VIAVISION

VOLKSWAGEN GROUP • SHAPING THE FUTURE OF MOBILITY

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Sustainable & Efficient
Green Fuels in the Fast Lane

Picture: DDP/Thomas Lohnes

5.5 percent
of all fuel consumed in Germany in 2009 originated from renewable resources.

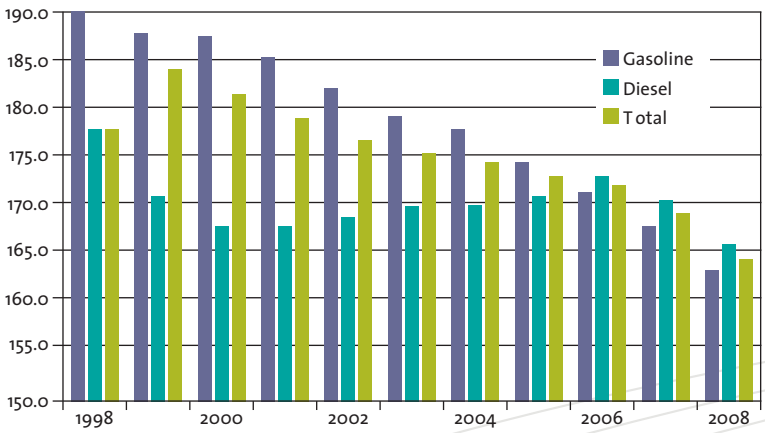
Almost 30 percent
of drivers want cars that are, above all, innovative and eco-friendly.

New Moderation

Efficient Engines Perform Better and Cost Less

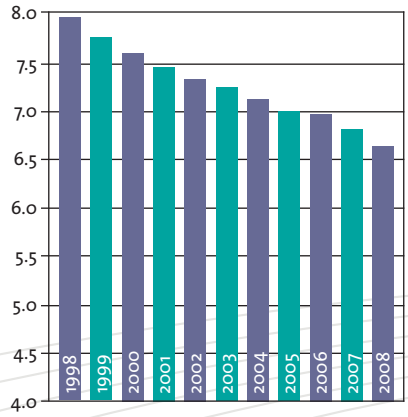
The question as to the nature of the engine of the future is not an easy one and so it is impossible to formulate an unambiguous answer. The industry is working on an electric engine that is suitable for the mass market, whilst hybrid engines continue to enter the market. At the same time, car manufacturers are working to further optimize the traditional combustion engine.
Energy efficiency and sustainability are the key words defining the future of mobility. Against a background of dwindling resources, increasing energy prices and the debate about climate change and environment protection; the challenges facing the car market are clearly defined. Efficient engines consume less and have a lower environmental impact: they are the key to individual mobility in evolving modern society and a prerequisite for a competitive economy in the future.

Changes in CO_2 emissions for newly registered cars:
(grams per kilometer)



The CO_2 emissions of new cars have been continuously decreasing since 1998. With an average of 164 grams per kilometer for all newly registered gasoline cars and 167 grams for diesel cars, the desired goals have not yet been reached; although there are some examples of best practice – with emissions of less than 90 grams CO_2 per kilometer. The average level of CO_2 emissions for gasoline cars has been decreasing at a faster rate than that of diesel cars. This is, among other things, due to the fact that especially large and heavy vehicles are equipped with diesel engines.

Changes in fuel consumption of newly registered cars:
(liters per 100 kilometers)

