Economics of On-Farm Biofuel Production

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Summary

Sustained increases in fuel prices since mid-2004 have stimulated interest in the technical and economic feasibility of on-farm fuel production. Local and international evidence reveals that it is technically feasible to produce biofuels from a variety of agricultural substrates such as fats and oilseeds. However, less clear is the economic wisdom of on-farm investment in biofuel production.

This paper firstly describes the importance of the cost of fuel to the broadacre farms in Western Australia. Expenditure by broadacre farmers on fuel and fuel-related services such as freight is shown to form a main component of farm business costs. Moreover, the export-oriented nature of most farm businesses means they are not able to directly and fully pass on all increased costs of production attributable to higher prices of fuel and energy.

Farmers also face other circumstances that increase their exposure to higher fuel and energy prices. They have already adopted energy efficient crop production techniques such as single pass crop establishment and there are no immediately available profitable options to greatly reduce fuel use in cropping. Moreover farmers over the last decade have altered their enterprise mix and allocated more farmland to cropping. Hence their business structures have increasingly revolved around their cropping enterprises which, relative to animal grazing enterprises, are greatly reliant on fuel and transport services and so rising fuel and energy prices challenge the profitability of farming, as shown by farm survey data.

This paper secondly assesses the merits of farmers engaging in on-farm production of biofuel. The particular cases of biodiesel production based on canola or an improved industrial oilseed are examined. Currently, the economics of biodiesel production based on canola are unfavourable in most circumstances. Diesel prices are not yet high enough to justify most individual farmers investing in their own on-farm production of biodiesel from canola. However, in the near term, especially if fuel prices continue to rise, it is conceivable that an economic case for biodiesel or ethanol production could be made, especially in regions where fuel will become increasingly expensive, where economies of size and capital sharing advantages could be on offer and/or where cheap feedstock such as an improved industrial oilseed is available or is likely to be developed.

There is no single trigger price of fuel to justify farmers investing in biofuel production. Each farm and region has unique characteristics that in combination will affect the trigger price at which it becomes sensible for that farmer to engage in biofuel production. Already some farmers in some situations are facing that trigger price. However, in many other cases it may not be until wheatbelt diesel prices increase a further 15 to 30 cents per litre that on-farm production of biodiesel, based on canola, becomes justified. If a high-yielding improved industrial oilseed becomes available then on-farm production of biodiesel is likely to become more widely justified at prices near current prices.

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Why do fuel prices matter to farmers?

Since mid-2004 farmers in Western Australia have experienced a strong upward movement in fuel prices (see Figure 1). Not since the 1980s have farmers experienced such rapid and prolonged increases in their fuel prices.

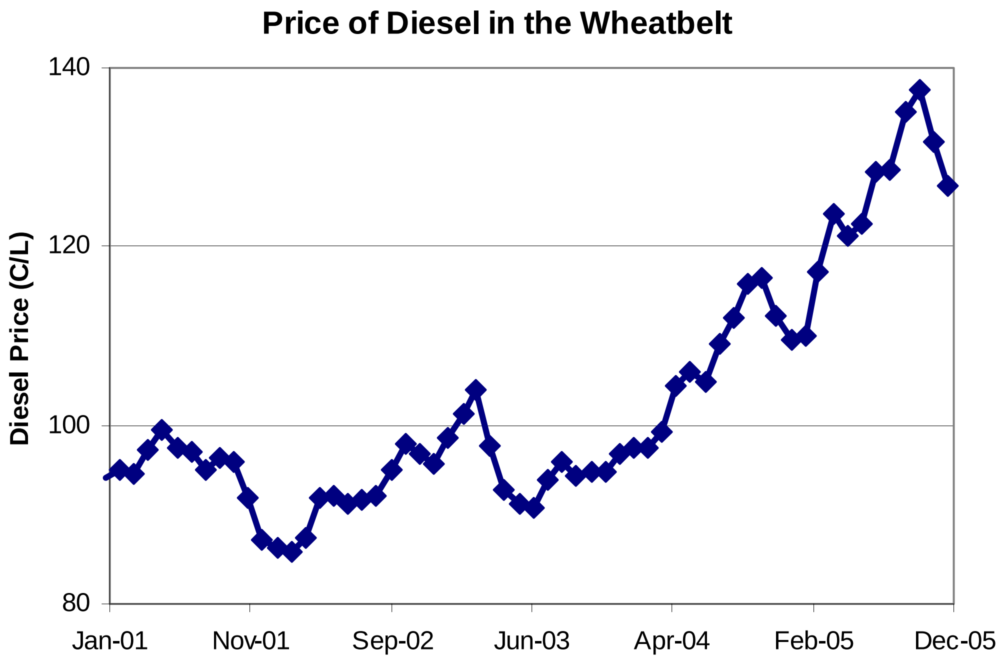


Figure 1: Diesel prices in the wheatbelt: Jan 2001 to Dec 2005

The increase in fuel prices has increased not only the cost of major on-farm activities such as crop establishment and grain harvesting but also has spilled over into cost increases for transport of agricultural products and inputs (animals, crops, wool, milk, feeds, fertilisers and chemicals) via all transport modes (road, rail, sea and air). Accompanying the rise in fuel prices has been an associated general rise in energy prices that also has underpinned rises in the prices of key agricultural inputs (fertilisers and chemicals).

