Technical requirements

Basically, ethanol can be used as a substitute for petrol in engines. For amounts up to 5% ethanol in petrol, it is not necessary to carry out technical modifications to the engine. At higher levels, the lower calorific value of ethanol (29.3 MJ/kg - 33% lower compared to premium petrol) is compensated by increasing the fuel level in the fuel-air mix (enrichment).
In the so-called 'flexible fuel vehicles', such technical modifications are already carried out by the engine manufacturers. In Europe, modified-engine cars are offered by Volvo, Ford and Saab, with truck and bus engines available from Scania.

Additionally, it is possible to modify older vehicles with additional equipment which regulates the temperature and mixture of the injected fuel according to the required engine loading.

Ford Cmax Flexible Fuel Vehicle (E85) next to a 995 l - company fuel pump

Source: Verein Regionaler Brennereien e.V., 2007

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Bioethanol

What is bioethanol?

Bioethanol is legally defined as ethyl alcohol obtained from biomass, having an alcohol content of at least 99%. Bioethanol can be used as an alternative fuel either in its pure form or as an admixture to petrol. There are a number of different mixtures with varying ethanol/petrol ratios, in which the E indicates the volume proportion of ethanol in the fuel mixture (e.g. E85).

Characteristics of ethanol

Raw material	Starchy (cereals, maize, potatoes) and sugar-containing (sugar beet, sugar cane) plants and cropse	
Yearly yield per ha	2,560 l / ha (from cereal)	
Fuel equivalent	1l Ethanol	0.66 l petrol
Calorific value	29.3 MJ / kg	43.5 MJ / kg petrol
Octane number	104 ROZ	95 ROZ petrol
Additional consumption	25 - 30 %	
CO2 reduction*	30 - 70 % **	
Technical aspects	Can be added to premium fuel up to 5%	

* Standard value, EU Directive
** According to fuel used in the manufacturing process

Source: FNR Biokraftstoffe 2007, supplemented by FNR Biokraftstoffe Basisdaten Deutschland 2008

The mixture of 85% ethanol and 15% petrol is normally described as E85 and is in widespread use in Brazil and the USA. However, in several European countries such as France, Germany and Spain, the market share has been steadily increasing in the last few years. In order to use this fuel, petrol engines need to undergo a technical conversion.

In accordance with the European norm for petrol fuels (DIN EN 228), the ethanol proportion in commercial petrol may amount to 5% **(E5)**. At higher concentrations, the fuel is no longer in compliance with the norm, which can lead to an invalidation of the warranty where such use is not covered by the motor manufacturers conditions.

In addition, the norm permits the admixture of **ETBE** (ethyl tertiary butyl ether) up to a proportion of 15%. ETBE consists of 47% ethanol and 53% isobutene. These so-called ethers are characterised by high octane numbers and because of this quality are added to petrol fuels to improve knock resistance.

Method of production

The basis for the manufacture of ethanol is sugar, which is obtained directly from sugar-rich plants (sugar cane) or from parts of plants (sugar beet). Starchy plants (cereals and maize) are suitable raw materials following the breaking down of the starch into sugar and are used as raw materials for alcohol production. Currently, research projects are looking at the production of ethanol from cellulose and hemicellulose (straw, wood) in order to make greater use of biomass which does not serve food production.

In general, the manufacture of bioethanol consists of three stages:

1. Enzymatic breakdown / dissolving of high-molecular sugar compounds (starch, cellulose) into simpler sugars (glucose), i.e. saccharification.

2. Conversion of sugar to alcohol and CO_2 using an alcoholic fermentation process.

3. Purification of the alcohol: distillation and removal of water (rectification, dehydration).

In the **fermentation** process, sugar (glucose) is fermented to alcohol and CO_2 using yeast enzymes, as shown in the following reaction equation:

$$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2\ CO_2$$

In the **distillation** process, water is removed from the alcohol. Alcohol has a lower boiling point than water (78.4°C compared to 100°C), meaning that it changes more readily to the gaseous phase, and this facilitates its separation from liquid water through an evaporation process. A subsequent purification stage (rectification) results in ethanol of 96% purity. However, mixtures with petrol up to 10% (E10) can result in phase separation, therefore the ethanol must have a purity of 99.5 - 99.9 % (water free) and is dehydrated in a final production stage.

The fuels used in the production of raw materials and the purification of the alcohol have a significant effect on the energy efficiency and the CO_2 emissions associated with the manufacturing process.
Sustainable ethanol production is based on the provision of renewable energy in the energy-intensive distillation process and a material cycle which is as far as possible closed.

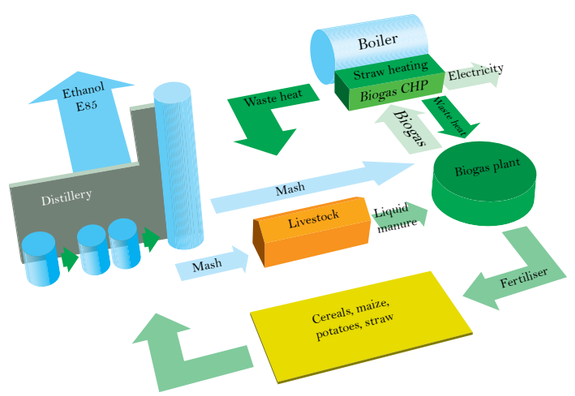
Ecological aspects

The manufacture of biofuels using environmentally-friendly methods is receiving increasing attention because of the rising demand for such fuels and the European directive on energy from renewable resources. In order to promote sustainability in the production process and the use of biofuels, the EU has recently concluded a European directive (2009/28/EC) which takes into account ecological aspects (Article 17).
These criteria for sustainability are intended to promote biological diversity and a reduction in CO_2 emissions.

- the intended reductions in the outputs of greenhouse gases achieved by the use of biofuels must amount to at least 35%
- from 2017, the reductions in greenhouse gas outputs must be at least 50%
- Production facilities which start producing after 2017 must achieve a reduction in greenhouse gas outputs of at least 60%.

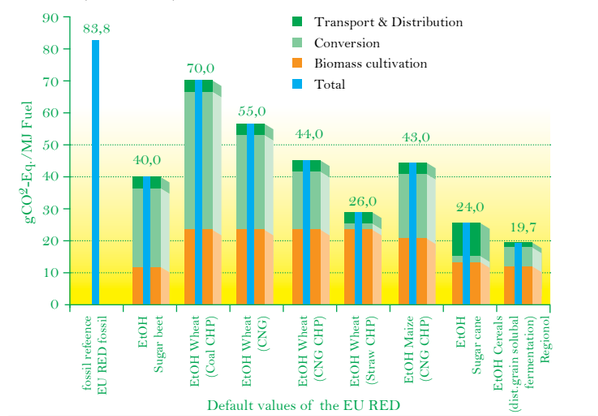
The EU has set standard values applicable to the various manufacturing systems for ethanol, which must be calculated using a specified methodology. The calculations of the EU have also given a very good greenhouse gas and energy balance for the use of renewable fuels in production processes (straw, biogas).

Sustainable ethanol production in a decentralised system



Source: Verein Regionaler Brennereien e.V., 2008

Standard values for greenhouse gas emissions for various bioethanol production methods (2009/28/EC)



Source: Deutsches BiomasseForschungszentrum, 2009 and Verein Regionol e.V.; 2009