Biodiesel Flowerpower

Facts • Arguments • Tips

ufop

2nd updated edition

Contents

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Preface

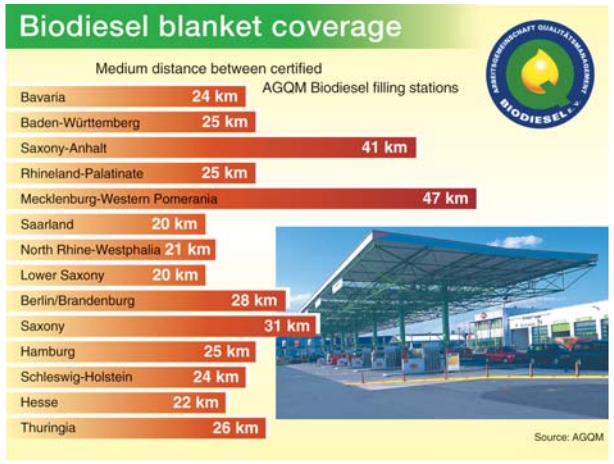
Preface

Biodiesel has become an established fuel in the last ten years and is now available in Germany at nearly every tenth filling station. Among the alternative fuels, biodiesel has conquered a substantial share of the fuel market. However, biodiesel customers have no wish to engage in experiments, they want an easy to use, environmentally friendly, economical and efficient alternative to mineral oil fuels.

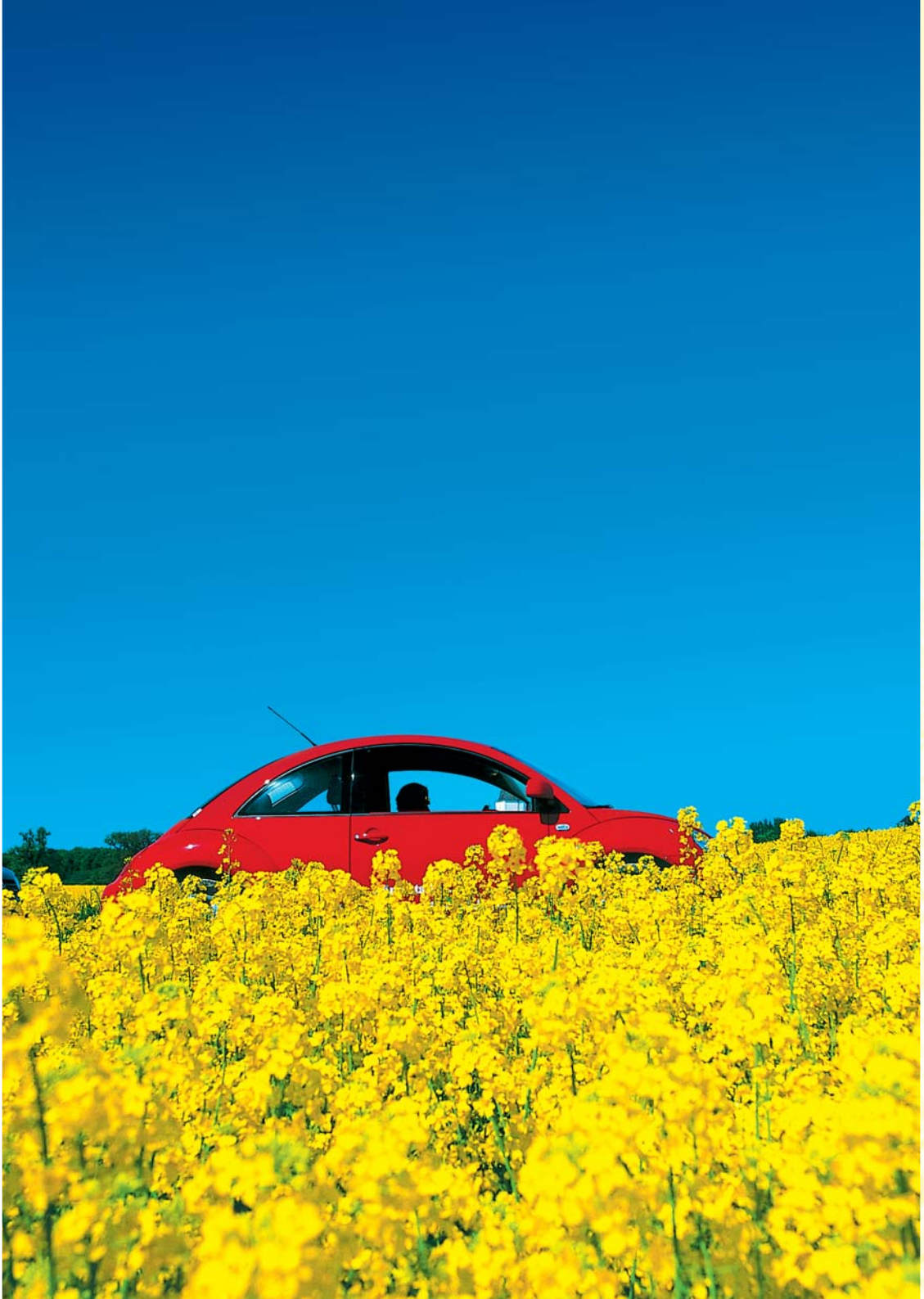
This brochure provides an overview of the technical background, environmental advantages, restrictions and perspectives of biodiesel.

The information on the following pages is based on research reports and studies and on over ten years of experience by the "Union zur Förderung von Oel- und Proteinpflanzen e. V."* (UFOP) with this alternative fuel. Further information and the sources of the material presented here is to be found at our Internet site:

WWW.UFOP.DE



* Union for the Promotion of Oil and Protein-bearing Plants



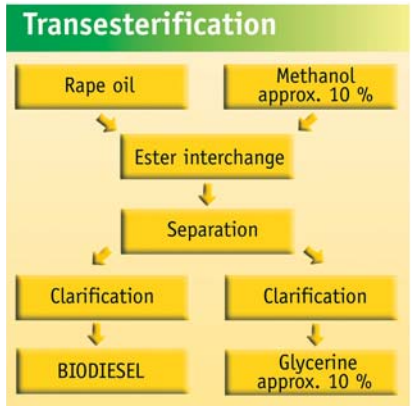
Flower Power

Biodiesel is genuine Flower Power, it is a biogenic fuel or, more precisely, a fuel produced from plants. To be very exact: biodiesel is manufactured from high-quality vegetable oils. Biodiesel manufactured and sold in Germany is nearly always manufactured from the most important indigenous oil-bearing plant – rape. The oil is converted into a modern diesel fuel with flow and combustion properties very closely approximating those of conventional mineral fuels by a simple rebuilding process of its molecular chains.