Farmers are concerned about these price increases for several reasons:

(i) The current generation of farmers, or their parents, remember the economic hardships in agriculture in the mid to late 1980s, largely attributable to unanticipated huge rises in fuel and credit prices. Admittedly farmers currently are not exposed to historically high credit prices but fuel costs form a significant component of farm operating costs and so farmers are right to be concerned about the impact on their businesses of high prices of fuel.

By illustration as shown in Table 1, a sample of 59 farms in the southern agricultural region of Western Australia reveals that these mixed enterprise businesses had, on average, expenditure on fuel around 9 per cent of their farm operating costs. On average, the total expenditure on fuel and the expenditure on fuel per effective hectare increased over the period 1995 to 2002. This was due to increases in the price of fuel over the period (66 c/L in 1995 rising to 90 c/L in 2002) plus a switch in the enterprise mix toward cropping. On average over the period farms became more crop dominant with the average percentage of farm in crop increasing from 46 to 55 per cent. Although cropping relies on greater fuel input than pasture production, nonetheless farmers over the period improved the efficiency of their fuel use in cropping operations such that expenditure on fuel per hectare of crop changed little.

Table 1: Average expenditure on fuel:
based on a sample of 59 southern region farmers in Western Australia

Year	Fuel as a percentage of farm operating costs (%)	Expenditure on fuel ($)	Fuel cost per effective ha ($/ha)	Fuel cost per crop ha ($/ha crop)
1995	9%	21,755	11.85	29.09
1996	9%	24,172	12.74	28.24
1997	9%	25,880	13.68	25.81
1998	8%	23,920	12.85	23.56
1999	8%	26,217	13.84	24.11
2000	9%	31,230	15.86	29.19
2001	9%	31,618	15.31	29.52
2002	8%	33,454	15.87	29.84

It is possible to roughly estimate the impact on historical farm profits if the farmers faced the currently higher prices for fuel. The estimate employs *ceteris paribus* assumptions such as the farmers not altering their historical pattern of use of fuel nor altering their enterprise and input mix. The rough estimates of retained profit are shown on the right vertical axis in Figure 2. The present value of the profit difference attributable to the impact of the higher fuel price during the period 1995 to 2002 is worth $121,000 in today's dollar terms. This estimate excludes other likely higher costs such as freight attributable to higher fuel prices. Also no allowance is taken for the likelihood that energy prices and energy-dependent inputs (e.g. nitrogenous fertilizers) would also be higher. In effect this means that the average farm over the period 1995 to 2002 would have experienced due to the higher price of fuel an accumulated loss of profit worth $121,000 in today's dollar terms.

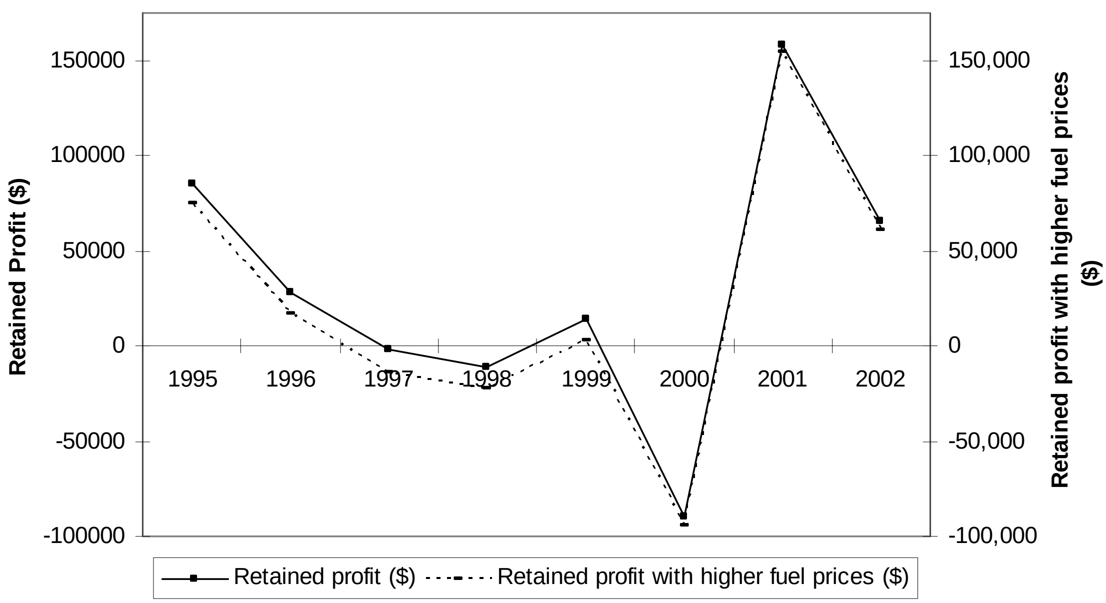


Figure 2: Average retained farm profit for a sample of southern region farms in Western Australia: 1995 to 2002

(ii) The main broadacre agricultural industries in Western Australia are export-orientated and have a limited capacity to pass on their fuel costs directly and fully to overseas' buyers. Most of the State's production of major agricultural commodities, wheat, barley, wool, canola and live sheep, are exported overseas. As such most farmers are price-takers and are in direct competition with other agricultural suppliers across the globe. If increases in fuel and energy prices worsen the comparative advantage of Western Australian farmers, then they will face a worsened cost-price squeeze and a real decline in farm profits. Any production region that will be less affected by fuel and energy price increases (for example, due to their greater proximity to markets or greater natural endowment of natural resources) relative to Western Australia is likely to increase their market share or be less susceptible to profit decline.

