

VIA VISION

VOLKSWAGEN GROUP

• SHAPING THE FUTURE OF MOBILITY

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The Right Kind of Momentum It Depends on the Drive System

**Around 75 percent
of cars in Germany
are petrol fueled.**

**In Brazil, 90 percent
of all cars produced run on
ethanol or an ethanol-petrol mix.**



From Otto to Electric

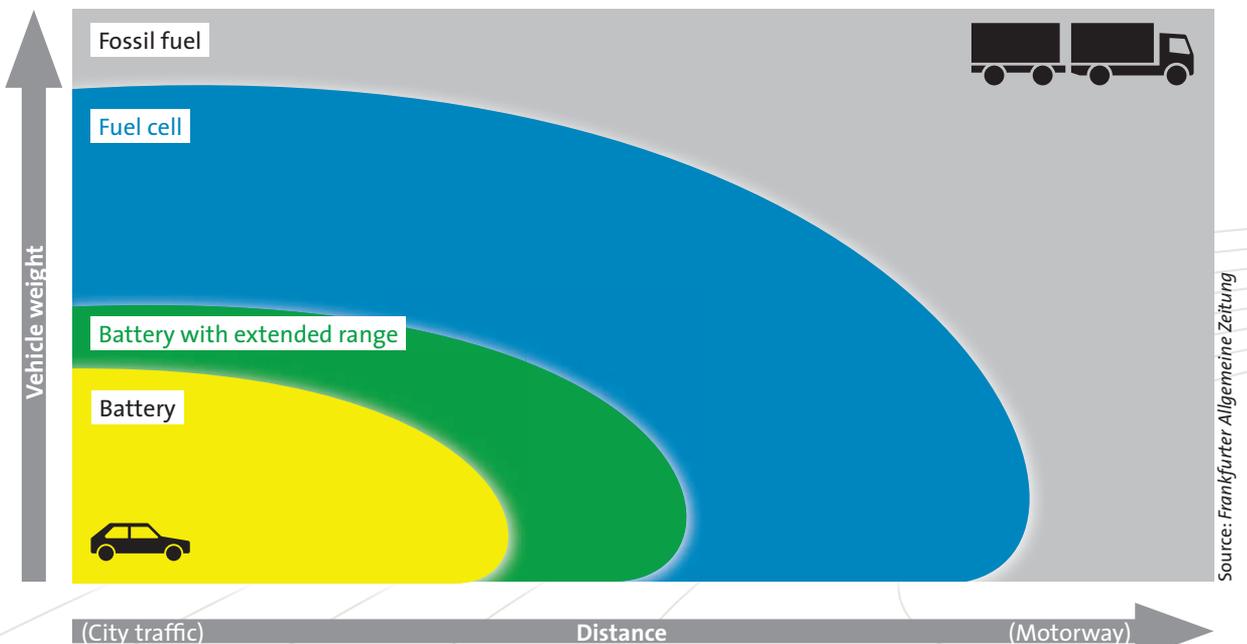
Many Roads to the Future of Mobility

In most current visions of the future of mobility, the essential elements of the drive system are clearly defined: tomorrow's car will be emissions-free, silent and electric. The industry is in agreement about this. There remain many steps to be taken in realizing this vision, and the precise roles to be played by different drive systems are still to be determined. **Experts predict that for the next 20 to 30 years, cars with combustion engines will continue to dominate our streets.** At the same time, alternative fuels, as well as the optimization of the classic combustion engine, are gaining in their significance.

Overview of the Different Types of Drive Systems

Petrol and diesel are still the first choice of energy source for **heavy goods vehicles on long distance routes**, journeys without much stopping-and-starting and for very heavy vehicles (grey). **Electric automobiles**, powered by battery only, are a sensible solution for **small cars covering short distances**, such as those occurring in **inner-city traffic** (yellow). An electric car designed to drive **longer distances** (green) needs an **extended range**, for example by means of an auxiliary combustion engine. **Cars with fuel cells** – with the requisite technical maturity – may be able to cover **the whole range** required for modern car usage, as well as for bus, pick-up and lorry usage (blue).