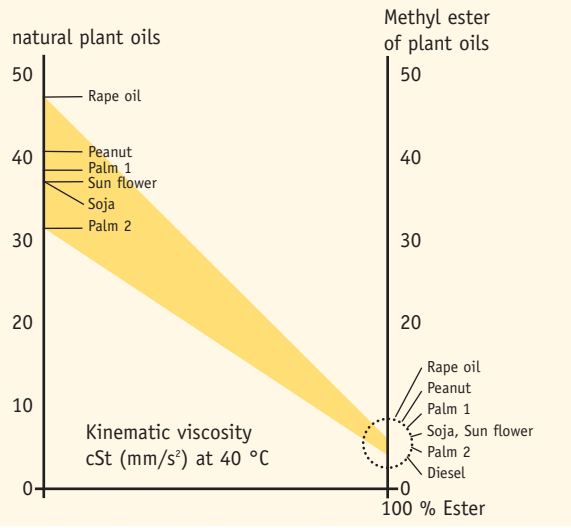
Biodiesel thereby fulfils the highest requirements of engine technology such as the modern high-pressure fuel injection systems (Common Rail).

Manufacture

The manufacture of a high-performance biodiesel from pure vegetable oil, a so-called ester interchange process is necessary. Oil and lipid molecules of both vegetable and animal fats always have the same structure. They consist of so-called triglycerides, a compound of the trivalent alcohol glycerine with three fatty acids.



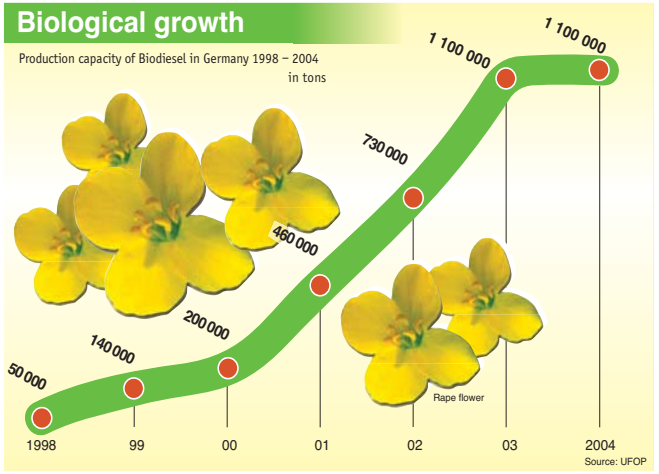
Improvement of viscosity of plant oils by transesterification



In addition to the vegetable oil, methanol (formerly called wood alcohol) is necessary to manufacture biodiesel. Methanol can be manufactured by the alcoholic fermentation of regenerative raw materials (starch or sugar). However, methanol is still produced from natural gas for economic reasons.

The reaction of vegetable oil with methanol in a ratio of around 9:1 by weight in the presence of a small quantity of an alkaline catalyst (for example 0.5 % to 1 % sodium hydroxide, potassium hydroxide or potassium methylate) occurs at 50 to 80 °C under normal pressure in a mixing machine. The glycerine of the vegetable oil molecule is detached from its three fatty acids and is replaced by three methanol molecules. The result is a fuel with flow properties (viscosity) approximating that of diesel fuel, which is prerequisite to its use in modern fuel injection pump systems and diesel engines. The produced glycerine is used largely as a raw material in the chemicals industry.

Biological growth

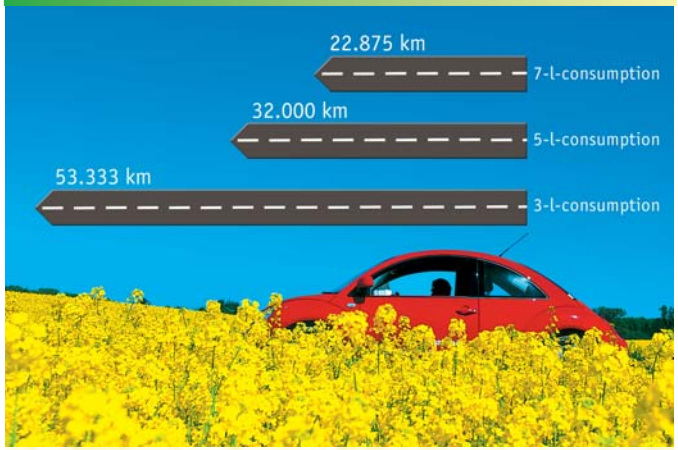


The production of biodiesel, as it is executed in Germany by around 20 companies with a total capacity of over 1 million tonnes per annum, is therefore practically waste-free, as the meal produced in the processing of rapeseed is displacing imported soy meal as a high-quality protein-bearing fodder. High-quality natural raw materials are refined without losses into environmentally friendly energy, chemicals and raw materials for fodder. These aspects largely determine the ecological balance of biodiesel (see Page 29).

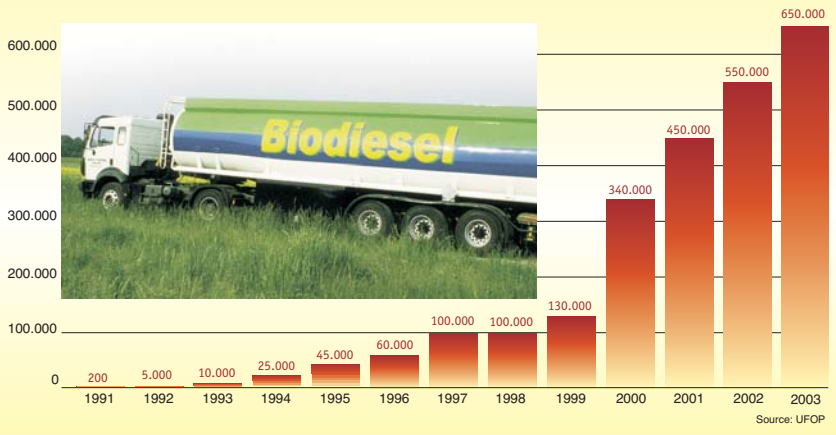
The concept of Biodiesel

Biodiesel constitutes an easily handled fuel with a high energy density, comparable with that of mineral oil and substantially higher than natural gas or hydrogen. Biodiesel can already be employed in a thermal engine such as a diesel engine economically and highly efficiently for mobile applications. Biodiesel, which is sold at over 1,700 filling stations in Germany and Austria, is therefore a genuine alternative to conventional diesel. However, a complete substitution is impossible. It is estimated that five to seven percent of the diesel fuel consumption could be replaced by biodiesel production with indigenous raw materials. 10 percent is conceivable within the European Union. The biogenic fuel biodiesel is therefore now at the peak of

With Biodiesel on tour
1.600 litre / ha of rape



Biodiesel sales in Germany (in tons)



all alternative fuels and, together with other concepts such as hydrogen engines and fuel cell technology, biodiesel will assume a supporting role in the mobility of the future, when the mineral oil wells have run dry.