The Western Australian farm sector does have some characteristics that make it less vulnerable to the impacts of high fuel prices relative to some other production regions. It has sea freight advantages for sales into south-east Asia, southern China and Middle East markets. It has modern grain freight, handling and storage facilities. Farm production is based on fuel-efficient, large scale, often relatively low input crop and animal production systems. For example, farmers have switched from the multiple pass crop establishment systems of the early 1980s to single pass, minimal disturbance systems that per hectare use less fuel. However, farmers in Western Australia face competition in some markets from a rapidly expanding agricultural sector in South America (particularly Brazil) with access to cheaper labour, fertile soils, GM technologies and relatively cheap energy sources (Greenville and Keogh 2005).

(iii) There is evidence that the natural environment for agricultural production in Western Australia is worsening, further weakening farmers' abilities to respond to other adverse impacts such as rising fuel prices. The gradual spread of salinity is lessening the area of potentially arable land (Kingwell 2003). Recent studies of climate change document a current drying and warming of the environment in the south-west of Western Australia (Sadler 2002, Pittock 2003) with predictions of a further deterioration (CSIRO 2001, Howden and Jones 2004). Excluding any impact of fuel price rises, climate change alone represents a great challenge to the profitability of broadacre farming in the south-west of Western Australia (John *et al*. 2005, Kokic *et al*. 2005, Kingwell 2006). If the recent rise in fuel prices is prolonged then, in combination with any worsening of the natural environment, broadacre farming in this State faces some serious commercial challenges.

In responding to those challenges farmers will need access to innovation and R&D services to deliver the needed productivity improvement (Mullen 2002, Kingwell and Pannell 2005). Support for such innovation will be one way that farmers and government can jointly ameliorate the likely adverse impacts of a sustained period of high fuel prices and a worsening trend in the natural environment.

(iv) Unlike their international rivals in export markets, Australian farmers are unlikely to receive additional financial support from government. The farm sector in Australia, broadly speaking receives relatively little financial support from transfer payments, tariffs and subsidies. The OECD (2005a) report that economic assistance to Australian agriculture (as a per cent of gross farm receipts) was around 4 per cent in 2003, markedly lower than the OECD average of 32 per cent. Similarly, the Productivity Commission (2005) calculates that the Australian agricultural sector has an effective rate of assistance of only around 4 per cent of industry gross value added, including budgetary, tariff and regulatory assistance. The OECD (2005b) also report that support to arable crop producers in OECD countries amounted to $US62 billion in 2001-03, accounting for 39 per cent of farm receipts from crops. Vocke *et al*. (2005) report on government assistance to US wheat producers and note that, without government payments, only 18 per cent of specialized wheat farms had farm revenue greater than economic costs in 2003. Inclusion of government payments enabled the percentage of farms with revenue greater than economic costs to rise to 31 per cent. US government payments in 2003 averaged $US17,000 per specialized wheat farm or nearly 20 per cent of their average gross cash income of $US94,000.

By contrast to their North American and European counterparts, the implication for Western Australian farmers is that their future prosperity, like their recent past, is unlikely to lie in extracting rent via the political economy to lessen the impact of rising fuel prices. Rather it is farmers' abilities to generate profit streams largely devoid of government assistance that will need to remain the focus of their business activity (Kingwell 2006).

(v) Although farmers in Western Australia have adopted fuel efficient production and material handling methods, nonetheless shifts in the enterprise mix of broadacre farming during the last decade have increased the exposure of farm profitability to fuel price increases. Following the collapse of the Reserve Price Scheme for wool in the early 1990s was a period during which wool prices, relative to grain prices, were relatively unattractive. In the mid-1990s the twin combination of some favourable seasons and historically high prices for grains, especially wheat, encouraged many farmers to switch away from wool production into grain production. As shown in Table 2 there is currently about 50 per cent more land sown to broadacre crops in Western Australia than was the case around 1990.

Table 2: Historical areas sown to main broadacre crops in Western Australia (‘000 ha)

	Wheat	Lupins	Barley	Oats	Canola	Total	Total (as % of area in 1990/1)
1990/1	3611	665	494	322	2	5094	
1993/4	3852	930	799	268	36	5885	116%
1997/8	4205	1207	1036	305	248	7001	137%
2002/3	4458	795	1140	314	349	7056	139%
2003/4	4917	667	1278	344	358	7564	148%
2004/5e	4900	700	1300	300	350	7550	148%

Many farms have become more crop dominant which means their reliance on and business risk exposure to upward movements in fuel prices has increased. Further, farmers have switched toward canola, barley and wheat production, all of which require nitrogenous fertilisers. By contrast, since the mid-1990s farmers have decreased their lupin production; a grain legume not requiring nitrogenous fertilisers.

For nitrogenous fertilisers, natural gas is a primary raw material required for the production of ammonia which is the foundation for virtually all forms of nitrogen fertiliser. An average North American ammonia factory requires about 33.5 million British thermal units (MBtu) to produce one tonne of ammonia. In the United States, for example, when natural gas is priced at about US$10/MBtu, one tonne of nitrogen fertiliser will cost about US$365 to produce {33.5 MBtu x $10 + $30 (fixed cost)} compared to about US$160 in 2002. Natural gas costs are currently over US$10/MBtu compared with prices of between US$2 to US$4/MBtu in 2002. Natural gas represents 70 percent to 90 percent of the production cost of one tonne of anhydrous ammonia - the building block for most other forms of commercial nitrogen plant nutrients. Because fuel prices are correlated (not perfectly) with energy prices, higher prices for petroleum and diesel can mean, but not always, higher prices for other energy products such as natural gas. When upward movements in both commodities occur then the profitability of grain production, especially cereals and canola, is adversely affected.

