every dealership should be able to present a comparable waste inventory.

- By channelling the waste streams from the customer service workshops in our dealership network, we aim to create closed material cycles – all the way to the use of secondary materials for first fills in new models.

- An enhanced quality management system is to be introduced for our dealership network covering the topics of industrial safety and environmental protection.

- A three-volume Environmental Manual is to be introduced, focusing on environmental advice, information and documentation for members of the Volkswagen dealership network.

- The amount of residual waste from scrap cars that requires landfill dumping will be cut to 15 percent by 2002 and to 5 percent by 2015.

- Within the framework of the motiv research initiative, in four years' time intelligent transport management (telematics) concepts are to be brought to readiness for market launch.

Volkswagen's Environmental History

Volkswagen has a long tradition of protecting the environment. Only if we succeed in conserving healthy conditions for life on earth by protecting the water, soil and air, can we maintain the essential foundations for the future of our products.

1947 Energy and materials saved by reconditioning parts and engines.

1952 New paintshop systems featuring intensive overspray rinsing with water screens.

1959 Further reduction in use of solvents in paints by converting to water-based dip primer.

1968 Volkswagen and Degussa pursue joint research into catalytic converters.

1971 Research into engines running on alternative fuels begins.

1972 The Volkswagen Environmental Department is founded – the first of its kind in the automotive sector.

1976 Volkswagen launches the low consumption pre-chamber diesel engine.

1982 Introduction of the turbocharged diesel engine.

1986 A pilot paintshop at Volkswagen begins using water-based fillers and undercoats.

1987 Modernization of the waste water treatment centre at the Wolfsburg plant.

1988 Flue gas desulphurization introduced at the Wolfsburg power stations.

1989 The Golf Diesel becomes the first car to feature an oxidation catalyst.

1991 Volkswagen launches the CitySTROMer, Hybrid Golf and Ecodiesel.

1991 The Volkswagen paintshops in Hanover, Emden and Wolfsburg are converted to low-solvent paints.

1992 Volkswagen becomes a signatory to the "Business Charter" of the International Chamber of Commerce (icc) on sustainable development.

1992 Volkswagen acts as mobility sponsor to the un Conference on Environment and Development (unced) in Rio de Janeiro.

1992 Series production of the tdi (Turbodiesel with Direct Injection) with an oxidation catalyst.

1995 Volkswagen's global environmental policy is formulated and published.

1995 The Volkswagen plant in Emden becomes the first European car plant to obtain certification in line with the ec Eco-audit Regulation.

1995 Management and Works Council sign a "Factory Agreement on the Protection of the Environment", the first of its kind in the industry.

1995 Volkswagen's first Environmental Report is published.

1996 Certification of the Volkswagen plants in Mosel, Brunswick and Salzgitter and of vw Kraftwerk GmbH in line with the ec Eco-audit Regulation.

1996 Certification of Volkswagen's Technical Development department in line with iso/dis/14001.

1996 Volkswagen presents the first ever ecological life cycle analysis of a car, for the Golf a3.

1997 At the company's Environmental Symposium, the Volkswagen Environmental Awards are presented to the winning suppliers.

Innovations on the environmental front call for intensive research and development activities. Back in the Sixties, Volkswagen was already conducting aerodynamic experiments in the company's climate wind tunnel in Wolfsburg.

Volkswagen's Environmental Reports

Every two years, the Volkswagen Environmental Report documents our progress on the environmental front. This is the environmental equivalent of the company's annual financial statements. Spanning all of Volkswagen's business processes, the Report also provides coverage of the full life cycle of our products: from research and development via procurement and production, marketing and service life, all the way to recycling.

The team behind the 1997 Environmental Report: from the left, Ulrich Menzel M.A., Dr. Jörg Munzel, Dr. Ina Thurn, Dr. Horst Minte and Ildikó Futaky.

The Environmental Report is a keystone in our comprehensive communication efforts on the environmental front. It is complemented by the Environmental Statements issued by those Volkswagen plants which have obtained certification in line with the ec Eco-audit Regulation. Moreover, the Report also supports the introduction of the Environmental Management System at the company.