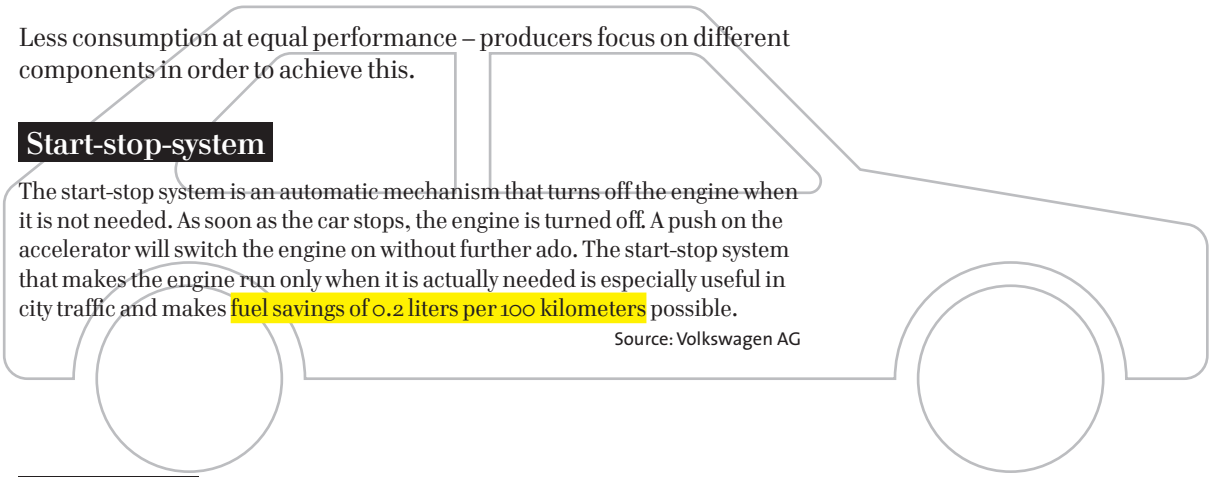


Although the total number of cars has increased, average fuel consumption has decreased by almost two liters over the last ten years. This has been made possible by efficiency boosting technologies like downsizing, recuperation or the start-stop automatic.

Sources: Frost & Sullivan; German Federal Motor Transport Authority

Economical Technology

Less consumption at equal performance – producers focus on different components in order to achieve this.



Start-stop-system

The start-stop system is an automatic mechanism that turns off the engine when it is not needed. As soon as the car stops, the engine is turned off. A push on the accelerator will switch the engine on without further ado. The start-stop system that makes the engine run only when it is actually needed is especially useful in city traffic and makes fuel savings of 0.2 liters per 100 kilometers possible.

Source: Volkswagen AG

Downsizing

Engineers have focused on downsizing engine capacity in order to decrease the fuel consumption of combustion engines. True to the maxim "less is more", the capacity of diesel and gasoline engines is gradually being reduced. The initial loss of performance is compensated for by direct fuel injection and greater air intake. Without any loss of torque, a 25 percent decrease in capacity will result in approximately ten percent less consumption and thus also reduce CO_2 emissions, too. In total, the equivalent of 4.1 metric tons CO_2 can be saved when the performance of the predecessor model is compared to that of the new, over the complete life cycle of a TSI engine. A smaller engine is also more efficient since it weighs less, results in less internal friction losses and reaches optimal combustion efficiency more frequently.

Sources: Institut für technische Verbrennung; Süddeutsche Zeitung; Volkswagen AG

Recuperation

Recuperation describes a rather simple principle: the generation of electricity using the energy that is released during breaking. The energy that is produced during the application of the brakes would be lost in the form of heat generated by friction but is instead transferred to the engine, using a generator, and recovered rather than wasted. This has a significant impact on both fuel consumption and CO_2 emissions, especially for car models that also feature a hybrid engine. The recuperated energy keeps charging the electric engine during the journey again and again; thus decreasing the consumption rate of the combustion engine by up to five percent.
Combustion engines use this energy to power the radio, car heating and lights so that the engine itself needs to generate less energy.

Set borders

Politics, too, have long determined the precise requirements of the car industry. The tenor: less greenhouse gas emissions, meaning less carbon dioxide emissions (CO_2) in respect of all vehicles.
The European Parliament has made binding specifications, setting a CO_2 emissions limit for vehicles within the European Union. Improvements in car technologies are due to drive down average CO_2 emissions to 130 grams per kilometer. Another ten grams per kilometer is to be saved by supplementing measures, like adding bio fuels to the mix.
The limit is not binding immediately but comes into effect over time: by 2012, 65 percent of a car producer's portfolio must meet this requirement, 75 percent in the year 2013, a year later 80 percent and finally 100 percent by 2015.