(vi) The fact that most broadacre farmers have already adopted fairly fuel efficient crop establishment and crop harvesting methods means the technical option of changing crop establishment methods to lessen fuel costs is not an option for the current generation of farmers, unlike in the 1980s. So many farmers will need to look elsewhere for other options.

What can farmers do?

In a world of higher fuel prices and more expensive energy that raises the prices of some other agricultural inputs, the main options available to farmers are:

(i) alter their enterprise mix on the basis of medium term prospective relative profitabilities of various enterprises. For some farmers this may mean a gradual switch into extensive, low input grazing systems. For others it may mean integrating an intensive grazing enterprise within the farm business. For others it may mean greater opportunism in cropping through changes in the types of crops grown, rather than adherence to fairly rigid rotation sequences. Finally, for some farmers it may mean producing special crops (e.g. industrial oilseeds, oil mallees or high starch wheat) that are sources of re-newable fuel.

The higher prices of fuel and fertilizers may suggest that some farmers should switch to grain and pasture legumes as sources of nitrogen for cereal and oilseed crops rather than continuing to rely on bag nitrogen. Certainly the higher prices of nitrogenous fertilisers and the lack of prospects of an offsetting upward movement in cereal prices, when combined with forecast continued favourable sheepmeat margins, suggests that mixed enterprise farmers who have increased the relative size of their prime lamb and sheep enterprises will continue to benefit and avoid some of the higher bag nitrogen costs of their crop dominant neighbours. Their greater commitment to leguminous pastures and finishing stock with relatively cheap feed grains is likely to remain a profitable venture. However, the wisdom of crop dominant farmers switching away from cereal cropping into much less crop dominant farming systems is questionable. Firstly these farmers are unlikely to have the stock numbers to capitalize on a shift toward more pasture and livestock, plus purchasing the sheep is a major capital investment. Secondly, crop dominant farmers may not have the time and knowledge to run a highly profitable sheep enterprise. Thirdly, given the very low price of lupins relative to wheat and barley, any shift into lupins and out of cereals is unlikely to boost profits in many situations. So although in theory it may seem desirable to lower the cost of bag nitrogen by substituting with other sources of biological nitrogen; in practice the transition costs and management skills required may make the wisdom of any large scale shift very suspect.

(ii) Take advantage of further economies of size to lower production costs or at least to lessen the costs of production increases attributable to higher fuel and energy prices.

(iii) Re-assess crop production systems to apply optimal rates of fertiliser tailored to seasonal and price conditions and ensure work practices (crop establishment, harvesting and cartage) are time and energy efficient. The focus of this reassessment is not just to identify cost savings but to identify profit-maximising strategies. Cost saving alone can be false economy because there is an optimal level of expenditure required to maximise returns. Failure to purchase and apply appropriate inputs only reduces farm profits. What that appropriate level of input purchase is, is a farm specific and season specific question.

(iv) Seek cheap sources of main inputs (fuel, fertilisers, chemicals) through bulk or co-operative purchases or engage in on-farm production of biofuel.

Are biofuels the answer?

As the prices of petrol and diesel have increased in recent years, attention has been drawn to the merits of farmers producing biofuels. A popularly quoted option for farmers is biodiesel. Typically this involves using a vegetable oil and subjecting it to a chemical transformation that then enables the resulting product to be used as is or blended with distillate, in some proportion such as 90:10 (B10); 80:20 (B20) or 50:50 (B50). The intention is to substitute an expensive product (refined diesel) for a cheaper product (transformed vegetable oil) in the conviction that the final fuel or blend has similar or identical performance characteristics to the refined diesel.

An overview of the transformation process is given in Figure 3 whereby a vegetable oil and methanol are chemically combined to yield a methyl ester (biodiesel), glycerol and fatty acids. The technical feasibility of producing biodiesel is widely acknowledged and portable plants displaying the production process are available.

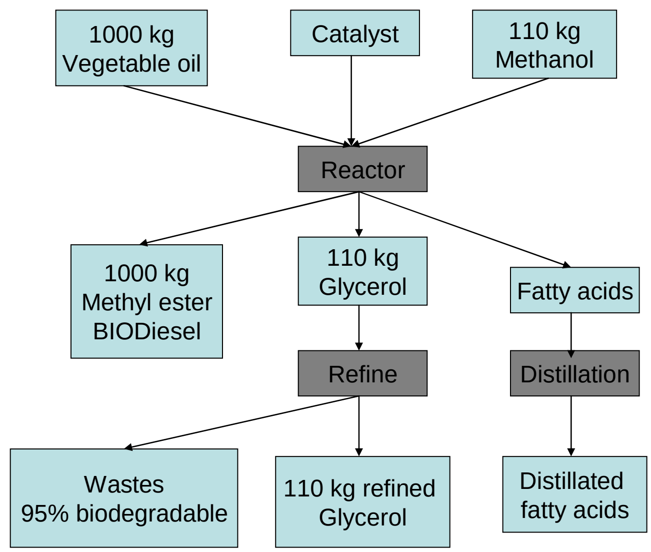


Figure 3: Schematic overview of the production of biodiesel and by-products.
Source: European Commission (2002)

Carter (forthcoming) has analysed the costs of producing 10,000L of biodiesel from 21 ha of canola grown in Western Australia's grainbelt. Key assumptions of the analysis are that the yield of the canola crop is 1.7 tonnes per hectare with 44% oil; its farm-gate price is $317 per tonne; the oil is extracted using a small scale cold oil extraction process and, after chemical catalytic transformation with methanol, an 80:20 (B20) biodiesel blend is created and used in a cropping programme of around 2,400 hectares. Key parameter assumptions and calculated values are listed in Table A1.