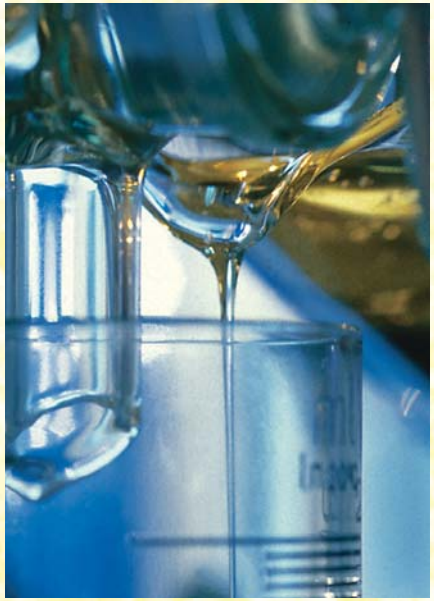
The restriction of the potential quantities results from the requirement of crop rotation of the rapeseed plant. It can only be cultivated economically and within ecological reason every third or fourth year. In contrast with grain or maize, rapeseed is not self-sustaining and monocultures are therefore impossible. Taking account of these requirements, a maximum potential cultivation of approx. 1 million hectares is ecologically achievable in Germany. Increases in the yield of oilseed cultivation and the reduction of the consumption of vehicle fleets is not taken into account in the estimated potentials. With the East European countries entering the EU, the potential area and thereby raw materials in the European Union will increase very significantly. Also, other vegetable

oils can be transformed into biodiesel. In view of the overproduction of agricultural products prevalent in our region, the cultivation of so-called regenerative raw materials for exclusive use in technology and for their energy opens a reasonable alternative to traditional food production for the agricultural industry. Instead of turning agricultural areas into fallow land due to overproduction, they can be used to produce energy. The cultivation of plants for their energy will then not compete with food production, an apprehension often expressed in connection with the discussion of raw materials. These areas will be available at any time according to the demand for food production – in contrast to permanent fallow.

fuel

The fuel of Biodiesel

Biodiesel has a natural lead for its development in comparison with diesel fuel. Its high cetane index, its almost complete lack of sulphur, is significantly higher lubricating capability and its built-in oxygen proportion of around 11 percent make it an intrinsically modern hi-tech fuel.
An overview of these and other important properties of biodiesel:



High cetane index

The cetane index is a measure of the inflammability of diesel fuel. Cetane is a long-chained hydrocarbon with 16 carbon atoms and ignites particularly well under the influence of high temperatures and high pressure without requiring an igniting flame or spark. It is therefore an ideal fuel for diesel engines. A cetane index of 100 designates a reference fuel. The higher the cetane index of a diesel fuel, the better the ignition and combustion and the more regular and smoother the engine runs. Commonly available diesel fuels have a cetane index of 50 to 52, and values of 53 to 54 are achieved by the addition of ignition accelerators. In this, biodiesel has a natural advantage. Its primary components are similar to cetane and this fuel therefore has a natural cetane index of 56 to 58 and can easily fulfil the requirements of engine manufacturers for high-quality fuels with high inflammability without additives.

Practically free of sulphur

Whereas the sulphur content of low-sulphur diesel fuel is reduced in the refinery in a high-energy process with additional CO_2 emission and a loss of the intrinsic lubricating capability, biodiesel is naturally almost free of sulphur (max. 0.001 percent and thereby at the limit of its detectability).

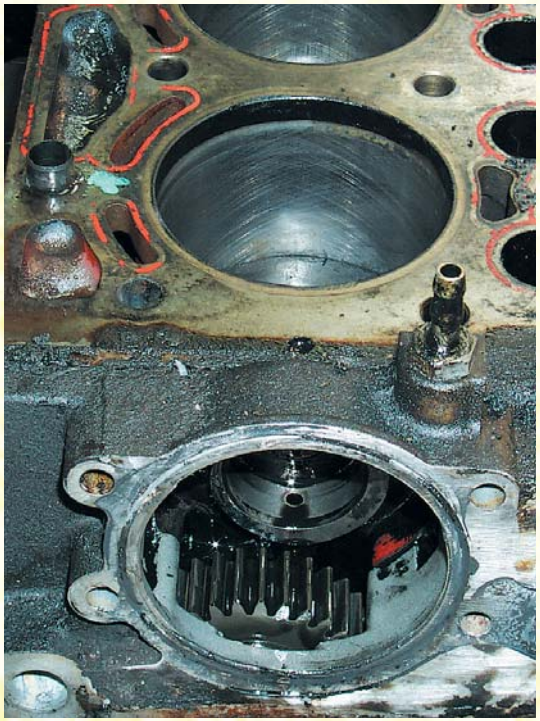
This characteristic of biodiesel also allows the simple and optimum use of an oxidation catalytic converter.

Clean combustion

The biodiesel molecule contains around 11 percent of oxygen. This oxygen contingent leads to an improved combustion and thereby to substantially less soot. The residues left inside the engine by the fuel are significantly reduced.

Lubrication capability and reduction of wear

Biodiesel has a very good intrinsic lubrication capability. Trials have shown that biodiesel lies far below the values specified in the standard for mineral oil diesel. The so-called HFRR value is a measure of the lubrication capability. In general, the lower the HFRR value, the better the fuel. Highly desulphurised mineral oil diesel fuel has an HFRR value of 500 or higher without additives, but the limit specified by the standard for diesel fuel is 450. Mineral oil diesel fuel therefore requires additives. In contrast, the HFRR value of biodiesel is approx. 200. Biodiesel is therefore suitable as a good lubricating additive to conventional diesel when added in proportions of only 1 percent. In the operation of an engine approved for biodiesel, the engine wear is significantly reduced. This is confirmed by the picture of a diesel engine shown adjacent. **After approx. 15,000 service hours, the honing is still perceptible.**



Fuel stability

One great environmental advantage of biodiesel is its rapid biodegradability. However, this advantage requires particular attention regarding the stability of the fuel. If biodiesel is exposed to a specific “oxidation stress”, i.e. high temperatures and frequent contact with (atmospheric) oxygen, or the influences of UV radiation or contact with non-ferrous metals, it ages faster than conventional diesel. In this case, the double bonds in the fatty acids of the biodiesel are broken and they react with oxygen. That is the starting point for the polymerisation of the fuel, i.e. long-chained molecules form which thicken the fuel and lead to blockages in the injection pumps and filters. To completely prevent this effect, which occurs only under extreme conditions, environmentally friendly additives are added during the production of biodiesel, so-called antioxidants. **Biodiesel based on rapeseed oil (RME) has a naturally high resistance to oxidation. This must be preserved for as long as possible.** A positive side effect: this also improves the storage stability and thereby the storage capability.