Source: Frankfurter Allgemeine Zeitung



Fossil fuel / combustion engine

- In 1876, Nicolaus Otto invents the four-stroke engine, known to posterity as the Otto-engine. Petrol serves as the main source of energy, but the combustion engine can also be powered by methane-based gases, as well as by ethanol and hydrogen.
- Car manufacturers estimate that around 25 percent of the energy currently used can be saved, thanks to start-stop systems and energy recuperation, or by using better tyres, with less rolling friction. By adding optimized fuel-injection technologies, and artificial cylinder capacity reduction (downsizing), a modern combustion engine can consume less energy than even the electric cars on the market today.

Alternative fuels:

- Sustainably produced, alternative fuels are becoming more and more important in replacing crude oil as an energy source: increasingly, there are currently more widely available regenerative sources of energy and, for this reason, there is a short to middle-term solution available to the energy supply problem.
- About 25 percent of the predicted fuel consumption of Germany in 2020 could be sourced from energy crops.

Source: FNR (Agency for Renewable Resources)

Diesel:

- Low consumption, long life-spans and low emissions: these are the advantages of diesel technology.
- Almost a quarter of the German car fleet runs on diesel. In 2003, this was a mere 17 percent and in 1999 just 13 percent. It is remarkable that out of all licensed heavy goods vehicles, 93 percent are fueled by diesel.

Source: German Federal Motor Transport Authority

Battery / electric engine

- Electric cars can either be powered by an electric engine with a rechargeable battery (mostly lithium-ion accumulators).
- 60 to 100 miles – this is presently the range of electric cars. This makes the electric car ideal for short range travel with low weight vehicles and for use in traffic, which is frequently stopping-and-starting.
- The main challenges for the electric engine are, above all, their low range and their high cost energy storage. If one was to drive an electric car over the same range as that covered by a 50 litre diesel engine, it would require a 1,000 kilogram battery. This battery would currently cost around 100,000 euros.

Source: Die Zeit

Fuel cell

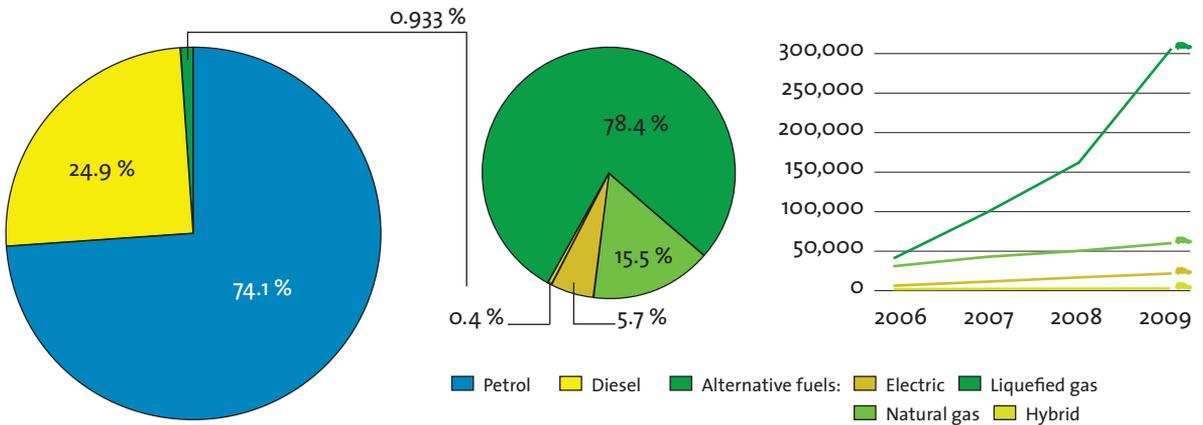
- Clean technology: in a fuel cell, hydrogen and oxygen react in a chemical process. In this process, energy in the form of electricity is released, thus powering the engine. The only by-product: water. Source: Clean Energy Partnership
- In the development of fuel cell powered engines, some obstacles remain to be overcome:
 - The cheap production of hydrogen from regenerative energies.
 - The development of a secure infrastructure.
 - The further development of fuel cells or hydrogen-storage technologies which are affordable and suitable for everyday use.

Battery with extended range / hybrid

- Hybrid engines consist of a mix of different drive technologies, usually the combination of electric and combustion engines. The electric engine's battery is charged either via recuperation of energy when braking or accelerating, or when it is directly plugged into a power outlet (plug-in).
- The combination of combustion and electric engines not only saves fuel but also reduces emissions.
- Because of the new technologies utilized, hybrid cars today cost around 7,000 euros more than equivalent conventional vehicles.

