Hale & Twomey

Enabling Biofuels

Biofuels Supply Options

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Thinking Energy

Executive Summary

An overview of biofuels and biofuels feedstocks supply indicates that for the 2008-2012 time frame sufficient volumes are available to meet the sales obligations contemplated provided there is flexibility to source imports of finished biofuels, most probably ethanol.

Our analysis indicates that biofuels are becoming more competitive with petroleum fuels because of high oil prices but that competitiveness, more particularly in the case of ethanol, will likely depend on the continued zero rating excise rate for industrial ethanol.

Supply of ethanol is feasible for the volumes indicated. A number of countries are increasing biofuels production capability and growth projections are high. But demand projections are also high. However New Zealand's requirements are relatively small in the context of international availabilities and likely trade flows.

We expect imported ethanol will set the benchmark for domestic manufacture. Currently the only ethanol produced in New Zealand is from Anchor Ethanol, which produces ~ 16 million litres per annum. Current oil prices landed in New Zealand would likely attract only about 2-4 million litres of Anchor Ethanol production to a fuels market because of the higher realisation available for the rest of production. Anchor's ethanol production is highly seasonal so this could be problematic for sales obligations defined as set percentages of unit sales. Flexibility for Anchor capacity to process other wastes for a further ~15 million litres would require investment in handling facilities at site.

A relationship between ethanol and oil prices has been observed based on data from 2004. However if oil prices fall domestic manufacture may become unviable raising the question of whether support is needed to minimise the investment risk.

Other feedstocks available include wastes and residues (industrial, agricultural, forestry) and purpose grown crops. New technologies are emerging which may be available toward the end of the target period. High level analysis of MAF returns for agricultural use across New Zealand indicates little compelling argument for converting current agricultural uses to biofuels (using maize as a benchmark for ethanol production) however some farming in particular areas where margins are lower may be attractive for new and emerging technologies. It is too early to say whether this will be an influence on biofuels availability before 2012.

Domestic manufacture of biodiesel is competitive with imported diesel at current oil prices although domestic manufacture faces the same oil price risk as for ethanol. Sufficient domestic feedstock from tallow exists to meet likely volume scenarios over the period 2008 - 2012 but investor confidence is likely to depend on the timing of mandatory requirements. Additional local demand for tallow could increase the domestic price as tallow's value will be assessed as the manufacturer's alternative to import feedstocks.

The impacts of supply on the timing and quantity of the targets will be considered in the Economics section when the influences of distribution and vehicle risks can also be considered.

Contents

1.0 Introduction

This report looks at the supply of biofuels to the New Zealand fuels market as well as supply of feedstock for manufacture of biofuels in New Zealand. It summarises the potential sources for ethanol and biodiesel and examines the options that are most likely to be feasible/economic over the period 2008 – 2012. It also indicates whether other options may become feasible as a result of, for example, changes in emerging production technology.

Currently there are no biofuels being used in commercial quantities in New Zealand. The availability of biofuels domestically for the New Zealand fuels market is limited. There is some production of ethanol which could be used as fuel but this is currently being absorbed in the non fuels market. There is no biodiesel being produced in commercial quantities, although there are a number of production initiatives which are currently being established or are planned for development.

Alcohols are produced by the fermentation of sugars. Traditionally ethanol has been produced from feedstocks with high sugar (or starch) contents. With acid or enzyme pre-treatments ethanol can also be produced from cellulosic (or ligno-cellulosic) feedstocks.

Biodiesel refers to diesel blended with methyl esters derived from animal fats or vegetable oils. Methyl esters are produced by reacting animal fats or vegetable oils with methanol[1]. Glycerine is also produced as a by-product. Biofuel feedstocks may be either "residues" (i.e. waste products from other activities) or "purpose grown". Residues have negligible production costs, as they are a by-product of other activities. However, they can have high collection and sorting costs if they are dispersed over a wide area. Some residues have alternative uses that could compete with biofuels.

Purpose grown feedstocks have costs associated with growing and harvesting the crop. However, purpose grown crops can be specifically bred to have desirable properties for biofuel production and may be less dispersed than some residues.

In this report we consider the availability of biofuels from the processing of currently available domestic feedstocks (such as tallow, waste oil) and waste materials (whey). We also consider the potential quantities available from other types of waste such as crop and forest residues. We consider the potential for biofuels produced from purpose grown crops (such as maize, sugar beet and rapeseed) and consider the potential against alternative forms of land use. For each source we summarise availability, the current market for these materials and their potential for use in biofuels manufacture.

Finally we summarise the international availability of biofuels, the sources of supply and the components making up the cost if they were to be sourced for the New Zealand fuels market.