Sources: EurActiv Network; German Federal Motor Transport Authority

Tomorrow's Mobility

Eco-Friendly Cars in Demand

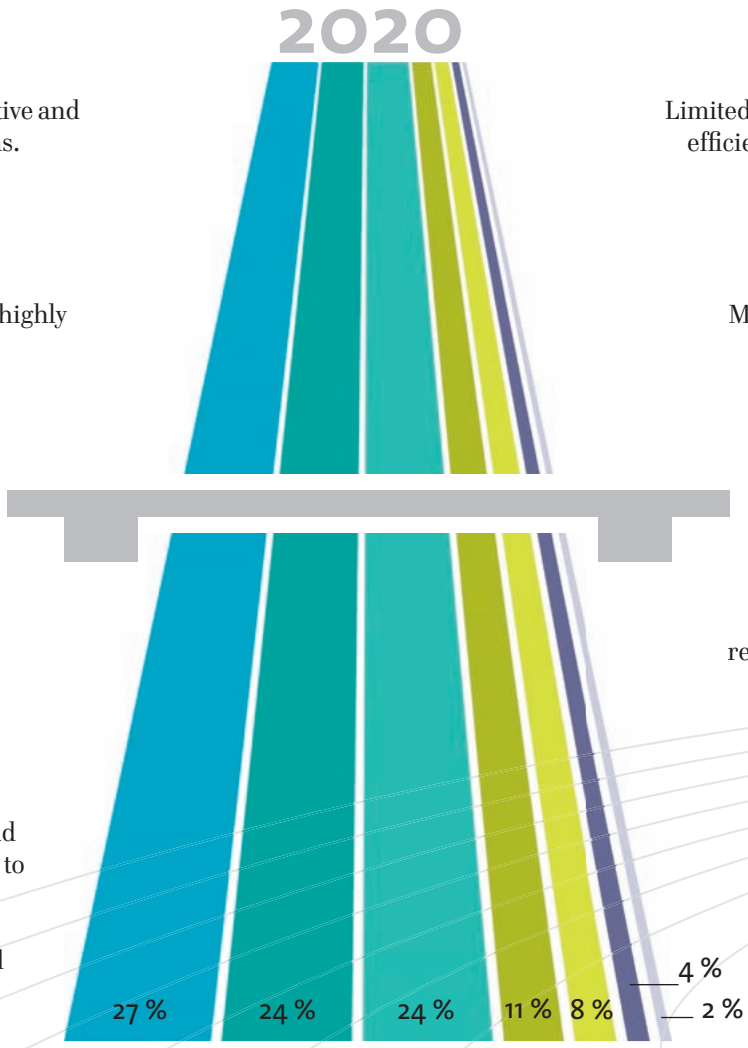
Green is in – a healthy and sustainable lifestyle is already much more than a minority statement. The requirements of mobility change along with society's value system: sustainability and individuality are becoming of greater importance, while luxury and engine performance are increasingly becoming a secondary issue.

Greenovator
Demand for innovative and sustainable solutions.

Silver Driver
Knows the product, highly conscious of quality.

High Frequency Commuter
Very mobile work travelers, mostly in the megacities of tomorrow.

Family Cruiser
Increasingly demand mobility with which to reach family and friends who are becoming more and more fragmented geographically.



Low-End-User
Limited budget, needs a cost efficient mobility solution.

Car Guy
Mobility as a symbol of freedom; fun and lifestyle, status and prestige.

Global Jetsetter
Demand for global mobility as a job requirement, requires exclusive premium support.

Sources: Arthur D. Little; German Federal Agency for Civil Education

On the roads of the future, the ecologically mindful "Greenovators" are already taking the lead, with a market share of almost 30 percent, and are leaving the fuel hungry "Car Guys" far behind, with their four percent share.