The Report addresses a readership as diverse as the structure of Volkswagen's customer base: established customers and first-time Volkswagen buyers; company employees, past and present; journalists and representatives of the media; environmental and consumer associations; banks and insurance companies; universities and local authorities; car lovers and car haters; plus any number of other interested parties around the world. Comprehensibility across all our target groups as well as sound business reporting are two of our key concerns as we compile the Report. We also take international requirements in terms of environmental reporting into account, including the draft din standard 33922 and the guidelines published by environmental analysts such as SustainAbility in London, the Institute for Ecological Economic Research (iöw) in Berlin or Future e.V. in Osnabrück.

The success of Volkswagen's first Environmental Report, published in 1995, exceeded all our expectations. Within two months of publication, more copies had been ordered than of all previous environmental publications from Volkswagen over a period of decades. To date, more than one hundred thousand copies of the Report in English, French and German, and of the Swedish summary, have been sent out in response to enquiries from over thirty countries. We have also received more than twenty thousand direct enquiries on all aspects of environmental protection. The Environmental Report has been published on a cd-rom and a summary can be found on the Internet via the Volkswagen home page http://www.vw-online.de. One particularly rewarding aspect has been the positive echo in the media.

With the assistance of the environmental and consumer institute *imug Beratungsgesellschaft für sozial-ökologische Innovationen mbH* based in Hanover, we have had the Report and the subsequent feedback analyzed by an independent third party. At the same time, a survey was conducted among Volkswagen employees. The results of these two studies – both positive and negative – have been fundamental in drawing up the concept for this, the second Environmental Report. We hope that we have succeeded in providing you with even more comprehensive and more readily comprehensible information this time around.

The next Volkswagen Environmental Report will be published in the autumn of 1999.

KPMG

1997 Volkswagen Environmental Report

Certification

In a letter dated June 18, 1997, volkswagen ag, Wolfsburg engaged us to examine the information presented in the 1997 environmental report. The responsibility for the preparation of the environmental report and the information disclosed therein lies with the Company's Board of Management. Based on our examination, our responsibility is to express an opinion on the environmental report in accordance with the draft of the pronouncement on *Generally accepted standards for the examination of environmental reports* (German Institute of Accountants, June 3, 1997).

"Based on our examination, we believe that the information presented in the 1997 environmental report of volkswagen ag, Wolfsburg, is accurate and not inconsistent with other representations made and supporting evidence provided. In our opinion, the environmental report adequately presents the direct environmental impact of the Company's activities during the 1996 financial year and up to the beginning of the new vehicle model year."

KPMG Certification GmbH
Umweltgutachterorganisation,
Wirtschaftsprüfungsgesellschaft
Niederlassung Düsseldorf
Am Bonneshof 35
40474 Düsseldorf

Wolfsburg, September 26, 1997

Volker Neumann
Accountant

Klaus Kall
Environmental Auditor

Glossary of Terms

Activated carbon filter
System provided in vehicles with petrol engines which retains fuel vapours which would otherwise be vented into the environment from the fuel tank. Subsequent operation of the vehicle flushes the filter with the intake air for the engine, thereby regenerating the activated carbon of the filter.

Amines
Basic hydrocarbons containing nitrogen. Due to their marked pharmacological activity, many amines have pharmaceutical uses. On the other hand, numerous amines may react with nitrate or nitrous acid to form nitrosamines, many of which are known to be carcinogenic; this may also occur within living organisms.

Asynchronous motor
An alternating current motor: up to 20 percent more efficient, lighter and requiring less maintenance than the →*direct current motor*.

Audit framework
Boundaries set when drawing up a →*life cycle analysis or Life Cycle Assessment*.

