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Biodiesel Perspectives

In Europe, the traffic volume and CO_2 emissions from this source are expected to increase by approximately 50% to about 1.1 billion t by the year 2010. Approximately 84% of these emissions are caused by road traffic. The use of biogenous fuels is intended to counteract this development. EU directive 2003/30/EC from 8th May 2003 on the promotion of the use of biofuels or other renewable fuels for transport puts these goals into concrete terms mainly by requiring that the market share of biofuels be increased from 2% in the year 2005 to 5.75% in the year 2010.

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The acceptance of fuels from renewable raw materials mainly depends on the tax rates. Therefore, the EU member states are given the possibility to exempt the biofuels listed in the EU directive from mineral oil taxation until 2006. In Germany, biofuels and the biofuel contained in fuel mixtures are preliminarily exempt from mineral oil tax until the end of 2009.

The list of definitions in the EU directive comprises a total of ten different biofuels. Of these, biodiesel (rapeseed methylester; RME) and unrefined (cold-pressed) vegetable oil are suitable as alternatives to conventional diesel fuel.

Diesel Fuels Are Gaining in Importance

The consumption of diesel and Otto engine fuel is developing in opposite directions. In 2001, diesel consumption first exceeded petrol consumption (*fig. 1*).

This development is going to continue because diesel vehicles have advantages due to the lower fuel price and lower specific consumption.

In agriculture, vehicles and machines with diesel engines are used almost exclusively. In the sectoral consumption of diesel fuel, agriculture occupies second place after road traffic, accounting for a consumption of 1.7 to 1.8 million t or 6 to 6.5% of total diesel fuel consumption.

Both biofuels are mainly produced from rapeseed and allow farmers to find direct access to „energy plant cultivation“ and to create a value added chain from crop cultivation to the processing and utilization of the products.

In practice, however, only biodiesel has been able to gain a considerable market share in the traffic sector (~ 2%). Due to the higher price, use in agriculture is currently not profitable in competition with tax-privileged agricultural diesel.

Extraction of Vegetable Oils

Vegetable oils are extracted in large central plants (oil mills) or smaller, decentralized plants. Central plants generally have advantages in the processing and supply of large batches uniform in quality. Decentralized plants are advantageous with regard to logistics as well as transport costs and support material cycle management.

In 2003, the central plants reached a production capacity of approximately 1.1 million t. The output of the plants varies greatly ranging between 2,000 and 120,000 t per year. The development and potential construction of small plants having production capacities between 1,000 and a maximum of 5,000 t per year is difficult to estimate. Especially plants of this size, however, are interesting for farms.

In international comparison, Germany with its production capacity holds the top position followed by France and Italy.

The production process of biodiesel is relatively mature. Vegetable oil (rapeseed oil) and methanol are used as raw materials, and vegetable methyl ester (rapeseed methyl ester, RME) as well as glycerine are the final products. By altering the molecular construction of the fat molecules contained in the oils previously extracted from vegetable plants, the physical properties of these oils

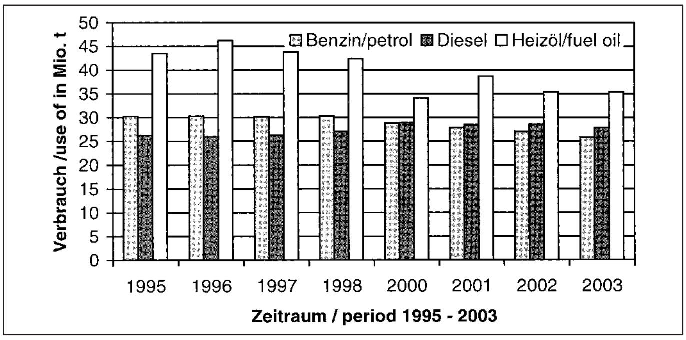

Fig. 1: Change of the use of petrol, diesel and fuel oil from 1995 to 2002 in million metric tons (acc. MWV 2003)

are changed such that they meet engine-specific requirements. In this process termed transesterification (or alcoholysis), one large fat molecule (rapeseed oil) is transformed into three smaller fat methyl ester molecules (RME) by replacing a trivalent alcolhol (glycerine) with a monovalent alcohol (methanol).

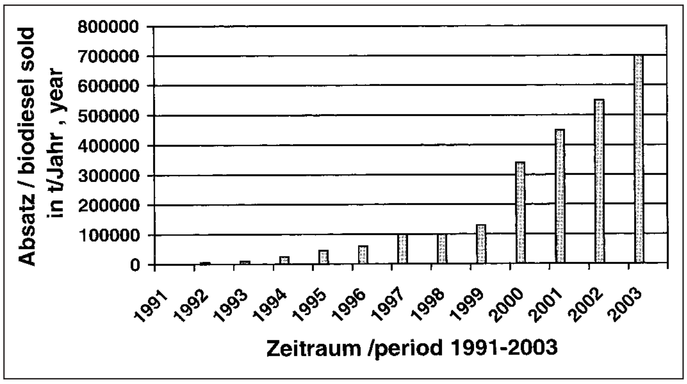

Fig. 2: Bio-diesel sold from 1991 to 2003 (data from UFOP; IWR; the amount sold in 1991 is 200 metric tons)

Biodiesel Production

For biodiesel production, different methods are employed which are designed either as continuous or batch techniques.