Bio-Power

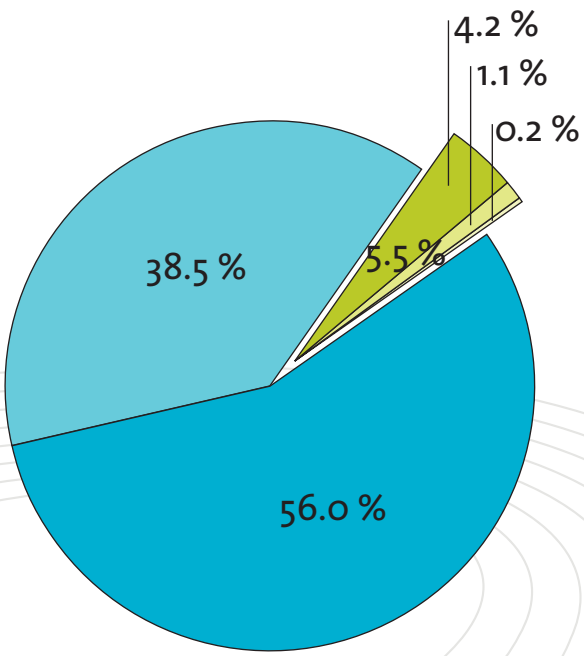
Fuels from Renewable Resources Gather Momentum

Thanks to optimized combustion engines, longer distances can be covered with less and less fuel. Because fossil fuels are not limitlessly available in the long term, alternative fuels are gaining importance. Bio diesel, bio ethanol and others, grant us independence from natural oil, are more environment friendly and, above all, renewable.

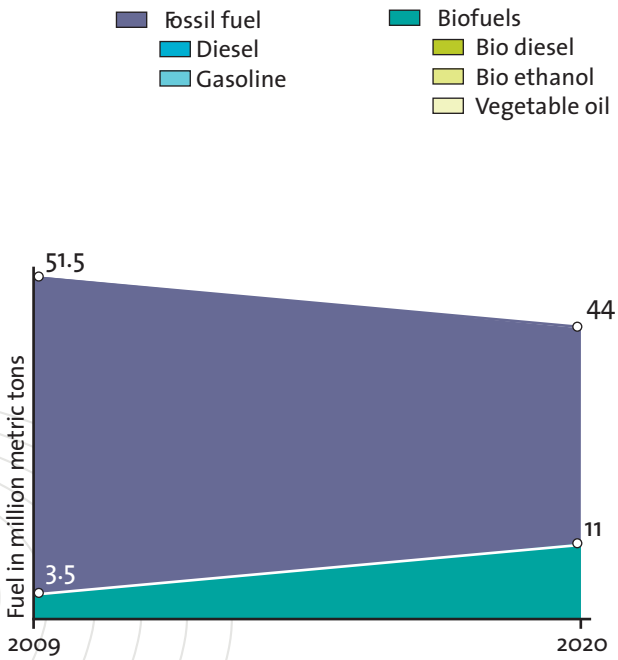
- ➔ Ten percent of all fuels are to be generated using renewable resources by 2020. This is regulated by the EU's renewable energy guidelines.
- ➔ 5.5 percent of German fuel consumption is already generated using renewable resources. To increase this proportion – and at the same time to preserve biological diversity – agricultural efficiency has to be improved above all else.

Sources: European Commission; Roundtable on Sustainable Biofuels

Fuel consumption in Germany



Consumption of primary fuel in Germany was 51.5 million metric tons in 2009 of which 3.5 million metric tons are generated using renewable resources – this equates to 5.5 percent.



While total fuel consumption decreased, biofuel sales increased: from 3.5 million metric tons in 2009 up to eleven by 2020. This would provide for about 25 percent of German fuel consumption.

Source: Fachagentur Nachwachsende Rohstoffe

Alternative Fuels Compared

Sugar Beet, Straw and Rape Will Power the Engine of Tomorrow

A substantial advantage of biological fuels is that they are almost CO_2 neutral. At combustion only about the same amount of carbon dioxide is released as the plant, from which the fuel is produced, absorbed during its lifespan, via photosynthesis. Currently bio diesel and ethanol are being used in the largest quantities. The future, however, belongs to bio gas and fuels synthesized from solid biomass; they save an especially large amount of CO_2.

