Department of Agriculture and Food
Government of Western Australia

BIODIESEL PRODUCTION AND USE BY FARMERS

IS IT WORTH CONSIDERING?

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Table of Contents

Executive Summary

This study considers technical, economic and financial factors associated with manufacturing biodiesel. It is prepared for members of the Western Australian Wheatbelt community who may be considering biodiesel manufacture and use on farm.

Biodiesel is a generic name for diesel made from plant or animal oils. It can be made from all plant oils such as canola, mustard, sunflowers, safflower, soybean, corn oil, palm oil plus used cooking oils and animal fats (tallow).

Biodiesel is considered by many as a superior fuel to mineral diesel because:

- Greenhouse gas emissions are lower than for mineral diesel.
- It has greater "lubricity" than low sulphur mineral diesel.
- It is more biodegradable than mineral diesel.
- It is possible to manufacture on farm from oilseeds like canola
- It is considered a renewable fuel.

Commercial production and importation of biodiesel has commenced in Western Australia (WA). It can be purchased in a 20% (B20) blend from at least seven service stations in Perth in April 2006. There are currently a number of large commercial plants either in the production or the planning phase across the State.

Internationally, feedstocks for biodiesel manufacturer include canola, soybean and palm oil and tallow. Many plant oils can be used as feedstock with the decision based on price, availability and characteristics of the final product. Currently palm oil is the preferred feedstock in Asia, soybean in the Americas and rapeseed (canola) oil in Europe.

If WA had to meet its current demand for diesel fuel purely from canola grown here then all currently cropped land would be required. This demonstrates the impact that the growing biofuels industry could potentially have on Western Australian agriculture.

It is essential that biodiesel manufacturing proponents carry out thorough "due diligence" studies to determine their own cost of production and levels of risk. All labour, fixed and variable costs along with the cost of capital and the competitive cost of mineral diesel should be included in business plans.

Risk factors include world crude oil price variations, as past oil shocks have seen prices ease back down after the rapid price hike as production ramps up and consumption falls.

Following the 1970's oil shock, the United States (US) built a large ethanol industry on the back of high oil prices but the 1980s and 1990s saw crude prices of US$10 - US$20 per barrel (bbl) which would have wiped out the new industry had it not been for US Federal Government intervention and support.

Following the recent rise in oil prices ABARE has predicted a medium term outlook for world prices of around US$47 per barrel (bbl) which is far lower than the current US$70 bbl plus. Proponents of biofuel projects need to be careful in relying on the price of oil remaining at the current high levels to make them viable.

Another risk is the availability of feedstock and its price. Domestic droughts and changes to international demand and supply can have large impacts on the local price of both canola as a feedstock and the by-products that are sold as stockfeed.

Federal Government Excise Grants and Credits need to be taken into account. Currently manufacturers can claim a renewable fuels grant equal to the excise on fuel of 38.14 cent per litre (c/L). But this will reduce to 50% by 2015 starting in 2011 which will impact on the viability of existing and proposed projects.

The cost of producing biodiesel depends mainly on the cost of the feedstock. The equipment, price of capital, labour and other inputs are relatively less significant.

Based on reported costs and our own investigations, the final cost to produce biodiesel in small plants in the wheatbelt after the sale of by-products is in the order of $1.40 from contract crushed canola. Based on the current canola pool price from the Grain Pool Pty Ltd (GPPL) of over $400 per tonne.

With the price of diesel at $1.50 per litre (less the on farm credit of 38c/L) resulting in a farm gate price of $1.12 per litre the production of biodiesel on farm is currently unviable. The viability of biodiesel production on farm would increase with sustained high oil prices and a reduced canola price.

Conclusions

Biodiesel is an important fuel option for rural and urban WA. It is relatively easy to manufacture, is renewable and has better lubricating and environmental properties than mineral diesel. However before proponents invest in biodiesel production, they will need to carefully review all factors. Whether proposing an on-farm or a co-operative biodiesel plant, they should examine all input costs and by-product income and use the opportunity cost of canola to assist their decision making.

Ultimately the key determinants will be the price of crude oil and the price of the feedstock which is extremely difficult to predict and requires excellent risk management.

1 Biodiesel

Biodiesel is a generic name for methyl or ethyl esters made from any tri-glyceride oil molecule. Tri-glyceride oils include all plant oils such as canola, mustard, sunflower, safflower, soybean, corn oil, palm oil etc. Used cooking oils can also be turned into biodiesel as well as can fats and tallow.

A chemical process called “transesterification” is used to “crack” the glycerol molecule and replace it with an alcohol molecule. A catalyst is used such as sodium hydroxide (Caustic Soda) and an alcohol such as methanol or ethanol.

2 Biofuels production and capacity

Transesterification of a vegetable oil was conducted as early as 1853. Rudolf Diesel ran his first diesel engine 1893 on peanut oil.

During the 1920s diesel engine manufacturers altered their engines to utilize the lower viscosity of fossil fuel (petrodiesel) rather than use vegetable oil, the result was, a near elimination of the biomass fuel production infrastructure. Only recently have environmental impact concerns and a decreasing cost differential made biomass fuels such as biodiesel a growing alternative

The revival of biodiesel production started with farm co-operatives in the 1980s in Austria. In 1991 the first industrial-scale plant opened with a capacity of 10,000 m³ per year. Since then the industry has grown rapidly with total world production exceeding 3 billion litres with the main focus being in Europe.

Biodiesel is only 5% of international biofuel production; the other 95% is ethanol.