Carter included costs of production associated biodiesel manufacture sometimes overlooked in comparative analyses, such as the opportunity cost of the farmer's labour and the opportunity cost of capital. He included the sale revenue of the by-products of biodiesel production. He found that mineral diesel was not yet expensive enough to warrant farmers investing in biodiesel production. Their funds would be better off continuing with production and sale of canola rather than switching resources into biodiesel production based on canola. For the set of price and yield assumptions he used, he found that the on-farm mineral diesel price (that is, the price rebated of excise) would need to rise to $1.15 per litre (currently (April 2006) it is around $1.00 per litre) for a farmer, acting as an investor, to break-even if using an exclusive canola feedstock for the production of biodiesel. Short and Dickson (2004) consider larger commercial biodiesel plants and find that several of the cost of production components can be much lower than the costs considered by Carter. However, Short and Dickson agree that canola (at least based on varieties currently grown) is not a preferred or likely viable feedstock source for biodiesel production.

Note, as pointed out earlier, the break even price will vary depending on the particulars of the farming system in question. For instance, a lower input system is likely to have a lower break even price.

The rise in mineral diesel prices during 2005 (see Figure 1) has reduced the current economic losses likely to be associated with on-farm production of biodiesel based on high quality canola seed. However, the 2005 and forecast 2006 pool prices for canola are around $345 per tonne, over $15 per tonne above the canola price used by Carter, thereby lessening the incentive to use canola for on-farm production of biodiesel.

The relative profitability of biodiesel production is affected by an array of influences. Sensitivity analysis reveals what changes in these influences are needed before production of biodiesel is economic. As listed in Table A1 some of the main cost components associated with on-farm production of biodiesel are the costs of methanol (28c/L biodiesel), labour costs (27c/L biodiesel), the opportunity cost of the canola oil (43 c/L biodiesel) and fixed costs of biodiesel production (13c/ L biodiesel). With economies of scale and co-operative ownership of a biodiesel plant it is feasible to lower the labour and fixed costs and perhaps the cost of methanol. However, the opportunity cost of the canola oil would remain high, based on recent and predicted pool prices.

The key issue in biodiesel production is provision of cheap substrate or feedstock as shown in Table 3. The preferred sources for biodiesel production are used cooking oils, tallow and palm oil; rather than canola seed or canola oil. However, for some farmers in some regions, gaining access to sufficient quantities of reasonably priced used cooking oils, tallow or palm oil may be difficult, so mustard or canola may be preferred due to their reliable local availability.

Table 3: Comparative fuel costs in 2004

Fuel type	Price ($/L)	Equivalent oil price as $AUD/barrel
Unleaded Petrol	0.31	49.28[a]
Diesel	0.34	54.05
BIODIESEL		
Used cooking oils	0.35	55.64
Canola seed	1.01	160.57
Tallow	0.66	104.93
Canola Oil	1.19	189.19
Palm Oil	0.75	119.24
ETHANOL		
Waste starch	0.18	28.62
C Molasses	0.26	41.33
Sorghum	0.37	58.82
B Molasses	0.48	76.31
A Molasses	0.71	112.88

[a] Equivalent to $US 36.96/barrel
Source: Short and Dickson (2004)

Biodiesel offers the advantage of being able to be produced locally with limited technical skill and requiring a modest capital investment. Large scale industrial production is planned in Australia so that total biodiesel production in forecast to be around 500ML by 2006 -07 (Biofuels Taskforce, 2005), based largely on tallow and imported palm oil. Presumably this production will be geared towards markets with specific needs for biodiesel and segments of the market with higher effective excise than farmers. Similarly, around 1000ML of ethanol production capacity is planned in Australia over the next few years. Again, this production is likely to be geared towards to general market rather than farmers per se. Hence, it is possible that in the medium term if there is greater interest in use of ethanol blends rather than biodiesel blends then some farmers may benefit, mostly through greater demand for their cereals that have a high starch content. Further, depending chiefly on the price of petroleum, it is very conceivable that farmers could profit from growing oil mallees as a feedstock for ethanol production. Oil mallees have some highly desirable characteristics that potentially make them very attractive as a future feedstock for biofuel production (Wu *et al*. 2005).

