Biodiesel as an alternative motor fuel

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Alternative motor fuels are considered to be one way of reducing the growing pressure from traffic on environmental and energy demands. They could create an alternative for the classic fossil fuels such as petrol, resources of which will be depleted in a few decades. A promising example of an alternative fuel that is currently ready for introduction, is biodiesel.

Biodiesel as a fuel can be derived from vegetable oils such as rapeseed oil, sunflower oil, palm oil or soybean oil. This means that it is a renewable fuel, unlike the traditional fossil fuels.

In order to obtain a high fuel quality, the vegetable oil undergoes a chemical reaction with methanol. The result is biodiesel, a methyl ester, such as rapeseed methyl ester (RME) or used vegetable oil methyl ester (UVOME). Biodiesel has fuel properties comparable to mineral diesel (see **Table 1**).

Because of the great similarity, biodiesel can be mixed with mineral diesel and used in standard diesel engines. Very few technical adjustments are necessary. So from a technical point of view, biodiesel can be applied almost immediately. Biodiesel is also less harmful to the environment as it is biologically degradable and contains practically no sulphur. Since the base fuel is an agricultural product, all countries have the ability to produce and control this energy source, a situation very different to the crude oil business. This may result in extra local employment, reduced dependence on oil-producing countries and could also be used as a way of stimulating and supporting agriculture. All these factors have led to an increasing number of experiments and demonstration projects concerning biodiesel.

Demonstration projects

In 1994 VITO became involved in the first biodiesel demonstration project. This project was carried out in close cooperation with AVEVE (sales department of the Belgian farmers association). Five cars were used in the project, driving on 100% rapeseed methyl ester (RME). During the two-year project the vehicles were driven more than 300,000 km and no major technical problems were encountered. The only adjustment required was the replacement of some rubber parts in the fuel system. Meanwhile a number of new car models are already being equipped with biodiesel-compatible materials (e.g. Volkswagen, Audi).

Tests showed that the engine performance of the biodiesel vehicles was slightly lower, though most drivers did not notice this small difference. Due to the lower calorific value of biodiesel, fuel consumption was slightly higher (approximately 0.5 litre per 100 km). Recalculated as energy, this means that energy efficiency was about the same. Lubricating oil analysis and check-up of the engines after the demonstration showed no additional wear due to the use of biodiesel.

With regard to the environmental aspects, there are certain advantages to using biodiesel. Emission measurements on a chassis dynamometer showed that less particles (approximately 30-70%) were emitted, especially for the vehicles equipped with an oxidation catalyst.

		Biodiesel		Mineral diesel
		RME	UVOME	
Density (15°C)	kg/l	0.878	0.88	0.835
Flash point	°C	111	110	81
Viscosity (40°C)	mm²/s	4.3	4.6	3.1
Cold Filter Plugging Point (CFPP)	°C	-12	-5	-8 (summer) -13 (winter)
Cetane number		48	49	50
Sulphur content	% m/m	0.002	<< 0.01	0.04
Calorific value	kJ/l	32,600	32,100	35,700

Table 1: Fuel properties of biodiesel (RME & UVOME) and mineral diesel.

Figure 1: 'Biodiesel demonstration in Belgium', a cooperation between VITO and AVEVE.

Emissions of the other pollutants (CO, HC, NO_X, CO_2) were similar or slightly lower. As biodiesel contains practically no sulphur, SO_2 emissions are reduced to almost zero. Another very important advantage is the fact that biodiesel is biodegradable.

Figure 2: The first commercial biodiesel production unit from used vegetable oil (UVOME = used vegetable oil methyl ester) is located in Müreck, Austria.

The inhibiting factor to the market introduction of biodiesel is its economic perspective. Unless the government takes serious measures (e.g. a full tax exemption) the price cannot be competitive. Moreover, the potential for biodiesel production from rapeseed is limited in Belgium. If the total area which is currently set aside were to be used for rapeseed production, only 1-2% of the total diesel consumption in Belgium could be replaced by RME. In order to meet the European goal of replacing 5% of the fossil fuels with biofuels by the year 2005, other (less expensive) raw materials should be found.

Waste vegetable oil

One possibility which may have a high potential (particularly in the Benelux) is used frying oil. Frying oil consists of either vegetable oil or animal oil. With the current trend towards healthy food preparation, an increasing amount of vegetable oils are being used for frying food. This is a positive trend where biodiesel is concerned, since biodiesel is preferably produced from vegetable oil.