Benzene
Cyclic hydrocarbon acting on the central nervous system, classed as definitely carcinogenic in the →*MAC* list. The benzene content of petrol is limited to a maximum of 5 vol.% pursuant to din en 228. Commercially available fuels have an average content of 2.5 vol.%. While the benzene present in the fuel is burnt in the engine, small quantities remain in the exhaust gas. By introducing the →*three-way catalytic converter*, Volkswagen has reduced benzene emissions by more than 90 percent, but is still demanding that petroleum refiners make further reductions in the benzene content of fuel.

Biodiesel
Fuel obtained from renewable oil plants, e.g. vegetable oil methyl ester (vme) to din 51606.

C-cat
Closed-loop three-way catalytic converter (→*three-way catalytic converter*)

Catalytic converter
→*Three-way catalytic converter*, →*Oxidation catalyst*.

Certification
Confirmation of compliance with an international standard by an independent organization. Some Volkswagen plants already participate in a voluntary Community-wide scheme for environmental management and auditing pursuant to the ec Eco-audit Regulation. Strictly speaking, this participation does not amount to certification but rather validation of plant specific environmental statements. Validation means that an officially approved environmental auditor or auditing organization assesses a plant's environmental management system and validates the environmental statement for a limited period of time. For reasons of ready comprehensibility, we use the term *certification* rather than *validation*.

CFC
Chlorofluorocarbons (→*halogenated hydrocarbons*).

CH_4
Methane: a colourless, odourless gas, the principal constituent of natural gas (→*CNG*) and biogas; produced in marshes, rice paddies and in digestion processes. Methane is a greenhouse gas with 24 times the greenhouse potential of →CO_2. Worldwide, anthropogenic methane emissions amount to more than 320 million tonnes per year. Experts estimate that agriculture accounts for more than 50 percent of these emissions. Worldwide, passenger car traffic accounts for less than 0.5 percent of methane emissions.

CHC
Chlorinated hydrocarbons (→*halogenated hydrocarbons*).

Chipless processing
Production and shaping processes in which no material is removed (e.g. forging, internal high pressure moulding).

CKD assembly
Completely knocked down assembly: cars knocked down into their component parts are assembled in another plant.

CNG
Compressed natural gas: consists of 75 to 98 percent →*methane*, the remainder being lower hydrocarbons (ethane, propane, butane) together with →*inert gases* such as nitrogen or →CO_2

CO
Carbon monoxide: toxic gas produced by incomplete combustion. Introduction of the →*three-way catalytic converter* and further emission abatement measures have made it possible to cut co concentrations to harmless levels even in the immediate vicinity of roads.

CO_2
Carbon dioxide: the stable and natural end product of combustion of organic substances. co_2 is thought to account for approximately 50 percent of the additional *greenhouse effect* brought about by human activity. Passenger car traffic accounts for approximately 6 percent of worldwide anthropogenic co_2 emissions.

COD
Chemical oxygen demand: especially in waste water, is used as a measure of the content of oxidizable (mainly organic) substances. The parameter measured is the amount of oxygen required for complete chemical oxidation of the substances present in the waste water.

Corporate average fleet fuel economy
Mean fuel consumption of all models from a single automobile manufacturer newly registered on a market during a model year.

Coolant emulsions
Mineral oil-in-water mixtures or mineral oils used in machining metals (→*emulsions*).

Demulsification units
→*Emulsions*

DIN/ISO 9000 series
The iso 9000 series sets out the requirements for quality management systems.

Direct current motor
Currently the predominant motor used in electric vehicles. Will probably be replaced in future by the asynchronous motor (→*asynchronous motor*).

EC Eco-audit Regulation
Regulation (eec) no. 1836/93 of the ec Council of June 29, 1993 relating to the voluntary participation of commercial enterprises in a Community-wide environmental management and audit scheme. An audit performed by independent auditors regularly and systematically documents and objectively assesses organizational and management systems relating to continuous improvement of environmental performance.

Elastomers
Elastic plastics, e.g. rubber.

Electrophoretic dip coating
Charged paint particles move within an electrical field, as in an electro-plating process, towards the sheet metal bodywork, which is also charged, and are deposited there.