More about the different drive systems in upcoming issues

Car fleet by fuel types (2009)



Looking at the current car fleet, it becomes apparent how dominant the position of the classical combustion engine is. **Almost two thirds of currently licensed cars still run on petrol.** However, the number of newly registered vehicles utilizing alternative fuels and engines has risen significantly: In comparison to the previous year, the number of cars powered by liquefied gas in 2009 increased by 89 percent, while natural gas-powered and hybrid cars gained 20 and 30 percent respectively. The proportion of alternatively fueled vehicles within the total car fleet is admittedly very low. Electric-powered cars currently only account for 0.003 percent.

Source: German Federal Motor Transport Authority

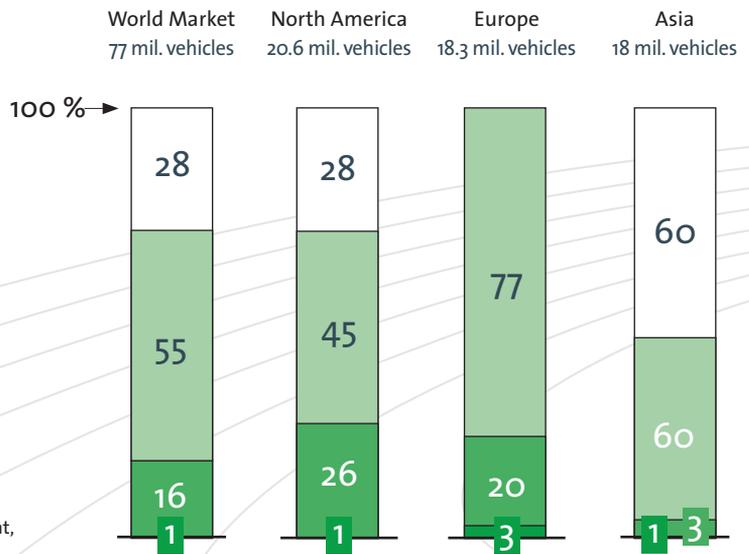
Growth scenarios – car sales in 2020

Which drive systems will be purchased in 2020?

Based on the assumption of a stable oil price of about 60 US dollars per barrel, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety predicts a worldwide share of electric and hybrid cars sold (including mild hybrids) of up to 17 percent in 2020. If the oil price rises (to 100 US dollars per barrel) a figure of up to 33 percent is possible. In the future, the simple combustion engine will be replaced, especially in Asia. In Europe, the optimized combustion engine dominates, with a 77 percent market share.

- Combustion engine
- Optimized combustion engine
- Mild hybrid
- Plug-in hybrid and electric vehicle

Source: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety



South America

Emerging Economies, the Engine of Economic Change



Picture: Vario Images

One fifth of the economic growth worldwide between 2000 and 2005 can be ascribed to Brazil, Russia, India and China – the so-called BRIC states. **Experts assume that the current largest national economies – the USA, Japan, Great Britain and Germany – will be replaced by China, India, Brazil and Russia within the next 40 years.** Of all the states in South America, Brazil already has the biggest share of global economic output by some margin (South America 2008: 4.7 percent, Brazil 2008: 2.6 percent).

Within the automobile sector too, South America is of growing economic importance. On the one hand, large amounts of ethanol are produced there – almost 24,500 million litres per year. On the other hand, around 70 percent of global lithium deposits are located there – a resource which is of increasing value, especially in the context of electric mobility. Sources: Focus Money; Spiegel Online; United Nations Conference on Trade and Development; Wirtschaftsblatt

South America in numbers, using the example of Brazil

	South America
Area in km ²	17,600,000
Population in millions	393
Population density	22 inhabitants/km ²
Population growth	1.12 percent

Brazil is the largest location for Volkswagen production in South America. VW do Brasil produces in four plants: in São Bernardo do Campo, Curitiba, São Carlos and Taubaté.