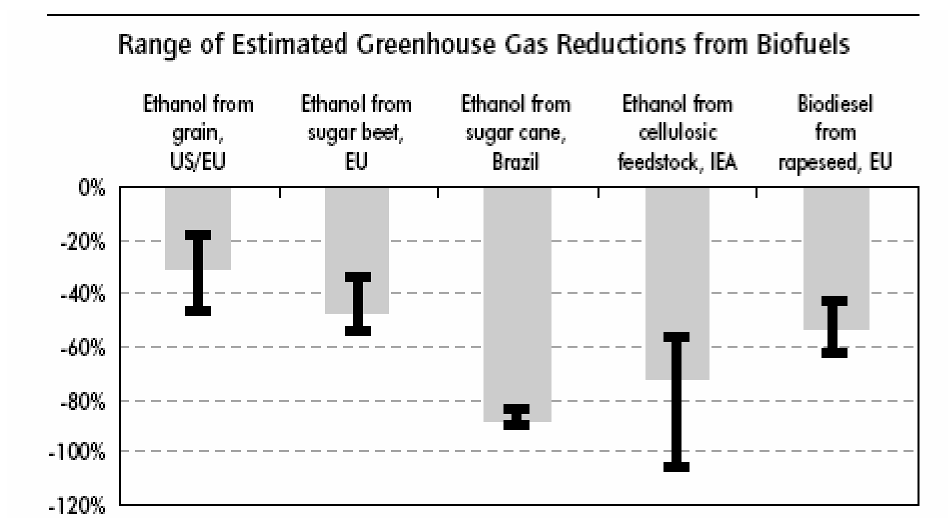
To make an oilseed crop more commercially attractive as a feedstock for biodiesel production requires the development of an oilseed crop that is relatively cheap to grow and which has high yield of oil per hectare and has a comparative advantage over traditional oilseed production. For example, if the new oilseed crop could be profitably grown in environments or locations not suited to current oilseed varieties or if it had agronomic or economic characteristics that ensured its comparative advantage over other possible crops grown at that location then a case could be made for its use in biodiesel production. For example, CLIMA and the Department of Agriculture are developing oilseed species and varieties especially for biodiesel production. It has identified some promising oilseeds such as lines of mustard that produce high yields of low quality oil. That is, the oil is not suitable for human consumption but suitable for biodiesel production. The economic issue is whether or not it is preferable to grow a conventional canola variety or to switch to a much higher oil-yielding seed that cannot be used to produce oil for human consumption but only for industrial purposes. If the sale price of this seed is much less than that of a conventional canola variety, then unless the oil yield is sufficiently high or the costs of production are sufficiently lower then it will be unprofitable for a farmer to switch crops.

In summary, it is likely that biofuels, especially fuel blends, eventually will become attractive as a fuel source, in the face of further rises in petroleum and mineral diesel prices. Currently, ethanol offers cost advantages for blending with petroleum due to its cheaper sources of feedstocks. At current costs and prices, on-farm production of biodiesel is likely to be commercially questionable in many settings. However, if cheaper or more suitable feedstocks become available or significant reductions in processing costs are achieved through economies of size and capital sharing or if fuel prices continue to escalate then in some situations on-farm or localized production of biodiesel is likely to become justified on commercial grounds alone.

Other Issues

Environmental and Health Benefits

The environmental and health benefits of biodiesel are well-documented. Cleaner and renewable, biodiesel cuts exhaust emissions, minimising black smoke, odour, greenhouse gas emissions (see Figure 4), air toxins, particulates and does not contribute to sulphur dioxide (SO_2) emissions (acid rain).



Note: This figure shows reductions in well-to-wheels CO_2-equivalent GHG emissions per kilometre from various biofuel/feedstock combinations, compared to conventional-fuelled vehicles. Ethanol is compared to gasoline vehicles and biodiesel to diesel vehicles. Blends provide proportional reductions; e.g. a 10% ethanol blend would provide reductions one-tenth those shown here. Vertical black lines indicate the range of estimates.

Figure 4: International estimates of greenhouse gas reductions from use of biofuels
Source: International Energy Agency (2004)

As a pollutant (e.g. fuel spills) biodiesel is non-toxic and degrades approximately four times faster than diesel. Within 28 days, pure biodiesel degrades 85 to 88% in water. Biofuels provide air quality benefits when used either in pure form or as a blended fuel. Benefits from ethanol and biodiesel blending into petroleum fuels include lower emissions of carbon monoxide (CO), sulphur dioxide (SO_2)

and particulate matter. Biofuels are generally less toxic than conventional petroleum fuels and in some cases reduce wastes through recycling – in particular agricultural wastes from cropland and waste oils and grease that can be converted to biodiesel. However, the use of biofuels can also lead to increases in some categories of emissions, such as evaporative hydrocarbon emissions and aldehyde emissions from the use of ethanol.

Biodiesel has a similar skin irritation effect to soapy water, therefore does not cause diesel dermatitis.

Are biofuels safe for use in agriculture?

In Europe where pure biodiesel and biodiesel blends have been in use for many years, major manufacturers of agricultural equipment have offered warranties for use of biodiesel. For example, warranties supporting the use of biodiesel have been issued by leading agricultural manufacturers including John Deere, Case-International Harvester, Ford and Same (Australian Renewable Fuels Limited 2005). In the United States, where biodiesel blends rather than pure biodiesel is much more common, most manufacturers have declared that use of biodiesel up to B20 blend will not void their materials and workmanship warranties, providing that the biodiesel is manufactured to a regulatory standard. In Australia, tests of blends of up to 10 per cent ethanol exhibit no adverse impact on new vehicle performance (Short and Dickson 2004).

Regulatory Requirements

Biodiesel is subject to the excise regulatory system when produced. The excise rate (38.143c/L) is the same as low sulphur mineral diesel. Manufacturers of biodiesel receive a rebate equivalent to the full excise rate. This will remain in place until 2011 and then be phased out over the next 5 years. The manufactured biodiesel must comply with Australian standards and records must be kept for inspection. The cost to test biodiesel to the current standard is approximately $3000 (Hobbs 2005). This implies a high per unit cost of testing for small on-farm batches of biodiesel. In addition, those who make or store biodiesel must be registered with the ATO as a fuel manufacturer to preserve the integrity of the excise system. The production premises and storage facilities must be registered, and it is necessary to maintain and keep well documented records for 5 years.