Picture: DDP/Jens Koehler

Bio Diesel

- **Resources:** rapeseed oil, palm oil, soya oil, old fats, algae
- **1 liter** ≙ 0.92 liter diesel (bio diesel is mixed with fossil fuel diesel, seven percent by volume is permitted)
- **CO_2-Savings:** 3 metric tons per hectare (bio diesel from rapeseed oil)

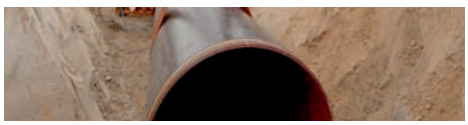
\+ reduction of particle emissions
– low energy output per hectare
– fossil methanol required for production
➔ In Germany bio diesel is made mostly from rapeseed oil.

Picture: DDP/Jörg Koch

Bio Gas (Bio Methane)

- **Resources:** energy crops, grasses, liquid manure, organic waste
- **1 kilogramm** ≙ 1.5 liters of gasoline or 1.3 liters diesel
- **CO_2-Savings:** 7.4 metric tons per hectare (bio methane from silage maize)

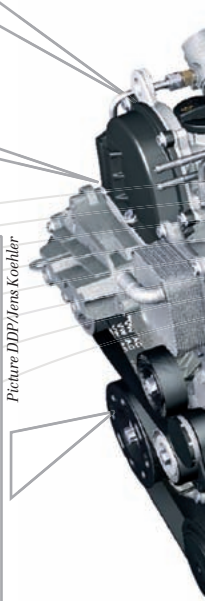
\+ high energy output per hectare
\+ existing infrastructure can be used: natural gas grid and natural gas vehicles
– is used mainly for electricity generation in Germany because of the funding provided by renewable energy laws
➔ Bio gas can achieve international competitiveness via its contribution to the natural gas grid.



Picture DDP/Jens Koehler

Natural Gas

Although it is a fossil fuel source of energy, natural gas, too is an environment friendly alternative to gasoline and diesel: natural gas vehicles emit almost no sulfur dioxide and sooty particles. Compared to a gasoline car, a natural gas car emits up to 25 percent less carbon dioxide.



Sources: Bundesverband der Energie- und Wasserwirtschaft; Fachagentur Nachwachsende Rohstoffe

Picture: DDP/David Hecker

Bio Ethanol

- **Resources:** crops, sugar beets, sugar canes, corn, cellulose
- **1 liter** ≙ 0.65 liter gasoline (bio ethanol is mixed with fossil fuel gasoline)
- **CO_2-Savings:** 9.4 metric tons per hectare (bio ethanol from sugar beets)

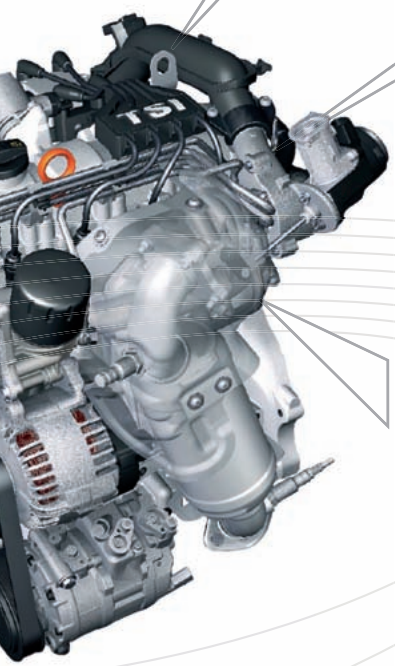
\+ high energy output per hectare
\+ mainly established technology
– the production of crops and sugar beets is more expensive than that of Brazilian sugar cane
➔ There are almost no vehicles in Germany running on pure ethanol (Flexible Fuel Vehicles).