3 Australia

Biodiesel has only recently been made commercially available in Australia. There are currently only 10 licensed producers of biodiesel with 15 more large plants in consideration.

Total biodiesel production capacity (as opposed to production levels) in 2004/05 is estimated at 90.7 million litres (ML). Almost all of this capacity uses tallow or used cooking oil but this will soon change as new plants will mainly use oil seeds. Current plans to expand production could, in theory, bring total capacity to 1,529ML by 2010.

The bulk of biodiesel production in Australia is sold in blends:

- B5 is a blend of 5% biodiesel with 95% petroleum diesel.
- B20 is a blend of 20% biodiesel with 80% petroleum diesel.
- B100 is pure biodiesel but is not very common.

Standard international practice is for the marketing of B5, B20 and B100 with the dominant blends being B5 and B20. There appears to be little or no original engine manufacturer acceptance of blends other than B5 or B20. Warranty acceptance is a key factor in growing the biodiesel industry domestically, and these two standard blends offer the best prospects for market growth. Biodiesel blends of up to 5% meet the Australian fuel standards for diesel.

4 Why biodiesel

Fuel made from vegetable oil has a number of distinct advantages over fossil fuel. Firstly, it is renewable and has positive environmental benefits. Instead of releasing stored carbon into the atmosphere, it is basically cycling carbon. Sunlight and CO_2 are two inputs that a plant needs to grow, and essentially the amount of carbon that is stored by the plant during its growing cycle is the same as what is released during combustion. This fact gives a distinct production advantage in that photosynthesis occurs naturally hence the energy requirements are provided free by the environment. This results in a net energy benefit. Life cycle analysis has shown that for every 1 unit of energy required in the production of biodiesel, there are at least 2.5 units of energy contained in the fuel.

Secondly, the technology required extracting and process biodiesel already exists. There are several hundred companies located around the world that produce oil expellers and associated equipment, and there are numerous companies that specialize in processing technology.

5 Per hectare oil production from plants

Table 1. Oils sources and contents

	% oil content
Apricot Kernels	42 %
Borrage	34 %
Brazil Nuts	63 %
Camelina	41 %
Copra	65 %
Corn Germs	50 %
Evening Primrose	25 %
Grapes	12 %
Groundnut with shell	47 %
Hemp	34 %
Jojoba	50 %
Karité / Shea Nut	39 %
Linseed	38 %
Mustard Seed	35 %
Neem Nuts	47 %
Niger Seed	40 %
Palm Kernels	45 %
Paprika Kernels	25 %
Peach Kernels	40 %
Poppy	45 %
Potato-Waste (fried)	40 %
Rape Seed / Canola	42 %
Safflower	35 %
Sesame	50 %
Soybeans	19 %
Sunflower Seed	42 %

Canola is the most common oil crop grown in Australia for use in making biodiesel but it has its drawbacks. Canola has a low water use efficiency which limits its ability to maximize yield. At this stage it is the most viable crop for biodiesel production for Western Australian farmers. The other potential feedstocks for biodiesel production in WA are:

- Soybean: 35 to 45 litres per hectare (L/ha) in the Ord River
- Rapeseed: 320 to 360 L/ha
- Mustard: 230 to 350L/ha
- Palm oil: 580 L/ha - imported
- Algae: 9,000 to 18,000 L/ha

7 Future crops for biodiesel

The next best crops are mustard. There are currently projects looking at the potential of using mustard to produce cheap, reliable, inedible oil for biodiesel production. There is also research being conducted on the use of the meal as a natural pesticide to reduce the use of chemical pesticides in the environment, (such as methyl bromide) and as a fertilizer. Camelina and Linola are also options suitable for WA.

Another potential source of oil is oil bearing trees. Two options include the Pongania pinnata tree and Kelor (Moringa oleifera). Not only could trees supply a source of oil, but they would also be a carbon sink and at the end of their productive life, provide a source of timber or cellulose that could possibly be used to produce another renewable fuel ethanol.

The one other possibility is strains of algae which consume CO_2 and produce oil. Tests on diatom algae found that a 1000 square meters pond over a twelve month period 7,600 litres of algae oil was produced. In comparison, the same size area when sown with high yielding canola plants was only capable of producing 190 litres of oil. The researchers concluded that 200,000 hectares of algae ponds would be capable of producing 3.8 billion litres of oil. Oil producing algae can be grown in partly saline which Australia has no lack of.

8 On farm based production

The attraction of on farm biodiesel production is the ability of an individual farmer to become self sufficient in their fuel use. As a rule of thumb, 5% of the total cropping area needs to be sown to canola to meet the farms annual fuel requirements. There are a number of ways of producing biodiesel on farm that are currently being investigated by farmers in the wheatbelt. They include:

- Buy oil and have it reacted to biodiesel by a contractor
- Buy oil and react it into biodiesel as and individual
- Buy oil and react it into biodiesel as a cooperative
- Grow canola, extract oil via a contract crush and react to biodiesel
- Grow canola, extract oil as an individual or cooperative and react to biodiesel

The most important driver of any of these options is the cost of the biodiesel and how that relates to the off road mineral diesel price on the farm.