	Brazil	Germany
Capital	Brasília (3.5 million inhabitants)	Berlin (3.8 million inhabitants)
Area in km ²	8,547,404	357,050 (about one 24th)
Population in millions	195.4	82
Population density	23 inhabitants/km ²	230 inhabitants/km ²
Population growth	1.08 percent	- 0.05 percent
Currency	1 real = 100 centavos = about 40 euro cents	1 euro = 100 cents = about 2.5 reais
Gross domestic product (GDP)	1,573 billion US dollars	3,662 billion US dollars
Per capita income	8,197 US dollars	44,660 US dollars
GDP growth 2009	0.2 percent (5.1% in 2008)	- 5.6 percent
Average gross monthly salary	about 480 euros	about 2,313 euros
Annual rate of urbanization	1.8 percent	0.07 percent



Sources: Germany Trade and Invest; International Monetary Fund; United Nations Conference on Trade and Development; United Nations World Urbanization Prospects

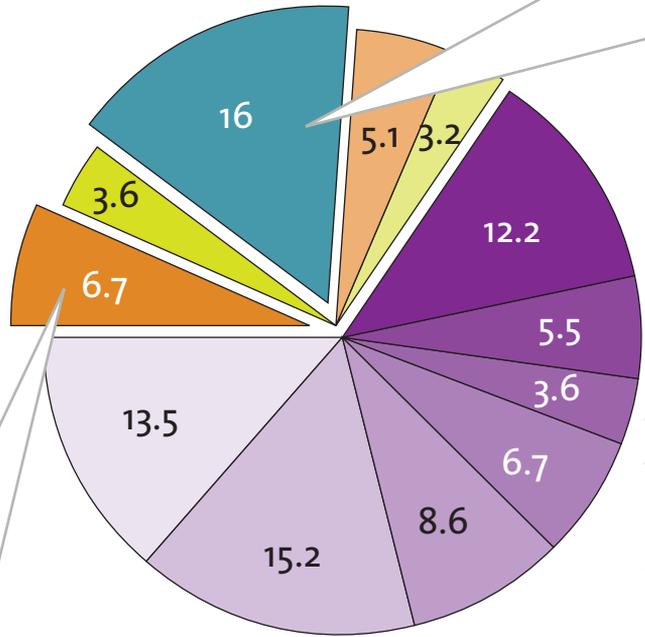
The Most Important Business Sectors of Brazil

GDP composition, in percentage terms, for 2008

- Agriculture, forestry, cattle-breeding
- Mining
- Processing industry
- Construction industry
- Electricity, gas, water

Services:

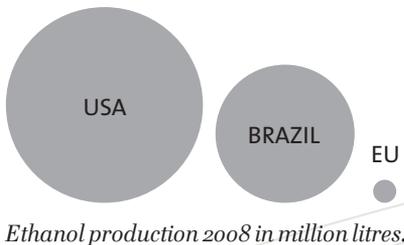
- Trade
- Transport and logistics
- Information service
- Financial service
- Real estate
- Administration, health care, public education system
- Other services



Source: Germany Trade and Invest

More than half of Brazilian GDP is generated by services. Particularly strong growth can be seen in the finance and insurance sectors (up by 9.1%), as well as information and communication (by 8.9%).

Agriculture



→ With a total of 24,500 million litres, Brazil is the second largest producer of ethanol in the world, behind the USA (34,068.6 million) and followed by the EU (2,777 million).

Source: Renewable Fuels Association (2008)

→ Utilizing 6.9 million hectares – equivalent to an area of 9.6 million soccer fields – 425 million tons of sugar cane are grown per year. Half of this is processed into around 17.8 billion litres of ethanol, the rest into sugar.

Sources: Inter-American Development Bank; José Goldemberg/University of São Paulo; União da Indústria da Cana-de-Açúcar

→ The net production costs for 1,000 litres of ethanol produced out of Brazilian sugar canes are 14.48 euros. The same amount of ethanol made from American corn costs 24.83 euros and 52.37 euros if made from German sugar beet. One litre of ethanol costs about 1.08 US dollars.

Source: José Goldemberg/University of São Paulo

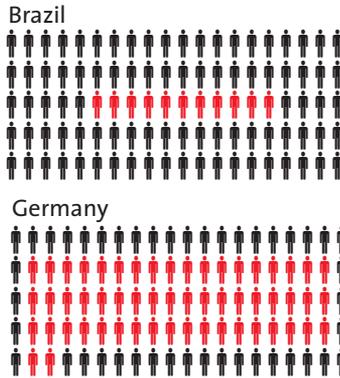
→ Global petrol consumption has decreased by three percent due to the usage of ethanol. It is estimated it will decrease by a further ten percent within the next 15 to 20 years.

