Biofuels – what are the technical options?

Bioenergy refers to the production of energy from biomass, i.e. from organic matter of plant and animal origin. The transportation sector uses bioenergy in the form of biofuels. This article provides an overview of the technical processes for producing liquid biofuels.

Photo: Walter

Bioethanol can replace petrol up to 100 percent. Particularly suitable are «flexible-fuel» vehicles, which already enjoy great popularity in Brazil.

Never before has so much biodiesel and bioethanol been produced and consumed around the world as today. Biofuels have become a key topic of political debate in the context of the predicted scarcity and increase in price of fossil fuels, climate change and the need to stabilize value creation and employment in rural areas. Experts are convinced that the international trade of biofuels will grow and offers tremendous potential.

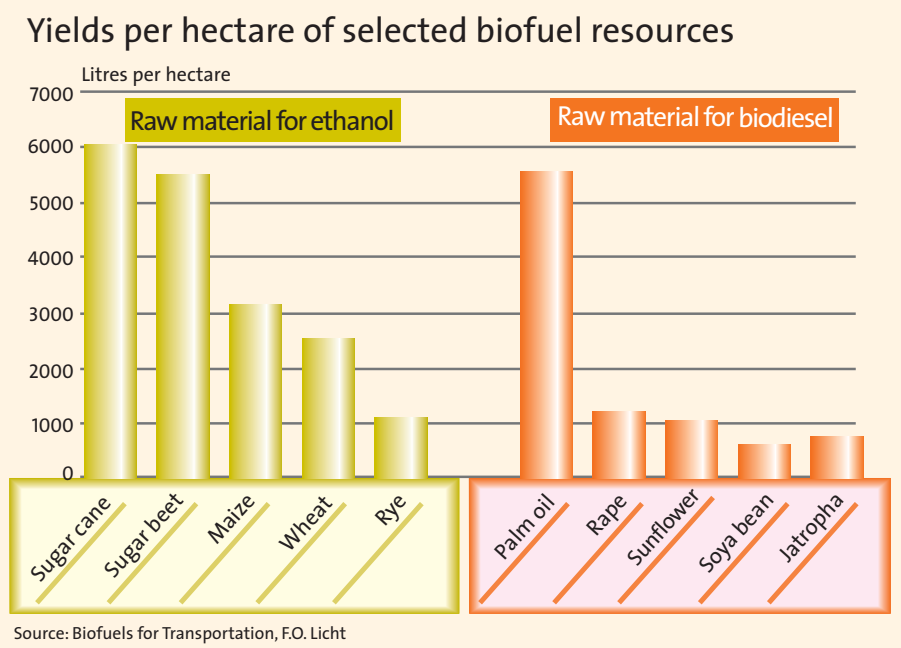
Biofuel is available as gas and as liquid fuel. It can be used for heat and power generation or as fuel in the transportation sector. Today, the most important liquid biofuels are bioethanol and biodiesel, both are suitable for use in conventional engines. Liquid biofuels are subdivided into first and second generation. First-generation biofuels include pure plant oils, biodiesel and bioethanol, which can be produced using traditional technology. Synthetic fuels (e.g. «biomass to liquid» – BtL) and ethanol from cellulose belong to the second generation, in which all of the biomass (entire plant and/or residues) is converted into liquid biofuel using sophisticated technologies.

How are biofuels produced? And which cars use them?