EMS
Environmental management system: the aim of introducing an ems is to integrate environmental protection into all corporate operations and fields of activity.

Emulsion filters
→*Emulsions*

Emulsions
In this report, this term denotes mixtures of fuel or oil in water. Industrial mineral oil emulsions are primarily used as coolants and lubricants (→*coolant emulsions*) for metalworking machinery. These usually consist of a mixture of 5 to 10 percent oil and 50 to 94 percent water. At Volkswagen, used emulsions are recycled by first removing dirt and swarf (→*emulsion filters*) and then separating them into oil and water in →*demulsification units*. The water is used to prepare new emulsions while the oil is returned to the mineral oil industry.

Ethanol
(C_2H_5OH): drinkable alcohol produced from renewable raw materials containing sugar or starch. Like →*methanol*, this is a suitable fuel for internal combustion engines.

Euro 2 standard
Passenger car exhaust emission limit values in accordance with Directive 94/12/ec; valid for new type-approval testing from 1.1.1996 and for new vehicle registrations from 1.1.1997 (→*table below*)

Euro 3 standard
ec Commission proposal for passenger car exhaust emission limit values from 1.1.2000 (→*table below*)

Exhaust gas recirculation
Recombustion of a proportion of the exhaust gases. The resultant increased content of →*inert gases* reduces the combustion temperature and thus cuts →*NO_x emissions*.

Federal Immission Control Act, section 52a
German legislation governing disclosure requirements relating to the organization of operations; appointment of a board member specifically responsible for operation of the plants subject to licensing; disclosure to competent authorities of how compliance with environmental protection regulations is achieved.

FSV (Recycling)
German scheme involving a voluntary agreement by all associations involved in automotive production and recycling to ensure the environmentally-sensitive recycling of scrapped motor vehicles.

Greenhouse effect
The natural greenhouse effect is fundamental to life on our planet, maintaining the average temperature of the earth's surface some 33 °c higher that it would be without natural greenhouse gases (from -18 °c to +15 °c). Water vapour is by far the most important natural greenhouse gas. Other natural greenhouse gases include →CO_2, methane, dinitrogen monoxide and ozone (O_3). The anthropogenic contribution towards the overall greenhouse effect is taken to be either the measured mean increase in temperature over the past century (0.45 °c) or the calculated increase in terrestrial radiant flux (long-wave radiation of a wavelength of 3 to 100 micrometres).

Euro Standards
(values stated in g/km)

Petrol-engined passenger car	Euro 2 standard	Euro 2 stnrd. corrected (1)	Euro 3 standard
CO	2.2	2.7	2.3
HC + NO_x	0.5	–	–
HC	–	0.341	0.2
NO_x	–	0.252	0.15
Diesel-engined passenger car			
CO	1.0	1.06	0.64
HC + NO_x	0.70/ 0.9 (2)	0.71/ 0.91 (2)	0.56
NO_x	–	0.63/ 0.81 (2)	0.50
Particulates	0.08/ 0.1 (2)	0.08/ 0.10 (2)	0.05

(1) Corrected by elimination of the 40-second warm-up phase.
(2) For vehicles with direct injection engines.
Source: EU

Halogenated hydrocarbons
Hydrocarbons which contain elements of the halogen group such as chlorine, fluorine, bromine or iodine. They have been used not only as refrigerants in air-conditioning units (cfc) but also for blowing foamed plastics or as flame retardants. They destroy the stratospheric ozone layer and are virtually completely non-biodegradable. Incomplete combustion of these substances can give rise to new highly toxic halogenated compounds (e.g. polychlorinated dibenzodioxins and dibenzofurans).

HC
Hydrocarbons: consist of carbon and hydrogen, e.g. petrol, diesel fuel, →*natural gas* and →*methane*. When hydrocarbons are burnt, a small proportion remains as hc emissions, the quantity of which is further reduced in the catalytic converter. hc emissions are governed by statute.

Heavy metals
Metals having a density of greater than 4.5 g/cm^3. Some heavy metals such as iron and zinc are essential to life while others such as lead and cadmium are toxic.

