State and prospects of the production and use of rapeseed oil fuel in Germany

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Abstract

There is a growing demand on pure rapeseed oil, used as a fuel for adapted automotive and stationary diesel engines in Germany. The main reasons are increasing prices for fossil diesel fuel and heating oil as well as advantageous regulations for biofuels. Today 13 industrial and more than 300 decentralised oil mills produce rapeseed oil, mainly for energetic use in Germany. Oil mill capacities are being extended, a significant scale has been reached already. The demands on quality of rapeseed oil, used as a fuel in compatible diesel engines are defined in the new pre-standard DIN 51605. Quality assurance systems for decentral processed rapeseed oil are being developed and established. In Germany about 50 mainly small sized enterprises offer solutions for the technical adaptation of conventional diesel engines for the use of pure rapeseed oil. Experiences in field tests with rapeseed oil fuelled engines are mostly better than expected. The prior applications for rapeseed oil fuel are niche markets, such as environmental sensitive areas and agricultural machines, due to a limited number of engine types with high numbers of items and the advantage of closed economic and material flow loops.

Key words: cold pressed vegetable oils, rapeseed oil fuel, market implementation

Introduction

There is a growing demand on pure rapeseed oil, used as a fuel for adapted automotive and stationary diesel engines in Germany. Reasons therefore are increasing prices for fossil diesel fuel and heating oil, advantageous regulations for biofuels as well as the public awareness of the excellence of rapeseed oil fuel, regarding environmental impacts and the development of regional markets. However, pure rapeseed oil used as a fuel raises important questions about deficits and chances of extended utilisation.

It is the purpose of this work, to show the state of the art of pure rapeseed oil fuel production and utilisation under German conditions. Based upon these facts prospects for further expansion of rapeseed oil fuel applications in Germany will be deduced.

Comprehensive results of various research works are combined, to show the state of art and need for action. Important data are collected, to show the market relevance of rapeseed oil fuel in Germany and expert discussions are held, to asses the prospects of rapeseed oil fuel.

Results

1. General Framework: Rapeseed oil fuel, which is also known as Pure Plant Oil (PPO) is extracted and purified or refined oil of rapeseed (*Brassica napus*). The difference between rapeseed oil fuel and fatty acid methyl ester (FAME or biodiesel) is, that there is no step of transesterification for rapeseed oil production, which particularly enables decentral production with reasonable costs and low energy demand. Value added in agricultural branch is high, when selling the fuel directly to the user. Furthermore, rapeseed oil fuel has a high biodegradability and a low ecotoxicity, which makes it not hazardous to waters.

Rapeseed is the most important oil crop in Germany, because cultivation of rapeseed is well established in agricultural practice and high oil yields from 1.2 to 1.6 tons per hectare is achieved. Rapeseed oil can be produced in small agricultural production units (decentralised oil mills) and used for many different applications, such as edible oil, lubrication agents or fuel for adapted engines. Important fuel properties, such as cold flow properties and oxidation stability are more favourable for rapeseed oil, than for other plant oils.

Growing winter rapeseed has been extended during the last years and reached an area of about 1.3 million hectares (table 1). The total yield increased to 5 million tons, which is a plus of 23 % compared to the average yield of the last 5 years.

Table 2: Growing and yield of winter rapeseed in Germany

	Unit	2000-2004	2005	Increase
Growing area	1,000 ha	1,184.7	1,323.1	11,7 %
Yield per hectare	tons/ha	3.42	3.78	10,5 %
Total yield	1,000 tons	4,048.7	5,005.0	23.6 %

The presently high demand on rapeseed oil fuel, used in adapted automotive and stationary diesel engines is caused by increasing prices for fossil diesel fuel and heating oil. Fossil fuel prices are high, because of a worldwide increasing demand on fuels with a simultaneous decreasing supply of resources. Biodiesel prices usually follow diesel fuel prices, whereas rapeseed oil fuel prices are connected to the less fluctuating world market prices for plant oils (figure 1).

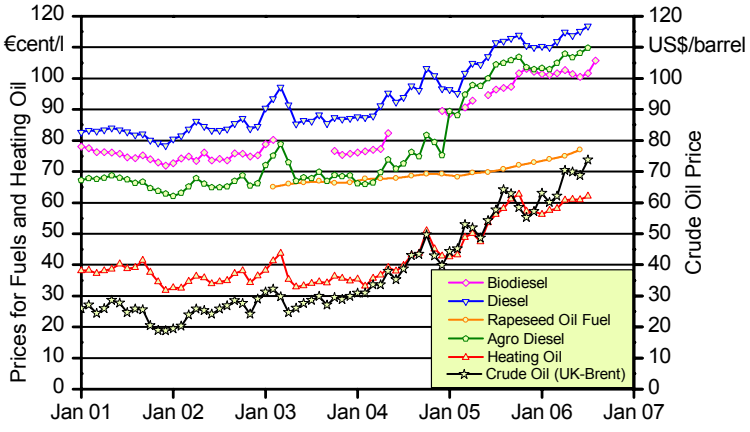

Figure 1: Price development of crude oil and fuels

Apart from the higher prices for fossil fuels, advantageous regulations for biofuels are another reason for their positive development in Germany. The EU directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport (minimum proportion of biofuels by 31st of December 2005: 2 %, by 2010: 5.75 %) and the council directive 2003/96/EC of the 27th of October 2003 on restructuring the community framework for the taxation of energy products and electricity, which enables excise tax reduction on biofuels are building the frame.