Water content

Another factor which can have a destabilising effect on biodiesel is the presence of water. Because biodiesel has hygroscopic properties and actually attracts water, the biodiesel manufacturers pay particular attention to ensure a very low water content. At the same time, this property means that the buffer capacity or the capability of binding water is significantly higher than that of diesel fuel. The occurrence of free water is therefore substantially reduced. Although it is biologically degradable, biodiesel therefore denies micro-organisms the basis for their development due to this property. Misgivings of bacterial growth in the biodiesel tank or in fuel-bearing vehicle components are therefore unjustified.

Winter capability

It is generally applicable that biodiesel must be suitable for use in winter to temperatures of –20 °C (measured as the CFPP value) in the same way as mineral oil diesel. Both fuels receive additives to ensure this. Otherwise, an irreversible flocculation (production of paraffins) occurs in diesel fuel, which blocks the fuel lines, injection pump etc. If this happens, expensive cleaning is necessary. In contrast, biodiesel is only thickened which, in contrast to the paraffin precipitation of mineral oil diesel fuel, is reversible. When the temperature rises, biodiesel returns to a thinner state and it is unnecessary to clean the fuel system. Biodiesel on the basis of rapeseed oil has a CFPP value of approx. –10 to –12 °C without additives as a result of its raw materials.

Other additives

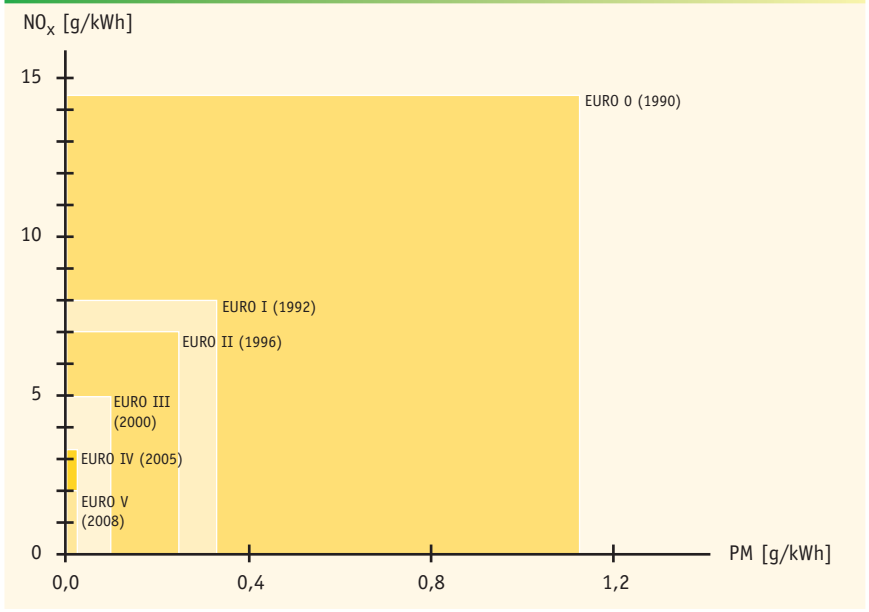
A series of additives are used in mineral diesel fuel to achieve specific properties of the fuel. There are also properties (winter capability, oxidation stability) of biodiesel which can be improved with additives, but an "additive package" as those mixed with conventional diesel is unnecessary for biodiesel. In this relation, the use of biocides is often discussed because biodiesel is quickly biodegradable. However, these toxic additives are unnecessary because water is necessary for bacterial growth. In contrast to conventional diesel, biodiesel is hygroscopic. Water is absorbed at a molecular level by biodiesel, which prevents all bacterial growth. Practical and analytical results confirm that this quality parameter can be upheld through the entire marketing chain to the end customer. Due to the necessary repetitive alternation between summer and winter qualities, the issue of the water content does not arise in practice.

Mixing with mineral oil diesel

Although the density of biodiesel is slightly different from that of mineral diesel fuel, both fuels can be mixed in any ratio due to their similar chemical structure. The mixture is stable and cannot be separated by mechanical methods. It is therefore also impossible to extract biodiesel which has escaped to the engine oil with partial flow filters.

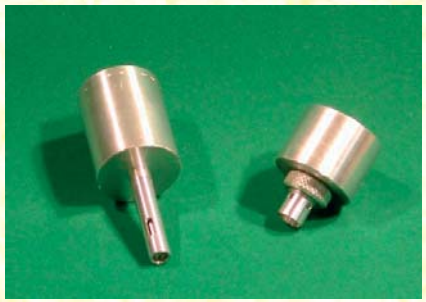
The subject of mixing will have more importance in the future in view of the more stringent emission requirements of the EURO IV (2005) and EURO V (2008) standards. Due to the different emission effects, it will be necessary for new vehicles to detect whether biodiesel or a diesel/biodiesel mixture is in the tank. With the aid of the biodiesel manufacturers and UFOP and

NO_x/Particle mass limit values for utility vehicles



in co-operation with Volkswagen AG, a sensor has been developed which informs the engine management system of the respective ratio of diesel and biodiesel in the fuel tank. This makes it possible to control the injection point and rate to a value most favourable to optimise reduced emission, an optimum solution to fully exploit the potential emission reduction

A-sample of the future series-type sensor with temperature measurement (and calibration curve)
Source: VDI-Berichte (2003)



Two prototypes of the fuel sensor (screw-in versions)

of biodiesel in the future despite the constantly increasing requirements.

Combustion odour of Biodiesel

The typical odour reminiscent of chips occurring during the combustion of biodiesel is produced mainly when the engine is cold or in vehicles without oxidation catalytic converters. The components which cause the odour are unburnt or only partially burnt hydrocarbon compounds. However, the catalytic converters which are standard in new cars break down these compounds efficiently. Particularly the low sulphur content of biodiesel leads to a much improved conversion of toxic substances in the catalytic converter.