9 The basic process

Oil Extraction

Canola oil can be extracted from the seed by a continuous mechanical press. There are a number of processes that are performed around the press in order to extract the most amount of oil. All the equipment required to perform these processes must be considered if a canola crushing plant is to be set up. They include:

- Storage of seed
- Ripple milling of seed
- Pre heating milled seed to 100 °C with a steam jacketed cooker
- Press to extract oil
- Filter or centrifuge fines from oil
- De-gum oil
- Vacuum dry oil
- Store oil
- Hammer mill meal
- Add water to meal
- Store meal

Biodiesel Production

The biodiesel reaction can be performed on farm. As with oil extraction there are a number of steps to the process that require equipment and infrastructure. They are:

- Titrate the oil to determine the amount of caustic to use.
- Dissolve caustic in methanol to produce methoxide. The biodiesel reaction requires approximately 20% methanol and 5g of caustic per litre of oil to be reacted with oil to produce biodiesel.
- Pre heat the oil and transfer to the reactor.
- Transfer methoxide to reactor, agitate and settle.
- 1L of feedstock oil produces 1L of biodiesel and 200mL of glycerine.
- Remove glycerine by-product layer from reactor and store.
- Recover excess methanol from glycerine and store.
- Transfer biodiesel to wash vessel and wash 3 times with 30% water per wash.
- Dry biodiesel and store.

NOTE Methanol and caustic are extremely hazardous materials. Successful biodiesel production should ensure that the operator is not exposed to these chemicals and that there is no chance of an explosion risk associated with methanol vapours which are colourless and odourless. Users of these products should adhere to dangerous goods guidelines for transport and storage (www.docep.wa.gov.au)

10 On farm scale biodiesel production costs

The viability of biodiesel made from canola grown on farm is dependent on four key factors:

- Canola price
- Meal price
- Capital cost of production
- Input cost for the reaction to biodiesel

The value of the feedstock oil made from canola can be determined using a matrix that relates the price of canola seed and meal (see table 2).

Table 2. Canola oil value (blue) $/L based on canola seed and meal values in $/t. Assume canola at 42% oil producing 580kg meal and 370kg (405L) of oil with a 50 kg loss.

		Canola Price ($/tonne)					
		300	325	350	375	400	425
Meal Price ($/tonne)	100	0.60	0.66	0.72	0.78	0.84	0.91
	150	0.53	0.59	0.65	0.71	0.77	0.83
	200	0.45	0.52	0.58	0.64	0.70	0.76
	250	0.38	0.44	0.51	0.57	0.63	0.69
	300	0.31	0.37	0.43	0.50	0.56	0.62

Once the value of the feedstock oil is calculated the cost of capital required to turn the oil into biodiesel needs to be calculated and converted to a price per litre of biodiesel produced. The cost of capital will vary widely depending on what existing infrastructure can be used and how much biodiesel is produced. The capital costs will also vary according to how much processing is done on farm, versus the same task performed by a contractor where a fee per litre is charges but requires less capital outlay.

Cost of the methanol and hydroxide components of the reaction become less with the greater amount of biodiesel produced because of bulk purchasing.

Individuals or groups should accurately cost out the feedstock price, cost of capital for crushing and reacting, and determine which of the models suggested in section 8 provide the lowest cost and lowest risk biodiesel production option. The cost of production must also be competitive with mineral diesel prices for the medium to long term.

11 A budget for on farm production

The following example costs out a situation where an individual replaces their entire mineral diesel consumption per year of 40000L with biodiesel using canola grown on the farm but contract crushed by a commercial processor. The oil is then reacted by the farmer using a farm built 5000L batch reactor where 20000L is produced before seeding and the remainder before harvest. A 20000L oil storage tank is purchased but an existing 20000L diesel tank is used for biodiesel storage.

Table 3. Capital cost of a farm built biodiesel plant and associated infrastructure.

Capital Costs	**Price**
Canola silo storage 2 x 50t	$14000
Seed auger	Use existing
Oil storage tank 20000L	$5000
Biodiesel storage tank	Use existing fuel tank
5000L farm built biodiesel plant	$15000
Biodiesel processing shed	Use existing
Electrical work	$2000
2 x transfer pumps	$2000
Total	**$38000**
Interest 8.5%	$3230
Depreciation 15%	$5700
Maintenance 5%	$1900
Annual capital operating cost	$10830
Capital cost $/L of biodiesel	**$0.27**

Table 4. Input costs for biodiesel production

Input costs for biodiesel	**$/L**	**Assumption**
Canola oil	0.57	$375 canola price $250 meal price
Crushing cost	0.22	$90/t contract crush
Transport	0.12	Canola to plant, oil to farm
Methanol and caustic	0.20	
Electricity	0.02	
Labour	0.03	
Total input costs	**1.16**	

Using the above example the cost of biodiesel in this case is $1.43/L. Mineral diesel for off road use would have to cost $1.81 ex. GST for biodiesel to be a viable alternative. Costing will vary according to which production model (see section 8) is chosen and the economies of scale that can be achieved by the various options. It is critical to ensure that biodiesel is a cost effective alternative to mineral diesel.

12 Constraints to on farm scale production

There are a number of constraints of a legislative nature that act to inhibit farm scale biodiesel production. Strict legal and regulatory requirements and standards have to be met when manufacturing or selling fuel to the public. These are designed for the large commercial oil majors, to safeguard the environment and the public by ensuring a consistently safe and reliable product.

To manufacture biodiesel in Australia you must register with the Australian Tax Office (ATO) as a manufacturer. Excise duty must be paid on all fuel produced and then credits are available for off road and commercial transport users.

Testing is mandated for commercial fuel and the Australian standard laboratory test costs $3000 per test.