Similarly, ethanol is subject to the excise regime. The chief differences are that the excise on ethanol will rise to a lower level than biodiesel and ethanol imports attract an effective tariff of full excise. This further implies that overall production of ethanol will be greater than overall production of biodiesel.

According to Hobbs (2005), in 2004 the passing of the Energy Grants (Cleaner Fuels) Scheme Bill 2003 mandated the taxation of the biofuels industry in Australia. This legislation saw the introduction of a mandatory registration scheme for all producers of biodiesel, with the collection of excise backdated to September 2003. All producers of biodiesel are required to register for the scheme. There is no exemption for 'personal use' or 'non commercial production'. It is illegal to produce 'home made' biodiesel or unlicensed biodiesel. Registration is on an annual basis.

Conclusions

Broadacre farmers in Western Australia are understandably concerned about high prices of fuel. Expenditure on fuel and fuel-related services such as freight form a main component of their business costs. The export-oriented nature of most farm businesses means they are not able to directly and fully pass on their increased costs of production attributable to higher prices of fuel and energy. They are price-takers on international markets.

Farmers also face other circumstances that increase their exposure to higher fuel and energy prices. They have already adopted energy efficient crop production techniques such as single pass crop establishment and there are no immediately available profitable options to greatly reduce fuel use in cropping. Moreover farmers over the last decade have altered their enterprise mix and allocated more farmland to cropping. Hence their business structures have increasingly revolved around their cropping enterprises which, relative to animal grazing enterprises, are greatly reliant on fuel and transport services. Further, broadacre farming is already experiencing the challenge of a decline in its natural environment. Indications of adverse climate change are already apparent and the gradual spread of salinity is reducing the stock of arable land. So rising fuel and energy prices are but another serious challenge to the profitability of farming.

In response to rising fuel and energy prices, should farmers engage in on-farm production of biofuel? The particular case of on-farm biodiesel production based on canola was examined. Currently (April 2006), the economics of such biodiesel production are not yet favourable in many settings. In many cases, diesel prices are not yet high enough to justify the farmer investing in their own on-farm production of biodiesel from canola. However, in the near term, especially if fuel prices continue to rise, it is conceivable that an economic case for biodiesel could be made, especially in regions where fuel will become increasingly expensive, where economies of size and capital sharing advantages could be on offer and/or where cheap feedstock is available or is likely to be developed. Also, if fuel prices continue to rise then the production of oil mallees as a feedstock for ethanol production also becomes increasingly attractive as does the production of high energy feed grains for ethanol production.

References

Australian Renewable Fuels Limited (2005) Warranties. Fact Sheet No. 5. Available at http://www.arfuels.com.au/default.asp?V_DOC_ID=899

Biofuels Taskforce, August 2005, *Report of the Biofuels Taskforce to the Prime Minister*, Australian Government

Carter, C. (forthcoming) Economics of biodiesel using canola. FarmNote, Department of Agriculture, Western Australia.

CSIRO (2001) Climate change projections for Australia. Melbourne: CSIRO Atmospheric research. http://www.dar.csiro.au/publications/projections2001.pdf [accessed 11 April 2005]

Greenville, J. and Keogh, M. (2005) Agricultural development in Argentina and Brazil: Emerging trends and implications for Australian agriculture. Australian Farm Institute, Surry Hills, Australia, pp.54.

Hobbs, S. (2005) De-centralised energy production. Australian Nuffield Farming Scholars Association, 2003 Scholarship Report, sponsored by RIRDC, pp.45.

Howden, M. and Jones, R. (2004) Risk assessment of climate change impacts on Australia's wheat industry. In Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, 26 September – 1 October 2004. Available at: www.cropscience.org.au

International Energy Agency (204) *Biofuels for Transport: An International Perspective*, Paris Cedex 15, ISBN 92 64 01 51 24, April 2004, pp.215.

John, M., Pannell, D. and Kingwell, R. (2005) Climate change and the economics of farm management in the face of land degradation: Dryland salinity in Western Australia. *Canadian Journal of Agricultural Economics* 53: 443–459.

Kingwell, R. (2006) Is Hanrahan sort of right? Will climate change ruin us all? Invited paper presented at the 50th annual conference of the Australian Agricultural & Resource Economics Society, Feb 8-10, Manly Pacific Hotel, Sydney, pp.22.

Kingwell, R. (Ed) (2003) *Economic Evaluation of Salinity Management Options in Cropping Regions of Australia*, GRDC & NDSP, ISBN 0-646-42276-6, pp.179.

Kingwell, R. and Pannell, D. (2005) Economic trends and drivers affecting the wheatbelt of Western Australia to 2030. *Australian Journal of Agricultural Research* 56:1-9.

Kokic, P., Heaney, A., Pechey, L., Crimp, S. and Fisher, B. (2005) Climate change: predicting the impacts on agriculture: a case study. *Australian Commodities* 12(1): 161-170.

Mullen, J. (2002) Farm management in the 21st Century. *Agribusiness Review* 10: paper 5, http://www.agribusiness.asn.au/Publications_Review/Review_Vol10/Mullen.htm [accessed 14 July 2005].

OECD (2005a) *Agricultural Outloo*k, Organisation for Economic Cooperation and Development, Paris.