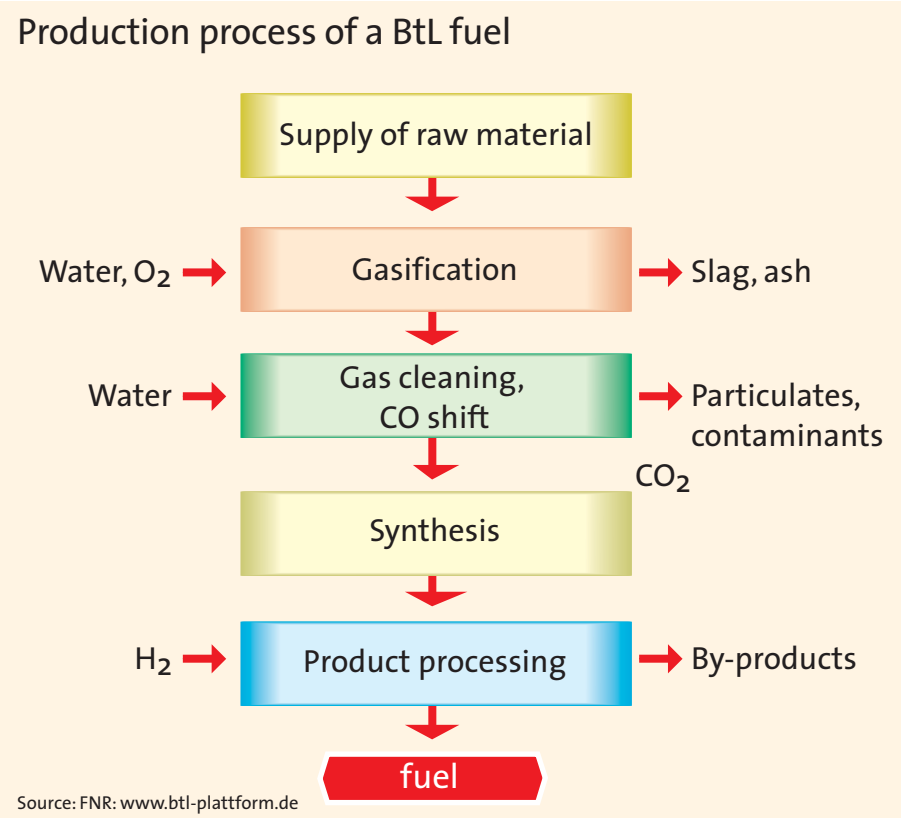
Pure plant oils are produced by pressing oilseeds. Recycled used cooking oil can also be used. The oil must be filtered to ensure that fuel filter and fuel pipes do not later become clogged. Diesel-powered vehicles can be converted to run on plant oil at a cost of 3,000 euros (in Germany). The plant oil engine, the so-called Elsbett engine, was developed back in the 1970s. Biodiesel is produced from plant oil and methanol by transesterification, one of the resulting by-products being glycerin.

Christine Clashausen
Hamburg, Germany
christine.clashausen@gfa-envest.com

At present, some 1.900 German filling stations sell biodiesel. Although not all vehicles can run on 100 percent biodiesel, all diesel engines can cope with a five-percent blend of biodiesel without any technical problems (at a very conservative estimate).
In contrast to biodiesel and plant oil, petrol is normally blended with bioethanol, produced by fermenting sugar and starch crops (grain, maize). The large quantities of dried slop obtained as a by-product of the fermentation process are recycled to generate energy for the production facility. Bioethanol can serve as a 100-percent substitute for petrol or can be blended (as in E85: 85 % ethanol and 15 % petrol). So-called flexible-fuel vehicles (FFVs), which can run on any blend of ethanol and petrol, have only been available in Germany since 2006. In Brazil, already 60 percent of newly registered passenger cars are FFVs. The EU currently allows mineral oil producers to blend five percent ethanol with petrol, while in the USA the blend limit is 10 percent. More recently, lignocellulose has also been used to produce ethanol. The cellulose is processed and broken down by (enzymatic) hydrolysis. After separation, the cellulose, like sugar, is fermented and distilled (as in Synfuel from the Canadian Iogen Corporation).
In the «Biomass to Liquid» (BtL) production process, the entire biomass is first of all gasified (thermochemical gasification). The gas is then cleaned of sulphur compounds, nitrogen compounds and other contaminants. Once cleaned and the hydrogen content increased (CO shift), in the next stage the gas is reliquefied, for example by means of Fischer-Tropsch synthesis. Subsequently, the fuel can be refined and specifically adapted to the desired fuel properties by blending (as in SunFuel from the Choren company). However, experts believe that even in 10 years' time, second-generation fuels will still not account for an appreciable percentage of overall fuel consumption.



Source: Biofuels for Transportation, F.O. Licht



Source: FNR: www.btl-plattform.de

Which raw materials are especially suitable for the production of biofuels?

Basically, the ideal resource for the production process will depend on the particular geographical location. Below, some raw materials are compared with reference to key criteria.