13 Fuel standards

The Fuel Standard (Biodiesel) Determination 2003 sets out the physical and chemical parameters of the Biodiesel standard. It also sets out the associated test methods that the Government will use to determine compliance.

The biodiesel standard is detailed in the following table. The legal instruments implementing the standards are:

Table 5 Fuel Standard (Biodiesel) Determination 2003

Parameter	Standard	Test Method	Date of effect
Sulfur	50 mg/kg (max) 10 mg/kg (max)	ASTM D5453	18 Sep 2003 1 Feb 2006
Density	860 to 890 kg/m 3	ASTM D1298 or EN ISO 3675	18 Sep 2003
Distillation T90	360C (max)	ASTM D1160	18 Sep 2003
Sulfated ash	0.020% mass (max)	ASTM D874	18 Sep 2003
Viscosity	3.5 to 5.0 mm 2 /s @ 40°C	ASTM D445	18 Sep 2003
Flashpoint	120.0°C (min)	ASTM D93	18 Sep 2003
Carbon residue (10% distillation residue) (100% distillation sample)	0.30 % mass (max) **OR** 0.050 % mass (max)	EN ISO 10370 ASTM D4530	18 Sep 2003
Water and sediment	0.050 % vol (max)	ASTM D2709	18 Sep 2003
Ester content	96.5 % (m/m) (min)	prEN 14103	18 Sep 2003
Phosphorus	10 mg/kg (max)	ASTM D4951	18 Sep 2003
Acid value	0.80 mg KOH/g (max)	ASTM D664	18 Sep 2003
Total contamination	24 mg/kg (max)	EN 12662 ASTM D5452	18 Sep 2004

Free glycerol	0.020 % mass (max)	ASTM D6584	18 Sep 2004
Total glycerol	0.250 % mass (max)	ASTM D6584	18 Sep 2004
Oxidation stability	6 hours @ 110°C (min)	prEN 14112 or ASTM D2274 (as relevant for biodiesel)	18 Sep 2004
Metals	≤ 5mg/kg Group I (Na, K) ≤ 5mg/kg Group II (Ca, Mg)	prEN 14108, prEN 14109 (Group I) prEN 14538 (Group II)	18 Sep 2004
Methanol Content	<0.20%(m/m)	prEN 14110	18 Dec 2004
Copper strip corrosion (3 hrs @50°C)	if the biodiesel contains no more than 10 mg/kg of sulfur – Class 1 (max) if the biodiesel contains more than 10 mg/kg of sulfur - No. 3 (max)	EN ISO 2160 ASTM D130 ASTM D130	18 Dec 2004
Cetane number	51.0 (min)	EN ISO 5165 ASTM D613 ASTM D6890 IP 498/03	18 Sep 2005

Source: Department of Environment and Heritage, 2006

14 Federal Government Excise Taxes

On 26 March 2006 the Fuel Tax Bill and the Fuel Tax Consequential and Transitional Provisions Bill was introduced into Federal Parliament.

The main focus of the Bill is to replace the Energy Grants Credit Scheme (EGCS) with fuel tax credits as part of larger fuel tax reform policy.

There are currently two systems in place in Australia that provide assistance to biofuel producers and users, the Cleaner Fuels Grant Scheme (CFGS) and the Energy Grant Credit Scheme (EGCS).

15 Cleaner fuels grant scheme (CFGS)

- Is a grant for producers of Biofuels of 38.1c/L that offsets the 38.1c/L excise that is applicable on all diesel and petrol fuels.
- The grant is to encourage the production and sale of cleaner fuels.
- It is available until 2015, but from 2011 to 2015 the grant decreases gradually to 19.1c/L for biodiesel and 12.5c for ethanol.
- The Grant is classified as revenue by the ATO which means the grant is treated as assessable income for producers.

16 Energy grants credit scheme (EGCS)

- The Credit offers differential treatment to on and off road fuel users offering a full credit of 38.1 c/L for off road users and half that amount 19c/L for on road users.

From 1 July 2011 imported and domestically produced ethanol will be treated the same, which will open the door to cheap imported ethanol from Brazil and possibly biodiesel made from palm oil from South East Asia.

17 Net effect of fuel taxation reforms

The key reform to the new Fuel Tax Bill includes changes to:

17.1 Energy Grants Credit Scheme (EGCS)

- The new fuel tax credits will provide a credit for fuel tax that is included in the price of fuel used for certain on and off road businesses. It will commence 1st July 2006, to the 30th June 2010.

- Alternative fuels acquired for off road business use will become eligible for a fuel tax credit equal to the amount of the fuel tax as in the past.

- Partial fuel tax credits will apply to all fuels used for business purposes on-road in vehicles with a gross vehicle mass of at least 4.5 tonnes; the net fuel tax paid on fuels used on-road in these vehicles will be converted to a road user charge.
- Biofuels will increasingly be subject to fuel tax over time, from an effective fuel tax rate of zero until 2011 to 19.1c/L for biodiesel and 12.5c/L for ethanol by 2015.

However, alternative fuels will continue to be eligible for a fuel credit under EGCS for fuel purchased before 1 July 2010, providing EGCS eligibility criteria are met. This includes:

(i) the activity must be road transport

(ii) the fuel must be biofuel or the biodiesel component of a blend (100% biodiesel or a biodiesel blend consisting mainly of biodiesel)

(iii) only used in vehicles over 20 tonnes or over 4.5 tonnes outside of defined metro areas

The amount of the credit will reduce to zero in five equal annual steps commencing 1st July 2006 and concluding 30th June 2010.