OECD (2005b) *Agriculture, Trade and the Environment: The Arable Crop Sector*, pp. 322. Organisation for Economic Cooperation and Development. Available at *http://new.sourceoecd.org/agriculture/9264009965*

Pittock, B. (ed) (2003) *Climate change - An Australian Guide to the Science and Potential Impacts*, Report compiled for the Australian Greenhouse Office, Canberra, Australia. pp. 239. Available at http://www.greenhouse.gov.au/science/guide/index.html

Productivity Commission (2005), *Trends in Australian Agriculture*, Research Paper, Canberra, pp. 170.

Sadler, B. (2002) Is south-western Australia a national canary? Indian Ocean Climate Initiative report, pp.9. Available at http://www.ioci.org.au/publications/reports.html

Short, C. and Dickson, A. (2004) Revised assessment of biofuels industry viability. ABARE report for the Department of Industry, Tourism and Resources, Canberra, April 2004, pp. 21.

Vocke, G., Allen, E.W. and Ali, M. (2005) Wheat backgrounder. Electronic Outlook Report from the Economic Research Service *Wheat Backgrounder / WHS-05k-01.*

Wu, H., Fu, Q., Giles, R. and Bartle, J. (2005) Energy balance of mallee biomass production in Western Australia. Paper presented to *Bioenergy Australia 2005 –"Biomass for Energy, the Environment and Society",* Rydges Hotel, Melbourne 12 – 14 December 2005.

Table A1: Key parameter values and calculated values for on-farm biodiesel production based on canola

Area of oilseed		21	ha
Canola yield		1.70	t/ha
Canola oil % weight		44.0%	
Residual oil (% of total seed weight)		10%	
Total meal produced		1.12	t
Specific Density of Canola Oil		0.914	
Total Oil Produced			L
Methanol Used (% oil volume)		20%	
Volume needed		106	litres needed
Glycerol Removed (% total volume)		25%	
Glycerol volume		190	litres removed
Glycerol weight		169.39	kg
Oil : Diesel conversion efficiency		90%	
Biodiesel produced / ha		**632**	**L**
Canola Price Pool		$328	t
Canola Price Gate		$316.7	t
Value of the Canola Meal		$250	t
Value of Glycerol		$ 0.20	kg
Meal and Byproduct Freight to market		$ 8	t
Cost of Diesel		$ 1.68	L
Energy Grants Credit Scheme	offroad	$ 0.39	L
	onroad	$ 0.19	L
Fuel used in offroad role		80%	
Weighted average EGCS		$ 0.35	L
Value of Biodiesel/diesel on farm		**$ 1.33**	**L**
Glycerol Return		**$ 0.06**	**L BioD**
Meal Return		**$ 0.59**	**L BioD**
Total Return		**$ 1.98**	**L BioD**

Total Tonnage pressed / yr			35.7	t/yr
Potential daily crush capacity			4.00	t
tonnes per hour crush capacity			0.167	t/hr
Total hours per year			214	hrs
Life of Crushing plant			5,000	hrs
Pressing costs			$ 0.07	L BioD
Methanol costs			$ 0.28	L BioD
Caustic Soda Costs			$ 0.01	L BioD
Production Input costs			$ 0.36	L BioD
Labour Costs/Contract Costs	per hour		$15.00	hr
	per litre		$ 0.27	L BioD
Oil Value (opportunity cost)			$ 0.43	L BioD
Byproduct Freight per litre of Biodiesel			$ 0.02	L BioD
Total Variable Costs			**$ 1.07**	**L BioD**
Maintenance costs			3%	of value
Insurance costs			2%	of value
Opportunity cost of capital (interest rate)			7%	
Cost of Oil Extractor			$ 6,000	
Cost of Biodiesel Transesterification Plant			$ 5,000	
Capital Investment			**$11,000**	
Lifespan			23.3	yrs
Salvage return			$ 1,100	
Depreciation			$ 424	Ann.
Fuel Testing			$ 400	Ann.
Total Fixed Costs			**$ 0.13**	**L BioD**
Canola Production	**$275.14**	**ha**	**$ 0.48**	**L BioD**
Whole Farm Overheads (/Ha)			**$ 0.11**	**L BioD**
Total Costs			**$ 1.80**	**L BioD**
Total Costs (-Opportunity cost of Oil)			**$ 1.37**	**L BioD**

Additional Data for Western Australia

Industry			**2000/1**	**2001/2**
Wheat	Expenditure on fuel, oil & grease	$	35122	32350
	Total cash costs	$	419205	497400
	Expenditure on fuel, oil & grease as a % of total cash costs	%	8.4%	6.5%
Mixed	Expenditure on fuel, oil & grease	$	21895	21440
	Total cash costs	$	280517	340140
	Expenditure on fuel, oil & grease as a % of total cash costs	%	7.8%	6.3%
Sheep	Expenditure on fuel, oil & grease	$	10860	12340
	Total cash costs	$	171680	186990
	Expenditure on fuel, oil & grease as a % of total cash costs	%	6.3%	6.6%
Beef	Expenditure on fuel, oil & grease	$	7910	7920
	Total cash costs	$	128202	149850
	Expenditure on fuel, oil & grease as a % of total cash costs	%	6.2%	5.3%
Sheep-Beef	Expenditure on fuel, oil & grease	$	12222	17070
	Total cash costs	$	172373	243950
	Expenditure on fuel, oil & grease as a % of total cash costs	%	7.1%	7.0%
Dairy	Expenditure on fuel, oil & grease	$	13214	16050
	Total cash costs	$	293612	322310
	Expenditure on fuel, oil & grease as a % of total cash costs	%	4.5%	5.0%

Source: ABARE (2004) Australian Farm Surveys 2004