Yield per hectare: Sugary field crops (e.g. sugarcane) have a far higher yield per unit area compared to starchy raw materials such as grain and maize (see chart). Among the oil fruits, palm oil stands out on account of its high productivity. However, palm oil can be used for biodiesel only in temperate zones, because pure palm oil solidifies when cold. Second-generation hectare yields are around 4.000 litres/hectare (in Germany), since the entire plant is used.

CO_2 balance: Depending on the production process (upstream emissions in the agriculture, emissions of transportation, processing, and distribution), the CO_2 balance cannot always be completely neutral. Nevertheless, biofuels generally make a considerable contribution towards reducing the emissions of greenhouse gases in the transportation sector.
Recent studies have passed positive judgement on BtL fuels with regard to their environmental and energy balances. BtL fuels also meet the emissions requirements of the EURO V standard.

Production costs: The high crop yields and lower land and labour costs (dominant cost factors in relation to these fuels) in the tropics constitute a decisive economic advantage for countries in these regions. Table 2 compares the production costs of various biofuels in Brazil, the USA and the

EU. If the price of crude oil rises to above 41 euros a barrel, Brazilian bioethanol from sugarcane becomes significantly cheaper than petrol. It is estimated that world sugarcane production can be increased to such an extent that ethanol from sugarcane could account for some 10 percent of global petrol consumption. This could enable numerous low-income countries to advance to important producers – and potentially also exporters – of a valuable new commodity. Biodiesel and ethanol have a lower energy density than petrol and diesel, which was taken into consideration in Table 2.

Future trends

Cellulose-containing biomass (wood, tall-growing grasses and harvest residues) can be expected to enhance the resource base considerably, since new conversion technologies for these materials are under development. Highly promising energy crops in this regard include fast-growing wood crops such as willow, poplar hybrids and eucalyptus as well as perennial grasses such as elephant grass (miscanthus) and switch grass. The availability of cellulose-containing biomass is far more plentiful than biomass from food crops and it can be harvested with less interference in the ecosystem. Furthermore, cellulose-containing biomass does not even indirectly compete with food crops for land. This aspect (food versus fuel) is the subject of debate, especially in relation to developing countries. However, second-generation biofuels will not play a major role in developing countries.

As already indicated, worldwide production and trade will continue to grow, with the consequence that international trade agreements (WTO), including agreements on standards (social and environmental standards), will become inevitable. For both the EU and the developing world, the words of the director of the German Biomass and Bioenergy Consulting Service FNR, Andreas Schütte, are of crucial importance for the future development and promotion of rural areas: «Farmers and foresters should not just grow biomass, but they must also suitably process it ready for the production facilities, to ensure that this link in the value-added chain remains in the hands of the rural economy. »

More information on biofuels is available from the website of the Biomass and Bioenergy Consulting Service FNR on bioenergy: www.bio-energie.de

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All diesel engines can easily cope with a five-percent blend of biodiesel.

Photo: agenda/Böthling

Table 1: Reduction in emissions with biofuels

Fuel	Fuel equivalent	$C0_2$ reduction
Plant oil (rape)	1 l replaces 0,96 l of diesel	> 80 % (based on diesel equivalent)
Biodiesel	1 l replaces 0,91 l of diesel	ca. 70 % (based on diesel equivalent)
Bioethanol	1 l replaces 0,66 l of diesel	30-70 % (based on diesel equivalent)
BtL	1 l replaces 0,97 l of diesel	> 90 % (based on diesel equivalent)

Source: FNR

Table 2: Production costs of biofuels and prices of fossil fuels*

Country	Ethanol	Petrol	Biodiesel	Diesel	BtL
USA	0.36 (maize)	0.45 (incl. tax) 0.32 (excl. tax)	0.50 (soya)	0.47 (incl. tax) 0,31 (excl. tax	
EU	0.70 (wheat)	1.09 (incl. tax) 0.34 (excl. tax)	0.56 (rape)	1.06 (incl. tax) 0.33 (excl. tax)	0,5-1,0
Brazil	0.27 (sugar cane)	0.69 (incl. tax) 0.33 (excl. tax)	0.52 (soya)	0.40 (incl. tax) 0.32 (excl. tax)	

*in euros per litre of energy equivalent
Source: Biofuels for Transportation, FNR