The Government also announced in December 2003, that alternative fuels would receive a 50% discount on energy-content fuel tax rates on the basis of a range of industry, regional and other factors (Table 6).

Table 6. Effective fuel tax rates for alternative fuels at 1 July, 2003 to 2015 (cents/L)

	Ethanol			Biodiesel		
Year	**Fuel tax**	**Production grant**	**Effective tax**	**Fuel tax**	**Production grant**	**Effective tax**
2007	38.143	38.143	**0.0**	38.143	38.143	**0.0**
2008	38.143	38.143	**0.0**	38.143	38.143	**0.0**
2009	38.143	38.143	**0.0**	38.143	38.143	**0.0**
2010	38.143	38.143	**0.0**	38.143	38.143	**0.0**
2011	38.143	35.643	**2.5**	38.143	34.343	**3.8**
2012	38.143	33.143	**5.0**	38.143	30.543	**7.6**
2013	38.143	30.643	**7.5**	38.143	26.743	**11.4**
2014	38.143	28.143	**10.0**	38.143	22.843	**15.3**
2015	38.143	25.643	**12.5**	38.143	19.043	**19.1**

17.2 Cleaner Fuels Grant Scheme (CFGS)

All producers of biofuels who register with the Australian Tax Office (ATO) must pay the excise tax of 38.143c/L but they are then eligible for a producer's grant which is currently 38.143c/L. With the new Fuel tax Bill this will fall between 2011 and 2015 to 25.643c/L for ethanol and 19.043c/L for biodiesel.

17.3 CFGS and EGCS - Increasing the cost of biodiesel

The current system advocates the use of Biofuels through the subsidised manufacturer of ethanol and biodiesel through the CFGS as a manufacturer's incentive but also allowing commercial consumers to claim the EGCS however the new changes will reduce the competitiveness of biofuels.

As biodiesel and diesel is predominantly used by commercial on and off road users rather than petrol and ethanol, the impact of increasing taxation on biodiesel and reducing Government grants is likely to have a negative impact on the future growth of the biodiesel industry.

The price of biodiesel is likely to rise as the Government moves to close a loop hole in how biodiesel blends are rebated. This is because there is currently an anomaly with regard to the definition of Biofuels in particular the blend of 49% biodiesel and 51% petroleum diesel based.

The old definition allowed the companies to claim for both products i.e. the 51% diesel and the 49% biodiesel to claim a credit amount of fuel tax. As long as the primary product was diesel i.e. over 50%, you could claim the whole amount.

Now, the Fuel Tax Bill 2006 tightens the definition to allow them to only claim for the diesel element i.e. the 51% for the credit amount of fuel tax. This will make biodiesel less viable as they cannot claim the full fuel tax rebate.

18 Diesel engines and low sulphur diesel

Low sulphur diesel will soon be introduced into Australia which has raised concerns about additional engine wear due to its low lubricating abilities.

The most cost effective way for refiners to produce low sulphur diesel is through a process called "hydro treating". This process removes sulphur from the fuel by treating it with hydrogen, but this can reduce the lubricating components found in diesel fuel. Stanadyne Automotive Corporation, one of America's largest fuel injection manufacturers, has been testing Biodiesel at varying concentrations as a fuel additive.

"…we have tested Biodiesel at Stanadyne and results indicate that the inclusion of 2% Biodiesel into any convention diesel fuel will be sufficient to address the lubricity concerns that we have with these existing diesel fuels. From our standpoint, inclusion of Biodiesel is desirable for two reasons. First it would eliminate the inherent variability associated with the use of other additives and whether sufficient additive was used to make the fuel fully lubricious. Second, we consider Biodiesel a fuel or a fuel component-not an additive…Thus if more Biodiesel is added than required to increase lubricity, there will not be the adverse consequences that might be seen if other lubricity additives are dosed at too high a rate."

A recent research project funded by the Saskatchewan Canola development Corporation, to evaluate the efficiency of commercial and vegetable based lubricity additives found that Canola Methyl Esters (CME) and a Canola Oil Derivative (COD) preformed the best in these lubricity tests. The CME's were effective at treatment rates as low as 0.1% (1000 ppm) and were shown to be very cost effective.

The project concluded that, "The application of canola based lubricity additives in both un-additized and commercial low sulphur diesel fuels has been shown effective in reducing engine wear by as much as one-half, thereby potentially doubling diesel engine life. Fuel economy gains of up to 13% have also been recorded… The engine wear reductions and fuel economy improvements appear to be directly related to diesel fuel lubricity.

19 Manufacturers Comments

Advice from engine manufacturers in Australia are that the maximum biodiesel blend for should be no greater than 5% (B5). Manufacturers have indicated that higher blends raise significant issues involving engine performance, efficiency, emissions and warranties. The Trucking Industry Council and the Australian Trucking Association support this position.

However New Holland has recently endorsed B20 diesel blends in Australia (Monday, 8 May 2006). New Holland has announced it fully supports the use of B20 blends – 20% biodiesel and 80% petroleum-based diesel - on all of its engines, other than those with a common rail fuel injection system. According to the company's marketing manager, Simon Vigour, the use of biodiesel is becoming more popular. But, he says, is not without its challenges. Cost is one consideration, as blends higher than 5% are more expensive. Biofuels also attract water vapours from the air, so fuel tanks should be kept as full as possible to limit the amount of condensation.