The new German "Energy tax law" assures a tax exemption for rapeseed oil fuel until 31.12.2007. Afterwards the fiscal privilege for rapeseed oil fuel will be reduced gradually. Starting from 2008 the tax rate amounts to 0.10 €/litre and will be increased subsequently until 2012 to 0.45 €/litre. Supplementary to these tax rates, vegetable oils which are used as pure biofuels in agriculture and forestry, remain completely exempted from tax. This tax exemption is durably and without any limitation of quantity. Together with a new regulation for agro-diesel fuel, which causes rising fuel costs for farmers, a strong demand for rapeseed oil compatible tractors and machinery can be observed.

2. Production of Rapeseed oil: Today 13 industrial and more than 300 decentralised oil mills produce rapeseed oil, mainly for energetic use in Germany. Processing in industrial oil mills is done by "warm pressing" and following solvent extraction, which leads to high oil yields of up to 99 %, but on the other hand requires several steps of refining. Due to the high expenditure, only plants with great production capacities of up to 3,000 tons oilseed per day operate economically successful (table 2).

Table 2: Features of industrial and decentralised oil mills

	Unit	Industrial oil mills	Decentralised oil mills
Number of plants (state 2006)		13	> 300
Processing technology		"warm pressing" + solvent extraction and refining	"cold pressing"
Processing capacity	tons/day	up to 3,000	0.5 – 25
Energy consumption	GJ/ton	1.7	0.1 – 0.5
Oil yield	%	99	75 – 85
Total rapeseed oil production (2005)	1,000 tons	2,150 – 2,180	170 – 200
Consumption of rapeseed oil fuel (2005) total	1,000 tons	196	
from decentralised oil mills	1,000 tons		50 (estimated)

As for industrial plants, also for decentralised plants, oil processing technology is state of the art. Equipment is now provided by many suppliers. The production is characterised by "cold pressing" with processing capacities from 0.5 to 25 tons per day (or more) without the need of refining, with low energy consumption, but also with lower oil yields from around 75 % to 85 %. Despite plenty of experiences, process optimisation is still possible and necessary for both, high production efficiency and high product quality. Furthermore, an effective quality management system for rapeseed oil fuel has to be established.

Table 3: Pre-standard DIN V 51605 (selected data), [1]

Properties / Contents	Unit	Limiting value	
		min	max
Characteristic properties for rapeseed oil			
Density, 15°C	kg/m³	900	930
Flash point	°C	220	
Heating value	kJ/kg	36,000	
Kinematic viscosity, 40°C	mm²/s		36
Carbon residue	mass-%		0.40
Iodine number	g/100g	95	125
Sulphur content	mg/g		10
Variable properties			
Contamination	mg/kg		24
Acid value	mgKOH/g		2.0
Oxidation stability, 110°C	h	6	
Phosphorus content	mg/g		12
Ash content	mass-%		0.01
Ca + Mg content	mg/kg		20
Water content	mass-%		0.075
Ignition performance		39	

3. Demands on Rapeseed Oil Fuel Quality: The demands on rape seed oil fuel quality were first defined in the Quality Standard for Rapeseed Oil as a Fuel (05/2000), which was the basis for the new developed pre-standard DIN V 51605. Therein the latest cognitions, regarding rapeseed oil production, analytics and engine applications are incorporated (table 3).

Beside others, like ignition performance, the main difference between rapeseed oil and diesel fuel is the viscosity. Whereas the viscosities of both fuels are similar at high temperatures, viscosity from rapeseed oil increases superproportional with decreasing temperatures. This is the reason, why conventional diesel engines have to be adapted to the special needs of rapeseed oil fuel, before rapeseed oil can be used properly.

4. Rapeseed Oil fuelled engines [2]: Purpose built rapeseed oil fuelled engines of recent times were developed in the 1980s. The most famous designer was Ludwig Elsbett. Because of the fast ongoing engine development to fulfil the demands of the user and the emission regulations, today adaptation of conventional diesel engines is typical. Structural measures for adaptation can be (among others):

- Preheating of the fuel
- Exchange of fuel and injection system components
- Modification of injection pressure and time
- Modification of the combustion chamber
- Adaptation of the engine management system
- Additional diesel fuel system (for cold start and low load operation).