Higher consumption with Biodiesel

Due to the lower specific energy content of biodiesel, a slightly higher consumption must be anticipated. However, in practical operation, this is significantly less than indicated by formal calculations because other favourable parameters of biodiesel allow a more efficient operation of the engine. In fleet trials, consumption rates 0 to 5 percent higher than with the use of diesel fuel were determined. It must also be noted that the engines were optimised for the use of diesel fuel.

Safety aspect flashpoint

Biodiesel compliant with DIN EN 14124 has a flashpoint of over 110 °C and other properties which indicate a lower potential hazard. For this reason, it is not a hazardous material and its handling is not subject to the operational safety rules. This is a great advantage over mineral oil diesel in storage and handling. Refuelling of utility machines from canisters in road construction, forestry or in leisure sailing is therefore much safer. The same applies to storage and transport in these environmentally sensitive areas.

Observation of approvals and information

Engine manufacturers are particularly important in the assessment of biodiesel fuel. Without the approval of various manufacturers, the success of biodiesel would be impossible. There is a very large number of approved biodiesel vehicles in Germany particularly because of the efforts of VOLKSWAGEN and its subsidiaries AUDI, SEAT and SKODA. Nearly all diesel models of these manufacturers sold since 1996 are designed to allow them to run on both conventional diesel and biodiesel. Other car and utility vehicle manufacturers such as DaimlerChrysler and MAN have designed individual series for use with biodiesel and determine the sales of biodiesel in the utility vehicle sector by granting their approval.

Because biodiesel has some of the properties of solvents, it can cause damage to the materials of unsuitable synthetic and rubber components in the fuel systems of vehicles. The manufacturers have overcome this in their approved vehicles by changing to resistant materials.

Biodiesel should therefore only be used in vehicles which have a corresponding approval. In doubt, the manufacturer or importer should be consulted. The positive side effect of these inquiries is the connected documentation of the demand for approved vehicles. However, numerous manufacturers are still sceptical on the subject of biodiesel, although it has been proved millions of times that a change to biodiesel-resistant fuel lines and seals can be conducted economically and safely.

A current overview of the granted approvals by vehicle and engine manufacturers is available in the Internet at WWW.UFOP.DE.

Biodiesel handling rules

Several items must be observed in the practical use of biodiesel to guarantee permanently smooth operation.

1. It may be necessary to change the fuel filter when changing to biodiesel after a long period in which mineral oil diesel only has been used. Because biodiesel acts as a solvent, residues of the diesel fuel can be released and block the filter.

2. For the same reason, surfaces which come into contact the biodiesel should be wiped clean immediately as also for conventional diesel.

3. If biodiesel is used in non-approved vehicles, some rubber and synthetic materials can be damaged under certain circumstances after longer usage. For example, it is possible that fuel hoses will swell. This can be remedied with hoses made of fluorinated rubber, which are standard fittings in approved vehicles. Your authorised garage can provide information on the type of the employed materials.

A regular inspection of the fuel system and replacement of the affected materials if necessary can be conducted quickly and economically.

4. The oil change intervals should be upheld as specified by the manufacturer. Regarding the employed engine oil, it is possible that the engine oil of utility vehicles will become diluted with fuel. However, this only usually occurs when the engine runs at low loads for longer periods.

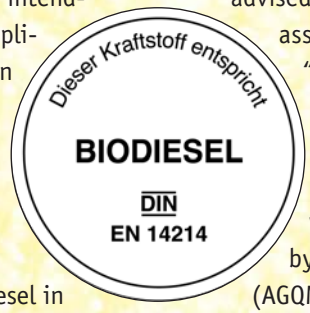
Biodiesel standard

With the development of the European standard DIN EN 14214, the minimum requirements on the quality of biodiesel were specified mutually at a European level by engine manufacturers and the biodiesel industry. The European standard for biodiesel has now become internationally acknowledged and is a guideline for the standardisation activities conducted by other countries. For example, the activities to develop Australian standard requirements are oriented rationally to the requirements of the European standard for biodiesel. The basis for the development of the standard were numerous activities in the development and validation of test methods for the respective quality parameters and numerous investigations into engines by vehicle manufacturers. In view of the necessary approvals for the use of biodiesel as a pure fuel and also for its use as an additive to diesel fuel, the biodiesel industry should endeavour to specify a world-wide standard similar to the efforts of the vehicle and mineral oil industries to specify the course and objectives of future standardisation activities for fossil fuels in the so-called World Fuel Charter.

However, the development of an obligatory quality standard for biodiesel also has legal consequences in the case of complaints against the fuel. Compliance with the European standard for biodiesel throughout the chain from the biodiesel manufacturer to the filling station is a prerequisite to the reliable operation of vehicles. In the case that evidence can be provided against a culprit of deviation from these parameters, this will lead to corresponding liability claims from the damaged party.

■ Fuel quality and marking ordinance (10. BImSchV)

The European standard for biodiesel was adopted in 2004 in the German fuel quality and marking ordinance (10. BImSchV). Public filling stations are thereby obliged to declare the minimum quality by markings on the fuel pump. For consumer protection purposes, the ordinance is intended to ensure that the supplier, or the filling station owner, is obliged to assure and provide the customer with the minimum quality specified by the standard.



With the adoption of biodiesel in this ordinance, biodiesel has become the first biological fuel amongst the so-called commonly traded fuels and is therefore subject, as all other fuels, to unannounced inspections by the responsible regional authorities.

Apart from the "Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e.V." (AGQM, German Workgroup for Biodiesel Quality Management), the authorities of the German federal states will also make unannounced examinations of the quality of biodiesel at public filling stations and the pressure created by the inspections is increasing to the benefit of the consumer.

A corresponding adjustment of the granted approvals is also being conducted by the automotive industry. In the future, vehicles will be approved for exclusive operation with biodiesel compliant with the European standard. Filling stations are therefore well advised to adopt the quality assurance system of the "Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e.V." and only to procure biodiesel whose quality is assured by a purchase contract (AGQM address, see Page 39).