Source: José Goldemberg/University of São Paulo

Automobile industry

- **Eleven out of 100 Brazilians own a car.** About four out of 100 own a motorbike. Source: Sindipeças
- **27 percent of the population earns 750 US dollars or more per month – sufficient to buy a car.** The number of newly registered cars from January to October, during the 2009 economic crisis, increased by 6.1 percent, compared to the same period the year before. Source: Germany Trade and Invest
- The sector booms: 19 manufacturers produce over 500 car models and more than 1.3 million people work in the automobile industry. The sector's share of total gross domestic product (GDP) is five percent, compared to industry's 25 percent share of GDP as a whole. Sources: Sindipeças; ZF Sachs
- **90 percent of all cars produced in Brazil run on ethanol** or an ethanol-petrol mix.
 - Price for one litre of petrol (2009): 1.35 US dollars
 - Price for one litre of alcohol (2009): 1.08 US dollars

Cars per 100 inhabitants



Volkswagen in Brazil

- 4** plants in São Bernardo do Campo, Taubaté, Curitiba and São Carlos
- 9** different models: Gol, Voyage, Fox, Polo, Polo Sedan, Parati, Golf 4, Saveiro, T2
- 822,000** vehicles produced on location, including Argentina (2009)
- 21,700** employees (2009)
- 600** car dealers
- 2,300,000** Euros planned investment volume between 2009 and 2014
- 22.7** percent market share within the car and light-duty commercial vehicles sector (2009)



Ethanol

Ethanol is nothing other than alcohol or ethyl-alcohol, an oxygenated hydrocarbon compound. This colourless, readily flammable liquid is used in different industrial sectors, as well as for fueling combustion engines. Flex-fuel vehicles, like the VW Fox, feature an engine which can run on alcohol, petrol or a mixture of both fuels.

Source: National Renewable Energy Laboratory

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Intelligent Mix

Increased Efficiency via Automobile Lightweight Construction

Lightweight construction materials



Photo: DDP/Kirsten Neumann

Steel

- durable at high flexibility
- long-lasting
- heavy
- cheap and easy to process



Titanium

- long-lasting
- durable
- expensive



Aluminium

- light
- torsion-resistant
- soft
- non-durable



Magnesium

- very light
- completely recyclable
- easy to process
- expensive



Carbon Fibre

- ultra light
- irreparable (if crashed)
- easy to process
- extremely expensive (elaborate production)



Specific density of lightweight materials in kilograms per litre.

Sources: Federal Ministry of Education and Research; Form & Technik GmbH; im-auto.de; TU Freiberg; TU Munich

By means of lightweight construction, cars can become lighter, more efficient and more environmentally friendly. In order to achieve an effective weight reduction – without compromising stability and safety – the intelligent use of different lightweight materials and high strength steel is vital. Among lightweight construction materials, the flyweights are fibre composite materials consisting of fibrous fabric in combination with resins or rather polymers and characterized by their strength and stiffness. Carbon fibre enhanced polymers (carbon) are an example of flyweight materials.

Source: Automobilwoche; TU Chemnitz, TU Munich

- Compared to conventional construction, using steel or aluminium, these fibre-enhanced, high-performance polymers, like carbon, save 60 to 25 percent in weight respectively.

Sources: German Association of the Automotive Industry; TU Munich



- 100 kilograms of weight reduction saves 0.3 to 0.5 litres of petrol over a distance of 100 kilometres, and lowers CO₂ emissions by up to eleven percent.

Source: Automobilwoche

- Lighter bodywork allows for the employment of smaller engines and brakes (Downsizing).

Source: Automobilwoche



First 1-litre car

The first 1-litre car by VW, whose 3.65 metre long body is made up entirely out of carbon fibre composites, weighs a lean 290 kilograms. The one-cylinder diesel engine accelerates to a maximum of 120 km/h; the braking system weighs a mere 7.8 kilograms. Next to carbon, aluminum and magnesium, this aerodynamically optimized research vehicle features a titanium and glass fibre reinforced polymer.

