

BIODIESEL and VEGETABLE OIL AS A FUEL

The idea of using vegetable oils as fuels for diesel engines is over a hundred years old. Rudolf Diesel conducted engine tests on plant oils and a prototype of his new engine was presented at the Paris exhibition of 1900, running on peanut oil. Plant oils, however, are far more viscous than fossil fuels which can result in poor combustion and formation of deposits. The problems can be overcome by adapting the engine to the fuel or, more commonly, the fuel to the engine; biodiesel.

Biodiesel

Biodiesel is a substitute fuel for compression-ignition (diesel) internal combustion engines. It is produced by the transesterification of waste or vegetable oils and animal oils, or fats with lower alcohols. Most vegetable oils can be converted into biodiesel but the cost of the vegetable oil feedstock is now a key factor in the least cost production of biodiesel for blending with fossil fuel diesel.

Advantages of biodiesel

Life cycle emissions of greenhouse gases from bio diesel made from rape oil are claimed to be 55% lower than fossil fuel diesel. Particulate emissions of biodiesel are measured as 20% to 39% lower than low sulphur fossil diesel and 10-29% lower than ULSD (ultra low sulphur diesel). SOX (oxides of sulphur) emissions from bio diesel are at least 80% lower than low sulphur fossil diesel and are comparable or lower than ULSD due to the negligible sulphur content of biofuels. NOX (nitrous oxides) emissions from biodiesel are slightly higher than those from low sulphur fossil diesel. However, evidence from the EU shows emissions of NOX from ULSD to be marginally worse than low sulphur fossil diesel. Emissions of NOX from biodiesel can be significantly reduced by advancing injection timing. Catalytic converters to reduce emissions from fossil diesel also function effectively with bio diesel.

It should be noted that as biodiesel contains 11% oxygen it has a lower heating value than fossil diesel. If using 100% biodiesel 5-6% more fuel volumetrically would be expected to be used to maintain the same level of power and performance in an engine.

The relationship between the input of fossil fuel necessary to produce biodiesel from rape oil shows a ratio of 1:1.9 to 1:3, depending on the production system; a positive gain in energy from the process.

The EU Biofuels Directive requires the UK and other countries to achieve 5.75% by volume use of biofuels by 2010. In November 2005 the Transport Secretary announced the Renewable Transport Fuels Obligation (RTFO). This states that in the UK 5% by volume of road fuel sales must come from renewable sources by 2010. It is hoped that this will reduce CO₂ emissions by 1 million tonnes a year.

Production of biodiesel

The esterification process uses methanol and a catalyst, either caustic soda (NaOH) or potassium hydroxide (KOH), to produce sodium or potassium methoxide which reacts with the vegetable oil or fat. Methyl or ethyl esters, which take the name of the feedstock; Rape methyl Ester, Soybean Methyl; Ester etc. and glycerine are produced. The reaction requires considerable agitation and can take up to 1 hour to react. High pressure pipe reactors are considered to be the way forward, bringing the reaction time down to minutes. The biodiesel can be used as a 5% blend with ultra-low sulphur diesel (ULSDF) with the EN590 standard for normal diesel maintained, and thus not affecting engine warranties.

Most modern diesel engines can run on pure biodiesel but few manufacturers will stand by a warranty where it is used above 5% inclusion rate. An EU standard EN14214 exists for biodiesel. In severe winter conditions biodiesel may suffer from waxing problems. The severity of waxing depending on the feedstock used. Rape methyl ester is the least susceptible to waxing. Additives can be used to overcome the problem.

Biodiesel is a solvent and will remove paintwork, and can degrade rubber hoses and seals in fuel lines in older cars not using synthetic components.

Straight vegetable oil

Straight vegetable oil (SVO) can be used as a fuel but diesel engines will not run on vegetable oil when they are cold. Engine modifications are available, either where there is a twin tank system, the engine starting and stopping on normal diesel, or a pre heater that heats the vegetable oil before it enters the fuel system.

Excise duty and VAT

Duty on road diesel is 47.1 pence per litre (ppl). Since 2003 the UK Government has granted a 20 ppl concession on biodiesel duty, thus the duty is currently 27.1ppl. This duty concession is only applicable to fuels that have undergone the full esterification process and have an ester content of 96.5%.¹ Straight Vegetable Oil is regarded as a fuel substitute by HM Revenue and Customs (HMRC) and is therefore liable to the full duty of 47.1ppl.

Duty is payable whether fuel is sold to others or retained for own use. VAT is applicable at the standard rate of 17.5% if the biodiesel is sold to others. If the fuel is for use only by the processor or producer, then VAT is not applicable.