Important requirements and test procedures of DIN EN 14214

Characteristics	Units	Limit values		Test procedures
		Min.	Max.	
Ester	% (m/m)	96.5		pr EN 14103
Density at 15 °C	kg/m³	860	900	EN ISO 3675 EN ISO 12185
Kinematic viscosity at 40 °C	mm²/s	3.5	5.0	EN ISO 3104
Flash point	°C	> 120		ISO/CD 3679
Sulphur content	mg/kg		10	
Carbon residue (from 10 % of distillation residue)	% (m/m)		0.3	EN ISO 10370
Cetane index		51.0		EN ISO 5165
Ash (sulphurous ash)	% (m/m)		0.02	ISO 3987
Water content	mg/kg		500	EN ISO 12937
Total pollution	mg/kg		24	EN 12662
Corrosive effect on copper (3 h at 50 °C)	corrosion grade	1		DIN ISO 2160
Thermal stability				
Oxidation stability, 110 °C	hours	6.0		pr EN 14112
Acid number	mg KOH/g		0.5	pr EN 14104
Iodine number			120	pr EN 14111
Content of Linolenic-Acid-Methylester	% (m/m)		12	pr EN 14103
Content of fatty acid-methyl esters with more than 3 double bonds	% (m/m)		1	
Methanol content	% (m/m)		0.2	pr EN 14110
Monoglyceride	% (m/m)		0.8	pr EN 14105
Diglyceride	% (m/m)		0.2	pr EN 14105
Triglyceride	% (m/m)		0.2	pr EN 14105
Free glycerine	% (m/m)		0.02	pr EN 14105 pr EN 14105
Total glycerine	% (m/m)		0.25	pr EN 14105
Alkali content (Na + K)	mg/kg		5	pr EN 14108 pr EN 14109
Phosphorous content	mg/kg		10	pr EN 14107

quality

Quality assurance

The customer satisfaction of biodiesel users is just as important as approval by the manufacturers of vehicles and engines. For this reason, the leading manufacturers and distributors of biodiesel in Germany and Austria have amalgamated in the "Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V." (AGQM) (Workgroup for Biodiesel Quality Assurance). Compliance with the mandatory standard and additional voluntary quality criteria and requirements are ensured by an extensive quality management system extending from the raw material to the tank of the biodiesel customer.

In Germany, the network of public filling stations encompasses around 17,000 stations. About every tenth, or over 1,700 filling stations now offer biodiesel. Biodiesel is thereby the first alternative fuel to be offered practically nation-wide at public filling stations. Apart from cars, HGVs can also be filled at most filling stations.

Of approximately 1,700 biodiesel filling stations, over 1,300 stations have adopted the AGQM quality assurance system under a brand licence contract since the system was introduced. The owners of these filling stations have pledged to comply with the standards and requirements of the AGQM. This also includes a mutual pledge that only biodiesel based on rapeseed oil methyl ester will be offered for sale at public filling stations. This is due to the fact that several vehicle manufacturers only approve rapeseed methyl ester (RME) for operation with biodiesel. The pumps of the participating filling stations are marked with a special symbol showing a yellow drop in a green "Q". This indicates to all customers that the filling station offers exclusively quality-assured

biodiesel. When looking for filling stations, biodiesel drivers can access a constantly updated Internet database. Apart from the addresses, other helpful information is available at WWW.UFOP.DE and WWW.AGQM-BIODIESEL.DE as well as the opening times, methods of payment and distances to nearby motorway exits. It is also indicated whether the listed biodiesel filling stations are participants in the extensive quality management system of the AGQM.

If deviations from the required standard are found during inspections at a filling station, the owner is immediately required to rectify the deficiency. Otherwise, the membership symbol may be withdrawn.

aspects

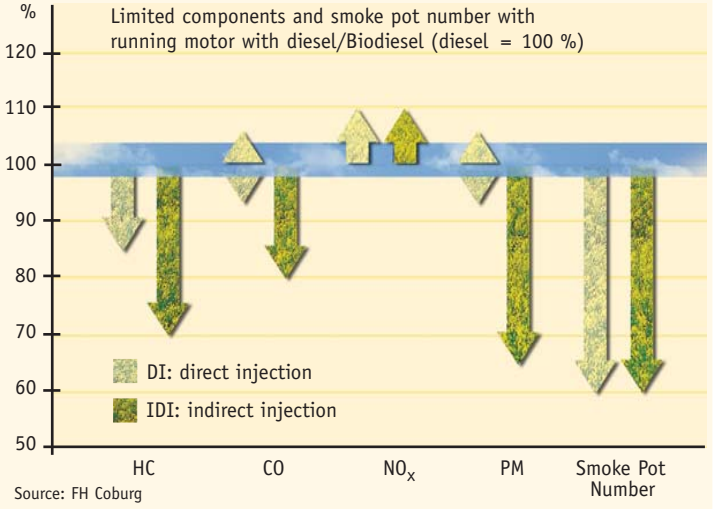
Environmental aspects

Apart from all the technical advantages and features of biodiesel, there is another more significant aspect in its favour: its environmental friendliness. Biodiesel and its use are the origin of local and global effects. Its rapid biodegradability and its almost closed CO_2 cycle set out the enormous bandwidth of its ecological value.

Comparison of emission

Numerous independent institutes have now confirmed the advantages of the emission from biodiesel in comparison with conventional diesel. For example, when biodiesel is used with a catalytic converter, only one third of the quantity of particles is emitted in comparison with low-sulphur diesel fuel. Unburnt hydrocarbons are also reduced. Only slightly higher NOx values have been noted when biodiesel is used.

Relative Emission Values



Source: FH Coburg

However, this increase, which is caused by the higher combustion temperature of biodiesel, is an effect not typical of the fuel, but of the engine. By adapting the engine management system in conjunction with sensor technology (EURO IV and V) it is possible to avoid this increase.

The particle and soot components of biodiesel exhaust gases also differ significantly from those of mineral oil diesel fuel. They are grey instead of black (with mineral oil) and have a more greasy consistency. They have a much higher soluble content and can therefore be more easily broken down in catalytic converters. Although the particles are smaller than those of conventional diesel, it has been shown that their carcinogenic and genetically damaging effects are lower.

Biodegradability

Methyl esters are now employed in large quantities in the production of washing powders. This example demonstrates that high requirements are made on the biodegradability of methyl ester (sewage plants). The Commission for the Assessment of Water-endangering Substances (KBWS), for which the Federal Environmental Authority is responsible, has had biodiesel on the basis of rapeseed oil tested to determine its effects on the environment and, as a result, has classified it as weakly water-endangering and thereby in the water endangerment class (WGK) 1. In contrast, mineral oil diesel fuel is classified as water-endangering and thereby in WGK 2. Biodiesel is rapidly biodegradable. It has been demonstrated that biodiesel is biologically degraded by over 98 % within 21 days whereas mineral oil diesel fuel is degraded by only 70 %. The favourable behaviour of biodiesel in comparison with mineral oil is shown by an example which unfortunately became highly topical in Spain in winter 2002/2003. Biodiesel is excellently suitable for cleaning beaches and coastal regions which have been contaminated with mineral oil.

Biodiesel is non-toxic

If biodiesel escapes unintentionally to the environment during its use, organisms are hardly damaged. In a major trial of the use of biodiesel in the diesel engines of leisure boats on Lake Constance, biodiesel proved its practical suitability and its environmental compatibility. Lake Constance is the largest drinking water reservoir in Europe. For this reason, strict rules already apply there to the use of fuels.