In Germany about 50 mainly small sized enterprises offer solutions for the technical adaptation of conventional diesel engines for the use of pure rapeseed oil. Adaptation costs vary from 1.000 to 7.000 €, depending on adaptation technology and engine size. Adapted engines are used in cars, busses, trucks, tractors, agricultural and construction machinery, stationary engines, trains and boats.

Up to now in Germany far more than 12 000 vehicles and stationary engines are operated with pure rapeseed oil fuel (approximately 50 % cars and 50 % trucks, tractors and others). Operational reliability is high for many engine types and most of the adaptation technique.

Economic efficiency is best for high engine utilisation, high price difference between diesel and rapeseed oil fuel, as well as high fuel consumption.

Within a field survey 111 rapeseed oil fuelled tractors of 10 different manufacturers and 7 adaptation companies are being tested for their technical and economic feasibility in practical use for three years. Scientific monitoring is done by the University of Rostock. Promising first results encourage the agricultural machinery industry to consider new developments of rapeseed oil fuelled tractors. Results are:

- Tractor malfunction depends on tractor and engine type as well as adaptation measures
- Functional efficiency is best for Deutz engines in Fendt and Deutz-Fahr tractors (50 of 66 tractors showed no or only marginal failures)
- Engine performance, limited exhaust gas emissions and fuel consumption is similar to diesel fuelled tractors.

Prospects

Favourable general framework, which resulted in high price differences between diesel and rapeseed oil fuel led to an unprecedented demand on rapeseed oil production facilities, rapeseed oil fuel and rapeseed oil fuelled engines in Germany. Oil

mill capacities are being extended, a significant scale has been reached already with locally high densities of oil mills.

For further development of rapeseed oil fuel utilisation with all advantages for the environment and regional economy, existing framework conditions, especially tax exemption or moderate taxation of biofuels, need to be continued. Existing insecurities, like biofuels taxation beyond 2007 or ambiguous regulations in the Renewable Energy Sources Act (what kind of plant oil and which processing technology is allowed for full power feed-in proceeds) need to be cleared, to allow better planning security for investors.

The present bottleneck in rapeseed oil supply needs to be removed by higher rapeseed acreage, more rapeseed imports and enlargement of plant capacities. Enlargement of production capacities can be rewarding, however, locally high densities of oil mills can cause competition about customers for oil and press-cake. Thus, despite the high efficiency of oil mills today, it is advisable to focus on local markets. Otherwise a decreasing demand, e.g. due to higher taxation of biofuels or the use of other plant oils for biodiesel production, could suddenly lead to poor plant utilisation.

Quality demands for rapeseed oil fuel are widely known and defined in the new pre-standard DIN 51605, which will be introduced in practice, soon. Quality assurance systems for decentral processed rapeseed oil are being developed and established.

Although rapeseed oil fuel producers and users are mainly aware of the need of quality assurance, only few act sufficiently. Thus, further consulting is necessary and additionally measures for quality improvement and assurance need to be enforced for better engine operation reliability and fulfilment of emission demands.

Engine adaptation technique is available and improved. Companies for adaptation arise and have full order books. The demand is especially high for agricultural machines, due increased agro-diesel costs and the possibility of agricultural fuel production.

Experiences in field tests with rapeseed oil fuelled engines are all in all better than expected. This applies for operation reliability, emissions and efficiency. The agricultural machine industry considers the chances of rapeseed oil technology and engages in the development of rapeseed oil fuel compatible tractors.

Besides further improvement of engine adaptation technique and development of the adaptation of modern engines, insecurities regarding warranty agreements for rapeseed oil fuelled engines need to be abolished. This can be solved either by close co-operations between engine adaptation garages and engine industry or new product development of the engine industry. Further tests with modern engines are necessary and exhaust gas after-treatment, like particulate filter systems have to be optimised for rapeseed oil fuel.

Prior applications for rapeseed oil fuelled engines are either fields, those are only a limited number of different engine types with high items and/or environmental sensitive areas, like tractors and agricultural machinery, transportation vehicles with high degrees of utilisation and cogeneration plants. With continuing great demand of the users, rapeseed oil fuelled tractors may soon be sold industrially with high product quality and reasonable adaptation costs.

Conclusions

The results show, that present conditions offer good prospects for a further extension of rapeseed oil fuel technology in Germany. This is mainly due to highly competitive prices of rapeseed oil fuel and a steady increasing number of contented users, demanding rapeseed oil fuelled engines. The prior applications for rapeseed oil fuel are niche markets, such as environmental sensitive areas and agricultural machines, due to a limited number of engine types and the advantage of closed economic and material flow circuits.

There is also a great demand on information about rapeseed oil fuel of both, the producers and users. Therefore a country-wide information and consulting program was initiated by the Agency of Renewable Resources (FNR). There is the challenge of clearing unsolved questions by further research. Chances are now particularly favourable for an extended use of rapeseed oil fuel with major benefits in adapted diesel engines for many applications.

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