In Europe, vehicles are designed for diesel fuel containing a maximum biodiesel content of 5%. This limit is a requirement of the fuel injection equipment manufacturers. As the diesel fuel specification permits up to 5% biodiesel, its presence does not require labelling (as for E5) in Europe. There are proposals to increase the maximum level of biodiesel in European fuel standards to 10%.

Peugeot Biodiesel Passenger Vehicle Testing

Peugeot Automobiles Australia provided the Federal Government Biofuels Taskforce with the results from extensive testing of passenger vehicles run on up to B30 in Europe since 1991. Peugeot tested B30 on: 800 vehicles driving under normal conditions and seven vehicles on endurance testing covering a total of 614,000 kilometres; Peugeot passenger cars since 1991 in the Paris area; and over 4000 vehicles covering a total of 200 million kilometres.

Peugeot reported no vehicle operability problems from any of its testing. The company considers that biodiesel provides good lubricity of the injection system and requires no major modification of the engine or vehicle. Peugeot considers that B100 is unsuitable for engines because of its low stability, low cetane and high viscosity, causing oxidation, deposits and fouling. The company considers that B100 would require the adaptation of materials, particularly elastomers, in the engine. In Europe, Peugeot and Citroën diesel cars are guaranteed to run on B30, as long as the biodiesel blends conform to quality norms.

20 Biodiesel Health and the Environment

Extensive tests have demonstrated that the use of a B20 blend (20% Biodiesel, 80% diesel) can reduce unburned hydrocarbons by 14%, decrease carbon monoxide (CO) by 9%, reduce particulate matter by 8%, decrease sulphates by 20%,and decrease PAH (Polycyclic Aromatic Hydrocarbons) emissions by between 13% to 50% .

At a 20% blend, there is an increase of Nitrous Oxide (NO_x) by 1% (a noxious greenhouse gas).

The Federal Governments Biofuels Taskforce concluded:

- all criteria air pollutants except NO_x were significantly decreased when replacing diesel with biodiesel
- CO and Volatile Organic Compound (VOC) emissions were lower for all types of biodiesel—pure or blend—when compared to Ultra Low Sulphur Diesel (ULSD), but NO_x emissions from biodiesel were higher
- with diesel sulphur contents less than 50 parts per million (ppm), only pure biodiesel or 20% biodiesel blend had lower PM emissions than diesel
- the 5% biodiesel blend was less environmentally friendly than ULSD in terms of particulate matter
- the Federal Governments Biofuels Taskforce found that there is insufficient data at the present time to assess the air toxic emissions from biodiesel

In a similar US study it was found environmental benefits in comparison to petroleum based fuels include:

- Biodiesel reduces emissions of carbon monoxide (CO) by approximately 50 % and carbon dioxide by 78 % on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was already in the atmosphere, rather than being new carbon from petroleum that was sequestered in the earth's crust. (Sheehan, 1998)
- Biodiesel contains fewer aromatic hydrocarbons: benzofluoranthene: 56 % reduction; Benzopyrenes: 71 % reduction.
- It also eliminates sulfur emissions (SO_2), because biodiesel does not contain sulfur.
- Biodiesel reduces by as much as 65 % the emission of particulates, small particles of solid combustion products. This reduces cancer risks by up to 94 % according to testing sponsored by the Department of Energy.[citation needed]
- Biodiesel does produce more NO_x emissions than petrodiesel, but these emissions can be reduced through the use of catalytic converters. The increase in NO_x emissions may also be due to the higher cetane rating of biodiesel. Properly designed and tuned engines may eliminate this increase.
- Biodiesel has higher cetane rating than petrodiesel, and therefore ignites more rapidly when injected into the engine. It also has the highest energy content of any alternative fuel in its pure form (B100).
- Biodiesel is biodegradable and non-toxic - tests sponsored by the United States Department of Agriculture confirm biodiesel is less toxic than table salt and biodegrades as quickly as sugar.[citation needed]
- In the United States, biodiesel is the only alternative fuel to have successfully completed the Health Effects Testing requirements (Tier I and Tier II) of the Clean Air Act (1990).

21 Energy Balance

Another benefit of using biodiesel is its positive energy balance ratio. “An energy balance ratio is a comparison of the energy stored in a fuel to the energy required to grow, process and distribute that fuel. The energy balance ratio of biodiesel is at least 2.5 to 1. For every one unit of energy put into the fertilizer, pesticides, fuel, feedstock, extraction, refining, processing and transporting of biodiesel, there are at least 2.5 units of energy contained in the biodiesel. Biodiesel has a positive energy balance ratio because it is an efficient carrier of solar energy.”

22 Toxicity

Biodiesel also degrades rapidly in the environment and is non-toxic. The LD 50 test (lethal dose) is greater than 17.4 g/kg body weight. In comparison, table salt is nearly 10 times more toxic.

Biodiesel degrades at the same rate as sugar. Within 28 days, pure biodiesel degrades 85 to 88% in water. Blending biodiesel with diesel also accelerates its biodegradability. A blend of 20% biodiesel and 80% diesel degrades twice as fast as diesel alone. It is the low toxicity, degradability and safety of biodiesel that make it a safe fuel to use in environmentally sensitive areas. There have been reports of companies actually using biodiesel to breakdown and degrade oil spills.

Biodiesel is being considered for use in marine environments as a lubricant for oil drilling and for powering marine engines. There is potentially a huge market for biodiesel to be used as an environmentally friendly fuel for use in sensitive ecosystems.