Emission of nitrous oxide during rapeseed cultivation?

In relation to the ecological balance of biodiesel, the side effect of rapeseed cultivation on the climate, the presumed nitrous oxide emission or the release of N_2O during rapeseed cultivation, has been and is still criticised. This argument was refuted in 1996 by an extensive extra-institutional study of the Federal Research Institute for Agriculture at Braunschweig-Völkenrode. For the first time, the actual nitrous oxide emission during

the cultivation of rapeseed was compared with that of fallow land in a sequence of several crops.

Germany has the most productive agricultural regions world-wide and thereby the most fertile soil. Today's high agricultural yield is due to the decades and even centuries of humus-enriching agricultural methods. This means that, if nitrous oxide is released to the atmosphere or nitrates to the ground water, it cannot be determined whether the nitrogen originates from fertilisers or from the organic components of the soil. This is a process which depends on the location (soil type) and the temperature (season).

It is therefore the objective of suitable fertilising for the location to supplement the nutrient supply to the cultivated species such that only the lacking elements are covered according to the course of growth. The nitrogen potential already existing in the soil and available to the plants is taken into account. **The study by the Federal Research Institute came to the conclusion "that areas taken abruptly and temporarily out of food production are not responsible for the reproaches of N_2O emission, the fallow areas emit almost the same quantities of N_2O without rapeseed cultivation and without fertilisation".**

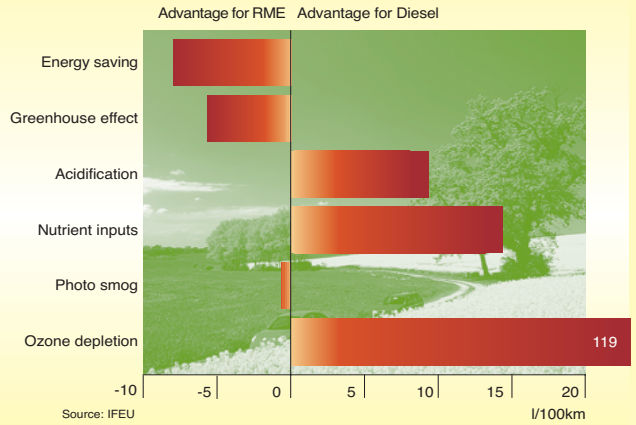
The shifting fallow areas in crop rotation reduce surplus food production and make it possible for the agricultural industry to revert to food production at any time if the conditions on the agricultural market change.

balance

Environmental balance

Since biodiesel became a serious alternative, there have been intensive discussions of the pros and cons of its use. Important aspects such as the material balance, the energy and CO_2 balance have been extensively analysed. Balances of this kind attempt to make a general and conclusive assessment of a material. This assessment, regardless of whether the use of biodiesel is good or bad, depends on the factors for the different balance calculation parameters used in the assessment. Global protection of the climate and resources is particularly important to many people and governments and the EU Commission promotes biological fuels mainly for this

Comparison RME and Diesel



Example how to interpret the top two bars in the diagram: The top two bars in this diagram indicate the results of energy saving and greenhouse effect for the comparison between RME and conventional diesel fuel for the basic scenario. If RME is used instead of diesel fuel on a distance of 100 km the amount of energy saved equals the amount of energy required to produce 8 litres of diesel fuel and the amount of greenhouse gases saved equals the amount of greenhouse gases emitted due to the production and consumption of 6 litres of diesel fuel. Converted into a different unit approximately 2.2 kg CO_2 equivalents can be saved for each litre of RME used.

reason. The member states have laid down quantitative targets for the share of biological fuels in the fuel market for the period 2005 to 2010. The local effects of environmental contamination and the quality of the air in city centres is also important. Accordingly, the relevant parameters are factorised higher.

Material balance

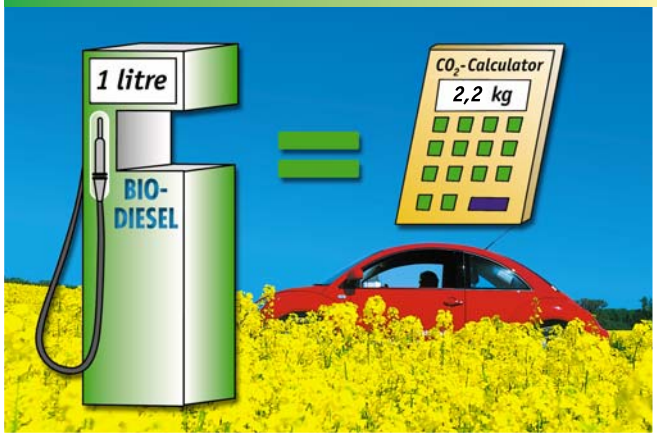
One form of balance calculation is conducted in relation to the flow of materials in the biodiesel chain: the rapeseed is processed in the oil mill to oil and rape meal, the latter displaces imported soy meal as fodder. The raw material rapeseed oil gained in this way is used to manufacture biodiesel in the biodiesel plant by rapeseed oil/methyl ester transformation (RME).

Glycerine is produced as a side by-product. Viewing the entire chain, there are increments in the balance calculation by fertilisers from catalytic converter deposits, biodiesel, glycerine, rapeseed meal and rape straw. Decrements in the balance are the methanol and potassium hydroxide required for the ester transformation and for the energy. The latter is used as a fertiliser after being neutralised. In the final purification of the end product, excess methanol is recovered and returned to the process. Also, the required water is returned to use for as long as possible. The production of biodiesel incurs practically no waste materials. All by-products are used.

Energy balance and CO_2-Balance

For this, it is important to determine what biodiesel is to be compared with. The production of mineral oil diesel fuel from fossil oil is usually taken for the comparison.

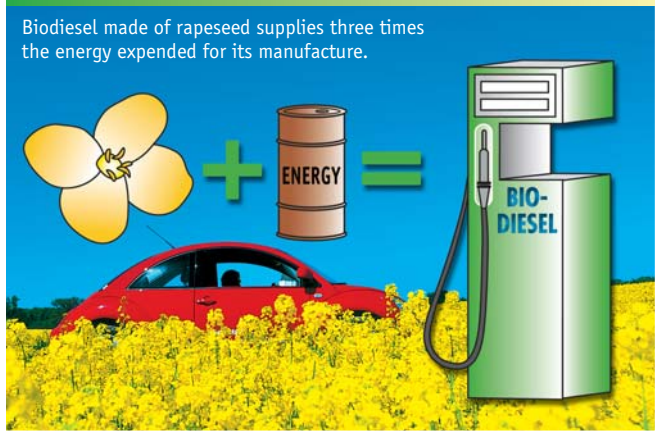
Climate protection through Biodiesel



The fundamental advantage of all regenerative energy sources is their almost completely closed CO_2 cycle. CO_2 is released in all combustion processes. However, the CO_2 produced in the combustion of biodiesel has been absorbed beforehand from the atmosphere by the rape plant during the photosynthesis process. In contrast to the use of fossil fuels, the combustion of biodiesel does not make a new addition.