High-build coating lines
Electrophoretic →*dip coating* using higher voltages to apply a thicker paint film.

High-grade base oil
Secondary raffinate from waste oil for use as original gearbox oil.

ICC
International Chamber of Commerce.

Inert gas
Gas of low reactivity.

Intelligent transport systems (ITS)
Use of information and communication systems to improve the efficiency of traffic management (telematics).

ISO 14001
Describes the requirements placed upon an environmental management system.

Lambda (λ) probe
Sensor in the exhaust pipe between the engine and →*three-way catalytic converter* to ensure an optimum air/fuel mixture.

Life cycle analysis
Documentation of material and energy streams.

Life Cycle Assessment (LCA)
Records overall energy and raw material consumption of a product from production to recycling. The assessment provides a comprehensive view of material and energy streams and indicates potential economies.

MAC
Maximum admissible concentration in the workplace.

Methanol
Alcohol (ch_3oh): colourless liquid, toxic if absorbed in relatively large quantities. May be produced from natural gas (→*CNG*), biomass, such as e.g. wood waste, from carbon and water and from hydrogen and →co_2. 3 percent of methanol may today be blended with petrol in order to improve knock resistance. "Multi-fuel vehicles" may be operated on any mixture of methanol, →*ethanol* and petrol.

MVEG cycle
European driving cycle for emission and consumption measurements on rolling road test benches.

N_2O
Dinitrogen monoxide (laughing gas): colourless and odourless gas. Virtually harmless to humans in the presence of sufficient oxygen. n_2o is a greenhouse gas with 290 times the greenhouse potential of co_2. Passenger car traffic is estimated to account for 1 to 2 percent of worldwide anthropogenic n_2o emissions.

Near net shape manufacturing
Manufacturing processes in which the least possible finishing of the workpiece is required in order to achieve the desired geometry (e.g. lost foam casting, metal sintering).

NF composites
Natural fibre composites.

NM VOC
Non-methane volatile organic compounds, e.g. propane, butane or →*benzene*.

NO_X
Oxides of nitrogen: taken to mean the sum of no and no_2 (nitrogen monoxide and dioxide). The gases are treated as a sum value by exhaust gas legislation (→*Euro 2 and 3 standard*). no is a colourless and odourless gas which, in the presence of oxygen, is rapidly converted into no_2. no_2 is a reddish-brown, acrid, toxic gas. Oxides of nitrogen are formed from atmospheric nitrogen during any combustion processes (→*three-way catalytic converter*). no_x contribute to the formation of acid rain and are partially responsible for the formation of ground-level ozone (→*ozone*).

Overspray
→*Paint sludge*.

Oxidation catalyst
A catalyst accelerates chemical reactions without itself being consumed in the reaction. Oxidation catalysts are used in motor vehicles in order to oxidize the →*CO* and →*HC* formed by incomplete combustion. In diesel engines, oxidation catalysts are used to oxidize the hydrocarbons (oil and fuel residues) attached to the →*particulates*, thereby also reducing the overall mass of particulates.

Ozone
(o_3): an acrid gas which, depending on its concentration at ground level, may cause damage ranging from mucous membrane irritation to reversible impairment of lung function. Ozone is formed naturally in the stratosphere at altitudes of 15 to 40 km, protecting the earth's surface from uv radiation. This protective ozone layer is damaged by →*halogenated hydrocarbons*. Ground-level ozone is formed from →*NO_X*, →*CO* and biogenic and anthropogenic hydrocarbons. Since uv light is required to form ozone from its precursor molecules, concentrations are higher in the summer months. Significant measures to abate ozone formation in the passenger car sector include increased use of vehicles equipped with catalytic converters and the rapid introduction of vapour recirculation at filling stations.