Picture: Fachagentur Nachwachsende Rohstoffe

Biomass-to-Liquid (BtL)

- **Resources:** wood, straw, diverse organic waste and remnants
- **1 liter** ≙ 0.97 liter diesel (BtL is mixed with fossil fuel diesel)
- **CO_2-Savings:** 10 metric tons per hectare

\+ high energy output per hectare
\+ processing is almost CO_2 neutral
\+ can be optimized to the respective engine (referred to as "designer fuels")
– still relatively expensive to produce
➔ BtL has not yet hit the market.



Picture: DDP/Nigel Treblin

Vegetable Oil

- **Resources:** rape, sunflowers, soya, coconuts and others
- **1 liter** ≙ 0.96 liter diesel (vegetable oil is used only as pure fuel)
- **CO_2-Savings:** 3 metric tons per hectare (rapeseed oil)

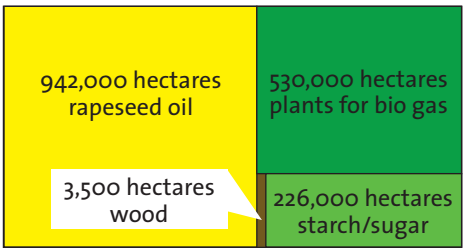
\+ uncomplicated, cost efficient production
– low energy output per hectare
– problems with the application of particle filters
➔ Vegetable oil is used mainly for trucks and in agriculture.

SunGas®

Under the name SunFuel® Volkswagen promotes alternative fuels like SunGas®. SunGas® is generated using renewable energy plants, bio waste and liquid manure; cleaned and refined to the highest natural gas quality. A car that is fueled by SunGas® has, at equal fuel cost, double the range of a premium fuel operated vehicle. On top of that, it emits up to 85 percent less CO_2.

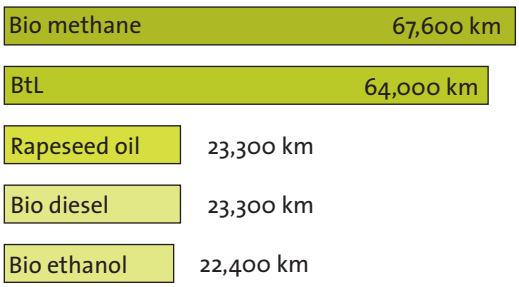
From the Field to the Tank

Renewable energy plants are being cultivated on 1,751,500 hectares – this equates to almost 4.8 percent of the total surface area of Germany. The bio fuel obtained saves many metric tons of greenhouse gases, when compared to fossil fuels.
While there is sufficient area and water for cultivation in Germany to produce alternative fuels, the situation in poorer countries is different: the cultivation of renewable energy plants can result in competition with food cultivation – a problem that needs a solution.



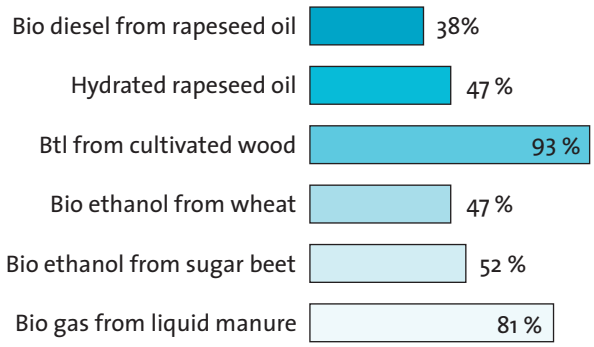
This is how many renewable energy plants have been cultivated in Germany in order to generate bio fuels.

Range per hectare:



With the fuel generated using one hectare of renewable energy plants you can drive – based on a fuel consumption of 7.4 liters per 100 kilometers for gasoline and 6.1 liters for diesel engines – different ranges. The range of these fuels would increase by up to 17,600 kilometers, if one were to take into account the energetic use of the byproducts of the production of rapeseed oil, bio diesel and bio ethanol.

Greenhouse gas reductions:



Compared to fossil fuels, greenhouse gas reduction levels are different, according to the particular bio fuel. BtL fuels and bio gas from liquid manure are especially environment friendly.

Sources: European Union; Fachagentur Nachwachsende Rohstoffe

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