Biodiesel with a positive energy balance

Biodiesel made of rapeseed supplies three times the energy expended for its manufacture.



In this way, every litre of biodiesel which replaces fossil diesel reduces the greenhouse effect. The atmosphere is not enriched with excess CO_2.

The energy aspect produces the following appraisal: to make mineral oil diesel fuel available, it is firstly necessary to expend energy, which is largely generated by combustion processes and therefore also releases CO_2 and other greenhouse effect gases.

For fossil diesel, mineral oil production, transport and refining must also be taken into account. The corresponding expenditures must also be taken into account for regenerative sources of energy. For biodiesel, these are cultivation, oil extraction, ester transformation and transport. In general, the entire chain to the consumer or fuel pump.

Vegetable oil and Biodiesel

Apart from biodiesel, pure non-ester transformed rapeseed oil is also suitable as a fuel. However, in contrast to biodiesel, the use of this native vegetable oil is only possible to a certain extent in conventional diesel engines. Unlike biodiesel, in which the vegetable oil is adapted to the engine, the engine must be adapted to the fuel if pure vegetable oil is to be used.

The properties of vegetable oils deviate too widely from those of standardised diesel fuel (viscosity, combustion properties etc). Combustion therefore leads to heavy deposits which practically prohibit use in conventional diesel engines. Only special engines or engines rebuilt for use with vegetable oil can use native vegetable oils as the driving energy for a long term without causing problems. However, this is also conditional on the vegetable oil branch agreeing on a standard for the fuel quality and combining this with a quality assurance system. The first initiatives to this end should be supported by all participants so that the development of vegetable oil technology is conducted correctly and responsibly. Product liability in relation to the quality of the fuel and the available engine and rebuilding concepts are important factors which must be observed.

Other problems are the restricted winter capability and the fact that vegetable oil engines cannot usually comply with the increasingly strict exhaust gas regulations applicable in traffic due to their rudimentary state of development. However, it cannot be denied that future developments in engine construction will open new potentials for the use of native vegetable oils, as the major advantage of biodiesel also applies to pure vegetable oil: these oil wells will never run dry.

Recommended reading:

Optimierungspotenziale und Umwelteffekte
Erste Internationale Tagung Biodiesel: Landbauforschung Völkenrode, Sonderheft 119 (1998)
Bundesforschungsanstalt für Landwirtschaft, Bundesallee 50, 38116 Braunschweig

Biodiesel – Potenziale, Umweltwirkungen, Praxiserfahrungen
Zweite Internationale Tagung Biodiesel; Landbauforschung Völkenrode, Sonderheft 239 (2002)

Rapsölmethylester in dieselmotorischer Verbrennung – Emissionen, Umwelteffekte, Optimierungspotenziale, Professor Dr. Jürgen Krahl
Landbauforschung Völkenrode, Sonderheft 233, ISBN3-933140-49-8

Untersuchung von Biodiesel und seinen Gemischen mit fossilem Dieselkraftstoff auf limitierte Emissionen (2003), Abschlussbericht zum Forschungsvorhaben
Institut für Technologie und Biosystemtechnik, Bundesforschungsanstalt für Landwirtschaft, Braunschweig-Völkenrode

Systematische Untersuchungen der Emissionen aus der motorischen Verbrennung von RME, MK 1 und DK (2003)
Landbauforschung Völkenrode, Sonderheft 252, ISBN 3-933140-74-9

Erkennung des RME-Betriebes mittels eines Biodiesel-Kraftstoffsensors
Landbauforschung Völkenrode, Sonderheft 257, ISBN 3-933140-79-X (2003)

Motoruntersuchungen mit Abgasnachbehandlungssystemen
Institut für Maschinenmesstechnik und Kolbenmaschinen, Universität Magdeburg

Life Cycle Assessment of Biodiesel: Update and New Aspects
Institute for Energy and Environmental Research Heidelberg GmbH (ifeu),
Wilckenstraße 3, 69120 Heidelberg

Macroeconomic evaluation of rape cultivation for biodiesel production in Germany. Preliminary report from ifo Schnelldienst No. 6
ifo-Institut für Wirtschaftsforschung, Poschinger Str. 5, 81679 München

Munack A, Krahl J, Marto A, Bantzhaff R (2003) Basic research on a sensor for detection of biodiesel and development of prototypes as well as mass production. VDI-Berichte 1798:331-336

Publications by UFOP:

Aussagen der Fahrzeughersteller

AGQM Biodiesel-Tankstellen und Großbezugsmöglichkeiten in Deutschland und Österreich

4 Jahre Einsatzerfahrung mit Biodiesel und Biohydraulikölen in einem Forstwirtschaftsbetrieb

Rapsöl als Kraftstoff?! – Informationen über den Einsatz von naturbelassenem Rapsöl

Nachwachsende Energien (DBV-Sonderdruck)

Projektbericht: Biodiesel & Sportschifffahrt in der Euregio Bodensee

Handbuch zur Umrüstung von Sportbooten für den Betrieb mit Biodiesel

Growth Market Biodiesel 2003

Biodiesel in bus fleets: Experience of Kreiswerke Heinsberg und Stadtwerke Neuwied

Further information on the subject of BIODIESEL:

UFOP • Union zur Förderung von Oel- und Proteinpflanzen e. V.
Reinhardtstraße 18 • 10117 Berlin • www.ufop.de

AGQM • Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V.
Reinhardtstraße 18 • 10117 Berlin • www.agqm-biodiesel.de

VDB • Verband Deutscher Biodieselhersteller
Am Weidendamm 1 a · 10117 Berlin · www.biodieselverband.de

The fuel market is moving.

Increasing prices and environmental consciousness are making alternatives to conventional fuels more and more interesting.

As the most successful alternative fuel, biodiesel has already occupied a permanent place at Germany's filling stations. Over 1,700 filling stations now offer the environmentally friendly fuel biodiesel, manufactured from rapeseed oil and methanol.

This brochure provides a fundamental overview of the technical background, environmental advantages, restrictions and perspectives of biodiesel.

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