23 By-products

The by-products from producing biodiesel on farm are glycerol, free fatty acids and wash water. Glycerol has a number of possible uses. In its crude form it can be used as a heavy duty detergent and degreaser. It is one of the few products that has good activity on sump oil, and is extremely effective for washing the shearing shed floor. Glycerol is currently being trialled by the Department of Agriculture and Food for its potential to ameliorate non wetting sands. If successful this could provide a use on farm without the need to further processing for sale.

A paper that was presented at the 10^{th} International Rapeseed Congress at Canberra in 1999, entitled “Glycerol as a by-product of biodiesel production in Diets for ruminants”, explored the possibility of using glycerol in feed diets for sheep and cows. “The results of these studies suggest that the glucose precursor, glycerol, is an excellent feed constituent, even when included in an impure form as derived from biodiesel production. Glycerol may serve as an ingredient, both in pellet concentrates or in total mixed rations. In pellet concentrates, the contribution to the hygienic quality of the feedstuffs might be of special interest. Economic assessment will be decisive of a wider use of glycerol as a dietary ingredient for ruminants.” If the glycerol can be purified, it opens up markets for moisturizers, soaps, cosmetics, medicines and other glycerol products. The glycerol can even be fermented and ethanol produced, which then can be used to make even more biodiesel! The free fatty acids that are washed out of the biodiesel can be separated from the wash water and used as a high quality surfactant or spreading agent.

A by-product of the crushing operation is press cake or meal. This is a high protein feed supplement and can be fed to all animals as part of their feed ration. Because a “cold press” is being used to extract the oil in this scenario, there is excess oil which is left in the meal. When mixing oats and legumes together for dry feed rations, a bag of canola meal in the feed mix was enough to ‘coat the oats’ and prevent the oat dust from covering the operator in itchy dust.

24 Solvent

Biodiesel is a good solvent. Biodiesel can, if left on a painted surface long enough, dissolve certain types of paints. Therefore it is recommended to wipe any biodiesel or biodiesel blend spills from painted surfaces immediately.

25 Storage

Biodiesel is made from vegetable oils and animal fats which can oxidize and degrade over time. The oxidizing process can produce heat. In certain environments, for example, a pile of oil soaked rags can become concentrated enough to result in a spontaneous fire.

All fuels have a shelf life including biodiesel and biodiesel blends. It is recommended that biodiesel be used within one year to ensure that the quality of the fuel is maintained.

Biodiesel is also extremely safe to store. It has a flash point of over 300 degrees Fahrenheit whereas petro-diesel has a flash point of around 125 degrees Fahrenheit. Storage and handling requirements are virtually the same as for diesel storage, except that copper, brass, lead, tin and zinc storage containers should be avoided

26 Performance

Operationally, biodiesel performs very similar to low sulphur diesel in terms of power, torque, and fuel without major modification of engines or infrastructure.

One of the major advantages of biodiesel is the fact that it can be used in existing engines and fuel injection equipment with little impact to operating performance. Biodiesel has a higher cetane number than US diesel fuel. In over 15 million miles of in-field demonstrations biodiesel showed similar fuel consumption, horsepower, torque, and haulage rates as conventional diesel fuel.

27 Compatibility of biodiesel with engine components

In general, biodiesel will soften and degrade certain types of elastomers and natural rubber compounds over time. Using high % blends can impact fuel system components (primarily fuel hoses and fuel pump seals), that contain elastomer compounds incompatible with biodiesel. Manufacturers recommend that natural or butyl rubbers not be allowed to come in contact with pure biodiesel. Biodiesel will lead to degradation of these materials over time, although the effect is lessened with biodiesel blends. If a fuel system does contain these materials pure biodiesel is being used, replacement with compatible elastomers is recommended. The recent switch to low sulphur diesel fuel has caused many OEMs to switch to components suitable for use with biodiesel.

28 Fuel filters

Biodiesel and biodiesel blends have excellent solvent properties. In some cases the use of petro-diesel, especially petro-diesel leaves a deposit in the bottom of fueling lines, tanks, and delivery systems over time. The use of biodiesel can dissolve this sediment and result in the need to change filters more frequently when first using biodiesel until the whole system has been cleaned of the deposits left by the petro-diesel. This same phenomenon has been observed when switching from biodiesel to mineral diesel.

29 Biodiesel in cold weather

Cold weather can cloud and even gel any diesel fuel, including biodiesel. Users of a 20% biodiesel blend will experience a decrease of the cold flow properties (cold filter plugging point, cloud point, pour point) of approximately 3 to 5° Fahrenheit.

Precautions beyond those already employed for petroleum diesel are not needed for fueling with 20% blends. However, neat (100%) biodiesel will gel faster than petro-diesel in cold weather operations. Solutions for winter operability with biodiesel are much the same as that for low-sulphur #2 diesel (i.e. blending with #1 diesel, utilization of fuel heaters, and storage of the vehicle in or near a building).

30 Biodiesel vs straight vegetable oil systems for the farm

For diesel engines, there are two main fuel alternatives to diesel. The first approach is to modify the fuel to run in the vehicle (which is biodiesel) and the second approach is to modify the fuel delivery system to use Straight Vegetable Oil (SVO). With a SVO system it is necessary to reduce the viscosity of the vegetable oil by heating the vegetable oil.