PAH
Polycyclic aromatic hydrocarbons: formed, *inter alia*, by incomplete combustion of organic materials and thus present not only in industrial, domestic and motor vehicle exhaust and flue gases but also in cigarette smoke and the fumes from grilling meat. Benzo[a]pyrene (a carcinogen) is frequently used as a reference substance for the presence of PAH. The catalytic converter cuts the PAH content of automotive exhaust gases by more than 95 percent.

Paint coagulate
→*Paint sludge*.

Paint sludge
Excess paint spray (overspray) during painting is absorbed in water and flocculated with coagulants.

Particulates
Particulate emissions from diesel vehicles consist of a core of pure carbon surrounded by a shell of adhering hydrocarbons, water, sulphates and trace quantities of other substances.
Particulate emissions are suspected to be hazardous to health. In recent years, Volkswagen has managed to cut particulate emissions by 70-80 percent both by measures within the engine itself and by using →*oxidation catalysts*. The reduction in sulphur content of diesel fuel is also contributing towards a decrease in particulate emissions.

PE
Polyethylene: mechanical and chemical properties are determined by crystallinity and degree of polymerization. A grade of PE can thus largely be tailored to requirements.

PP
Polypropylene: a thermoplastic combining elevated hardness, toughness and rigidity with heat resistance. Thanks to PP's good heat resistance it is well suited to reprocessing: used products may be ground, melted and pelletized to return the PP to the materials cycle.

PVC
Polyvinyl chloride: a product of chlorine chemistry (contains up to approximately 56 percent chlorine); vinyl chloride residues may initiate cancer. Incineration to recover energy content may result in the formation of dioxins.

Residue incineration
Recovery of energy content from production waste, e.g. pelletized paint, or from waste oil or tyres.

Roller rocker arm
Roller-lifted valve control: intermediate component (lifter) between the camshaft and valve which converts rotary motion into linear motion.

Sintering
Method of fusing together small particles of various materials using elevated temperatures and pressures.

SKD assembly
Semi-knocked down assembly: cars partially knocked down into their component parts are assembled in another plant.

SO_2
Sulphur dioxide: a colourless, acrid gas, which irritates the skin and mucous membranes and, at relatively high concentrations, causes breathing difficulties. SO_2 reacts with water to produce sulphuric acid which is considered the prime cause of acid rain. Sulphur dioxide is predominantly formed by the combustion of energy sources containing sulphur. In Germany, passenger car traffic accounts for less than 1 percent of SO_2 emissions.

Stirling engine
An external combustion hot gas engine named after Robert Stirling which exploits the fact that less energy is required to compress a gas (usually hydrogen or helium) at low temperature than is released when it expands at elevated temperature. The advantages of the Stirling engine are primarily the high degree of efficiency of 35 to 40 percent, low-pollutant combustion and the possibility of using various fuels, even solar power. In the future, the Stirling engine could consequently be of interest in hybrid power units and for power generation. The engine's complex design is, however, a drawback.

Sustainability, sustainable development
Concept encompassing the conservation of natural resources and environmental protection, the realization of social values and justice for current and future generations together with healthy economic development.

TFM
Transverse flux motor: electrical motor for traction applications.

Thermal emulsion and rinsing water separation
Separation of →*emulsions* using heat.

Thermoplastics
Plastics which soften on heating.

Three-way catalytic converter
A catalyst accelerates chemical reactions without itself being consumed in the reaction. The catalytic converter used in petrol-driven cars uses noble metals such as platinum, rhodium and sometimes also palladium as the active coating. It is capable of breaking down all three statutorily limited exhaust gas components, CO, HC and NO_x, hence "three-way", at an efficiency of more than 90 percent if the engine is operated at an optimum air/fuel ratio (→*lambda probe*).

Waste Management and Product Recycling Act, section 53
German legislation relating to the conservation of material streams and the minimization, reutilization and environmentally-compatible disposal of wastes.

WBCSD
World Business Council for Sustainable Development: an association of 120 companies from 35 countries. Its aim is to intensify cooperation between governments, companies and other organizations and promote high standards of environmental protection in business.

The card that was attached here has been used but if you would like further information or have any questions simply contact:

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