Blending biodiesel with mineral diesel negates the duty reduction and duty is payable on the mixture at the full heavy oil rate. Biodiesel used off-road benefits from a lower rate of duty of 3.13ppl, but if mixed with off-road red diesel (whose duty rate is 6.44ppl), the full heavy duty diesel rate of 53.27 applies.

A further duty concession is delivered by the RTFO mechanism. If the fuel distribution companies fall short on the target for 2010 of 5% by volume bio fuel, they have to buy out the shortfall volume at 15p/l. This buy out is redistributed to the bio fuel manufacturers in the UK, so producers could receive between 0 and 15p/l payment depending on the volume of short fall and bio fuels produced.

Oilseed rape and single payment scheme energy top up payment

The Energy Aid Payments Scheme applies to any crops except sugar beet, grown for energy purposes, including biodiesel, provided that the land used is not set-aside. The payment is €45 per hectare, but subject to the maximum guaranteed area so could be subject to deduction if the threshold area is exceeded.

Biodiesel production – small scale

On-farm production of biodiesel from rape oil is generating significant interest. Small scale batch refineries are produced by the following companies:-

Green fuels – www.greenfuels.co.uk
UK Fuel tech – www.ukfueltech.com
Bioking – www.bioking.co.uk .

¹ A producer of biodiesel must send a sample to HMRC to prove that the ester content is 96.5%.

There are a number of statutory regulations that affect this type of operation and are mainly administered by the Environment Agency. A Pollution Prevention and Control permit or Waste Management Licence may be needed depending on the scale of production, and the latter if used cooking oil. The various reactors use different methods to filter and remove soaps that result from the reaction and the resulting water or magnesium silicate filtrate must be disposed of safely.

Health and safety are important considerations in on-farm production as methanol vapour is highly flammable and poisonous, and sodium and potassium hydroxide react violently with water. All electric motors used in a refinery should be ATEX rated (regulations for controlling explosive atmospheres).

Glycerine produced by the esterification process has a pharmaceutical use, but it would be ill placed to factor in any value for this for on farm production.

Costs of production of biodiesel

Feed stock costs and fuel duty account for the main cost of biodiesel, the costs of production can be broken down as follows:-

Item	Cost
Feedstock (rape oil)	45.6
Distribution	6.5
Esterification	10.3
Duty	27.1
VAT @ 17.5%	15.6
TOTAL	105.1

Biodiesel production – large scale

3.18 Million tonnes of biodiesel were produced in Europe in 2005, Germany being the main producer with 1.67 million tonnes of production. The UK produced 51,000 tonnes. 2006 production is set to increase to 6.07 Million tonnes in Europe, with UK production reaching 445,000 tonnes.

The main production plants in the UK are Argent at Motherwell 50,000 tonnes, Greenergy at Immingham 100,000 tonnes, Biofuels on Teeside 250,000 tonnes and D1 oils on Teeside 32,000 tonnes.

Biodiesel feedstocks

The trend in Europe has been to move away from oilseed rape as a feedstock for biodiesel production on cost grounds. Cheaper feed stocks such as palm oil, used cooking oil and soya oil are now commonly being used. All production facilities in the UK are near a deep water port to enable importation of cheap feedstock. An indication of feedstock prices are as follows:-

Feedstock	Cost (p/l)
Crude palm oil	25
Soya oil	43
Sunflower oil	44
Rape oil	45
Used cooking oil	25-30

Pressing of oilseed rape on farm

Cold pressing of rape seed on farm yields 75% of the oil present in the rape. (30-34% of the 40 – 44% oil being extracted). Toll crushing extracts the last oil through the use of hexane solvents. Warming the seed before pressing can improve the oil yield.

Rape cake or meal produced by pressing is a good animal feed. An energy value of 5.3 kwh² per kg resulting from the oil residue in the cake, making it a useful fuel for boilers as a replacement for wood chip. If used as a fuel in boilers instead of wood chip, the increased ash production, 5% ash as opposed to 0.5% from woodchip needs to be considered. Typical costs of production for rape oil on farm are 45-50p/l depending mainly on the rape feedstock price and on the extent of usage of the press.

Rape presses vary significantly in price, but as an indication a German press with the capacity to crush 100kg/hour rapeseed, producing 36 litres per hour of rape oil would cost £12,500.

Rape oil produced by cold pressing must be filtered to remove particles and to prevent gumming before use as a biodiesel feedstock.

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² Heating oil has an energy value of 9.8 kwh/l