Generally the main components of a SVO system are:

1. A second fuel tank
2. A fuel solenoid valve to switch between tank 1 (diesel/Biodiesel) and tank 2 (vegetable oil)
3. A method for heating the oil

There are a number of SVO systems available worldwide, that have been in use for a number of years. The idea of using heated vegetable oil as an alternative fuel is not a new one and has been used successfully in Europe for a number of years. In Germany, there are actually small groups of farmers (2-4) who grow rapeseed, crush the oil themselves with their own oil expeller, feed the meal to their own livestock, and then use the oil in their farm machinery.

Biodiesel has the convenience that you use it just the same as diesel. SVO however, requires a little more effort. To successfully use vegetable oil as a fuel, you first need a warm up stage and then also a shut down stage. To use a SVO system, you start your engine on diesel, and once the engine has reached operation temperature, and the oil is hot, you change from diesel to vegetable oil. You then continue on vegetable until you are 10 minutes or so from your destination and then switch back to diesel to allow the lines to clear. Shutting down too late, will leave more vegetable oil in the fuel system, which may make it harder to start the engine once it has cooled down. It is simply a matter of heating the glow plugs longer, or cracking the bleed valve on the fuel filter assembly and hand pumping some diesel through.

Instead of using the radiator fluid for heating the oil, it is possible to use an in-line electric heater. By using an in line heater, you keep a regulated temperature and don’t run the risk of contaminating your fuel system with radiator fluid. It is also a lot simpler and quicker to install an electrically heated conversion. The down side of an in-line electrically heated system is that you are limited to using oil that is liquid at room temperature. You are unable to use solid oil, tallow or fats as a fuel.

There is a lot of debate about the long term effects of SVO on diesel engines. Research has shown poor engine performance, choking, engine wear and engine failure, while other research has shown that properly heated oil is quite suitable as an alternative fuel. Internationally, there are a large number of people using SVO systems quite successfully.

A research project, Advanced Combustion Research for Energy from Vegetable Oils (ACREVO) was conducted by a consortium of eight European research Institutes and Universities. The objective was to look at the burning characteristics of vegetable oil droplets under high pressure and high temperature conditions, and to try and address problems such as poor atomization, coking and to understand the mechanics of deposit formation associated with vegetable oil combustion.

The paper reads,

"*the flames have been studied with particular regard to stable gasses (CO, CO2, NO_x, 0_2 and hydro carbons), temperature, soot formation and burnout at different rapeseed oil preheating temperature. All the data have been compared with those obtained from a classic diesel oil under the same burning…The overall combustion performance of the rapeseed oil are very satisfactory in comparison with the diesel fuel while the rapeseed produces almost 40% less soot than diesel fuel…It has been established that an addition of 9% ethyl alcohol (95%) bring a great benefit regarding the pre-heating oil temperature. In fact, the presence of alcohol allows a reduction in the inlet oil temperature from 150 degrees Celsius, to 80 degrees Celsius. Moreover, the combustion of the emulsion produces less soot and at the exhaust, the amount is almost one half less than that produced by the rapeseed oil.*"

31 Conclusion:

With rising global fuel prices biodiesel is now seen as a viable alternative that Australian farmers can now consider with confidence.

34 Legislative Council of Western Australia

Thursday, 11 May 2006

302. Hon NIGEL HALLETT to the Minister for Agriculture and Food:

Will the minister outline how Western Australia will be able to supply a significant portion of its biofuel diesel requirements without the introduction of high-yielding genetically modified canola crop trials to try to increase low production?

Hon KIM CHANCE replied:

I thank the member for some notice of this question.

Before I give a formal answer to the question, I make the point that canola is unlikely to ever form a major feedstock for biofuels. Canola is a plant bred for human consumption. As a result of that, it has been bred from a narrow range of breeding lines that limit the presence of some of the more toxic acids that occur naturally in oilseeds. That narrow gene pool limits the yield factor available in canola. There is probably more opportunity to get high-yielding crops from the native grape seed variants, but there is no such thing as high-yielding canola at this stage. Similarly, canola is a plant that grows only in the most favoured agricultural circumstances; that is, where rainfall is high and reliable and soil fertility is high. There are not too many parts of Western Australia in which canola is grown reliably. It is far more likely that oilseeds for biofuel will come from the likes of cranberries and mustards, which grow east of the dry end of the canola zone.

A multifaceted approach is being adopted for the development of feedstocks for the biofuel industry in Western Australia. New variety and species development is already under way through the Department of Agriculture and Food and the Centre for Legumes in Mediterranean Agriculture, better known as CLIMA. This includes the development of conventionally bred higher oilseed yielding varieties with broader adaptation to a range of environments and the development of a wider range of annual crop species, such as mustard, camellina and linola, suited to current cropping systems.

Developing production systems that increase the capacity to produce a larger volume of these oilseeds will also be a component of the research program undertaken by the Department of Agriculture and Food. That is now in the budget papers. The development of perennial oilseed crops, particularly oil-producing trees suited to marginal soil conditions, and algae with the ability to produce fatty acids in saline ponds also offers longer-term alternative ways of developing feedstock for the industry and is under investigation.

Of particular interest to Western Australia will be new chemical technology under development in Europe and the United States that can convert straw and biomass to long-chain alkanes, which are the basic components of biodiesel, using the Fisher-Tropsch process. The basic concept is well established and processing plants for this purpose are under development overseas. The honourable member, as I said, would no doubt be aware that there is no such thing as high-yielding GM canola strains available for release. Existing GM canola strains are all moderate-yielding varieties bred for human consumption and selected for their herbicide-resistant qualities rather than for yield or drought tolerance.

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