The product costs are significantly influenced by the technology used and the processing required to reach desired product purity. For plants having a throughput of more than 50,000 t/year, these expenses range between € 90 and € 110 per tonne of RME. In decentralized batch-type biodiesel plants which have a capacity of 400 to 800 t/year and are in the process of development, potential production costs range between E 420 and E 450 per tonne under favourable conditions and between E 640 and E 670 per tonne under unfavourable conditions (according to Falk, 2002).

Currently, biodiesel (rapeseed methyl ester, RME) is the most widely used biofuel in Germany. In diesel engines, biodiesel is used either in a pure form or as an admixed component. This does not cause any considerable problems with the engines. Most modern diesel vehicles can use biodiesel without conversion measures. Only in some cases do the fuel-carrying peripheral systems (injection pump, fuel pump, pipes) need to be adapted. Different suppliers (UFOP, IWR) provide information about the vehicle types which are approved for biodiesel operation by the manufacturer. The supply network, which comprises approximately 1,500 private and company fuel stations, covers the area relatively well. Bottlenecks occur in rural areas and along motorways.

The advantages of biodiesel are:

- Use of domestic, renewable raw material in production
- Contribution to a (though small) reduction of dependence on petrol imports
- Reduction of CO_2 emissions
- Lower transport expenses
- No hazardous material
- Biodegradability
- The calorific value (32 MJ/l) is only insignificantly lower than the calorific value of diesel (35 MJ/l)
- A high cetane number (56 to 58 as compared with 50 to 52 for diesel)
- The C/H ratio is almost identical in biodiesel and diesel. The oxygen content, however, is higher (more than 10%). As a result, fewer particles are produced during combustion.
- Sulphur-free
- Very good lubrication properties in the engine
- Improvement of the exhaust emission situation.

As compared with diesel fuel, the content of legally limited exhaust emission components (HC, CO, particles, and smoke number) is lower. Only NO_x can increase slightly. Reduction ranges between 10 and 40%. If catalytic converters are used, it may reach up to 90%. Since biodiesel is free of sulphur, oxidation catalysts, which provide a good reduction effect, can be employed if pure biodiesel is used.

For economic reasons, virtually no special RME engines will be developed due to the small share of RME on the fuel market, while engines will often be run alternatingly with biodiesel and diesel fuel in practice. This requires engines equipped with electronic map ignition, which can distinguish between different fuels using permittivity sensors. The development of such an engine management system is underway. Such engines are also quite well able to fulfill the requirements of the EURO-IV exhaust emission standard, which will become mandatory for road vehicles in 2005. Some manufacturers are already announcing biodiesel operation approval for their new EURO-IV engines. According to current knowledge, engines which meet the EURO-V exhaust emission standard effective as of 2008 will no longer be able to be run with biodiesel.

The quality requirements for biodiesel are defined in the fuel standard E DIN 51606 at the national level and DIN EN 14214 at the European level. The Work Group Biodiesel Quality Management (AGQM) examines samples of the biodiesel delivered to fuel stations. Positively evaluated fuel stations receive a quality seal in addition to the sticker which shows the DIN standard designation.

The fuel station network comprises more than 1,500 stations and is growing continuously. According to the AGQM, approximately 30% of the biodiesel is sold by public fuel stations, while 70% is dispensed by large customers and fleet operators. Consumption has also experienced rapid growth even though it has always lagged behind capacity development. This influenced the market- and price development positively for the customer. The development of the quantities of biodiesel sold is shown in *Figure 2*.

In the year 2003, biodiesel accounted for approximately 2% of the total fuel consumption of diesel engines.

As regards the price of biodiesel, the producers follow the development of the diesel price. Virtually every change in the biodiesel price was copied by the biodiesel suppliers. A comparison of the fuel station prices of the past 18 months shows that the biodiesel price (without mineral oil tax) was € Ct. 7.5 to 13.2 (on average 9.5) lower than the price of diesel fuel (full tax rate).

Since the beginning of 2004, the admixture of biodiesel (and other biogenous fuels) to diesel fuel during the refining process has been permitted at any desired ratio. Some mineral oil companies are already practicing a ~5% admixture. Unfortunately, this has had no effect on the fuel station price so far.

At present, the use of biodiesel in agriculture has no importance because agricultural diesel is used to run tractors and self-propelled machines as long as they are not used commercially. Agricultural diesel is conventional diesel taxed at a lower rate. This rate has been applied since 2001 after the Mineral Oil Tax Act was amended. It amounts to € 0.29 per litre (without VAT). With regard to a possible alteration in this regulation, biodiesel use may also gain greater importance in agriculture. The acceptance of the use of biodiesel in agriculture can only be controlled via the price.