Legally, waste vegetable oils belong to a special type of waste, called 'vegetable and animal oils and fats'. This waste should be collected and treated separately from other types of waste. In reality only a small amount is collected separately. Most of the oil, particularly waste oil and fats from households, are disposed of with the other domestic waste. The collected oils and fats are mainly used in animal feed or cosmetics. Apart from this, the easiest way of dealing with it is to burn the oil. Other possibilities include the preparation of soaps by hydrolysis or purification and reuse as lubricating oil or hydraulic fluid. The production of diesel fuel from used vegetable oil seems to be a very promising alternative for waste treatment.

UVOME

Most of the experience concerning the use of waste vegetable oil for biodiesel production is situated in Austria. Tests show that the fuel, which is called UVOME (used vegetable oil methyl ester), is comparable to RME in composition, fuel properties, performance and engine emissions.

In 1996 VITO started a second two-year biodiesel demonstration project, to demonstrate UVOME as an alternative fuel for diesel vehicles. The project is being carried out in cooperation with Van Gansewinkel, a

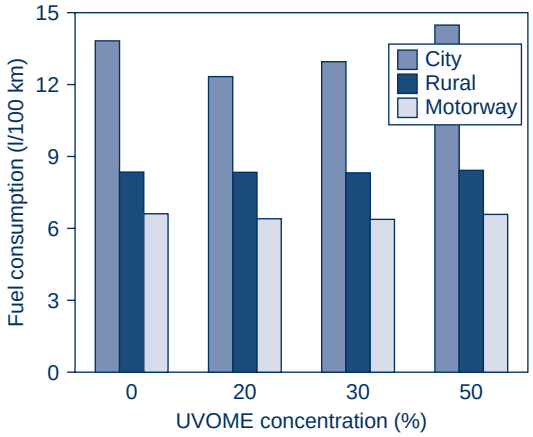
company specialising in waste collection and treatment. The University of Graz, Austria, provides technical advice. As there are currently no production facilities in Belgium, the fuel is produced in a small commercial production unit in Austria (see **Figure 2**).

Five test vehicles were also used for this project: two cars and three refuse lorries. The emphasis now lies on comparing the different blends of diesel fuel and UVOME. The concentration of UVOME in the diesel fuel will gradually be increased during the project. Measurements of emissions and energy consumption are now performed with a system developed at VITO, called 'VOEM' (VITO's on-the-road energy & emission measurement system). The system can be installed inside the vehicle and measurements are performed on the road, i.e. in real traffic conditions. A distinction is made between city driving, rural traffic and motorways.

Although the demonstration period is still ongoing, some preliminary results can be mentioned. Fuel analysis shows that UVOME has fuel properties and composition comparable to RME. After more than one year of the demonstration project, no technical problems have arisen. Measurements on the road, as well as refuelling lists, show no increase (even a small decrease) in fuel consumption for blends with a low UVOME concentration (see **Figure 3**). The same tendency can be seen in engine performance: acceleration tests show that with low UVOME concentrations, no power is lost. Other results will be published once the project has finished.

The current price for UVOME is the same as RME (approximately BEF 40-45 per litre). UVOME is now produced in a very small production unit (see **Figure 2**). Production capacity of the installation is around 800-1,000 tons per year. It is estimated that with large-scale production the price could be reduced to BEF 30-35 per litre. A small tax reduction would make UVOME competitive with mineral diesel (price around BEF 27 per litre).

Figure 3: Measurements with the VOEM system: comparison of the average fuel consumption of an aggressive driver with different UVOME-mineral diesel blends.



Belgium may have a renowned frying tradition, but it is estimated that even with an efficiently organised waste oil collection, UVOME could only replace 3% of the total diesel fuel consumption in Belgium. Added to the potential of RME, this means that the aforementioned European objective (to replace 5% of fossil motor fuels with biofuels by the year 2005) could be achieved.

The demonstration projects, which are financially supported by the European Commission (via the Altener programme) and the Flemish Government (ANRE), play an important role in the introduction of biofuels into society. However political goodwill is essential for the fast introduction of biodiesel, an alternative fuel that is, certainly from a technical point of view, ready for market introduction.

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