2.0 Domestic Feedstocks

2.1 Biodiesel from Tallow

Biodiesel produced from tallow is typically produced by the reaction of tallow with an alcohol, such as ethanol or methanol, in the presence of a catalyst. The term generally refers to methyl esters (sometimes called "fatty acid methyl ester", or FAME) made by transesterification, a chemical process that reacts a feedstock oil or fat with methanol and a

[1] Note that the methanol needs to be sourced from a renewable source if the biodiesel is to be considered truly renewable.

potassium hydroxide catalyst. Transesterification results in the production of biodiesel methyl esters and glycerine, a by product which can be used to make cosmetics, medicines and foods.

2.1.1 Current Availability of Tallow

Tallow consists mainly of triglycerides containing fatty acids with 16 or 18 carbon atoms. As a general principle triglycerides containing more saturated acid components have a higher melting point than those with more unsaturated components. Thus tallow has a higher melting point than most oils derived from seeds. More saturated oils have higher melting points than less saturated oils. Raw tallow consists of over 95% triglycerides, the remainder being made up predominantly of free fatty acids[2].

Currently New Zealand produces around 150,000 tonnes of tallow annually from the rendering of waste materials produced from meat processing. Of this volume approximately 130,000 tonnes is exported with the balance absorbed in the local market for use in a variety of applications, including cooking mediums, soaps and industrial applications such as lubricants. Of the volume produced variations in quality are classified according to the amount of free fatty acid (FFA) content, with the lower number indicating lower content levels (and higher accordingly). Of the tallow produced approximately 80% is less than 4% FFA, 15% 10 FFA with the balance being edible grades which are primarily used as cooking mediums. Tallow with higher free fatty acids (FFA) tends to need a greater number of refining processes to convert the higher levels of FFA's. The cost of the higher quality feedstock (such as FFA 4) must be weighed up against the cheaper cost of the refining process.

The production of tallow is spread relatively evenly across New Zealand, but volumes shipped through individual ports around New Zealand differ. Table 1 indicates the ports where tallow is shipped from[3].

Table 1

Source (at port)	'000 tonnes
Bluff	18
Timaru	37
Napier	18
New Plymouth	18
Tauranga	18
Auckland	25
Total	134

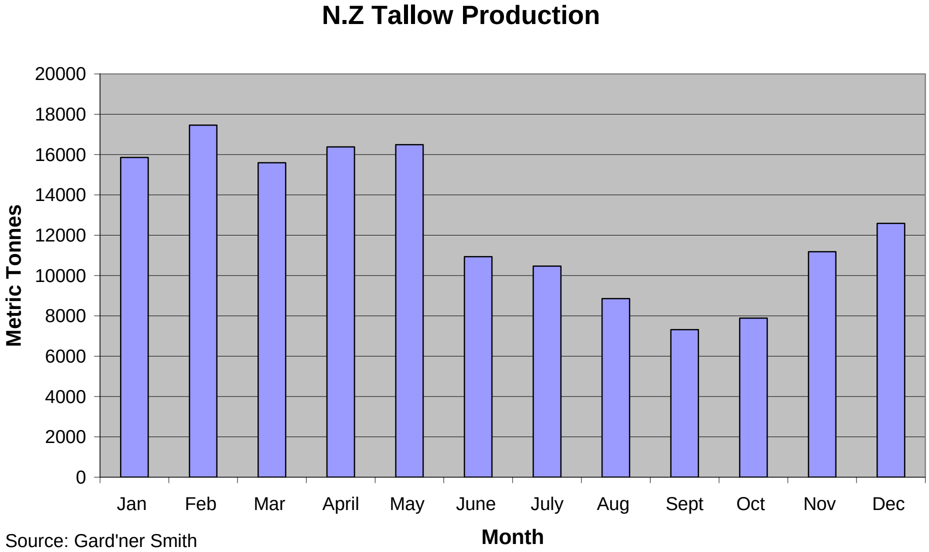
Production varies with the seasonal variation in meat processing. Figure 1 indicates a typical profile of annual production and highlights that seasonal variation in production volumes is significant[4]. Volumes through individual ports can also vary significantly.

[2] Costs of Biodiesel Production, John Duncan 2002

[3] Personal communication, Gard'ner Smith – actual volumes vary; we have applied the percentage guesstimates supplied by Gard'ner Smith to 2004-05 export volumes (see p 30).

[4] Personal communication, Gard'ner Smith

Figure 1



Source: Gard'ner Smith

Of the volumes exported China takes the bulk of the volume (60-70%), with the balance spread between Taiwan, Korea, Pakistan and other Asia/Pacific countries. Of the export volumes approximately 80% is FFA 4, 20% FFA 10.

Production in Australia amounts to 450-500,000 tonnes per year, of which some 60% is exported to the same range of markets. According to industry sources the interest in tallow produced in Australia and New Zealand has been strong following discovery of the first US case of bovine spongiform encephalopathy (BSE) in 2003, which resulted in bans on US beef imports in some Asian countries. Toward the end of 2005 Japan lifted this restriction but re-imposed it in January 2006 after imports of an initial suspect shipment[5]. While it is difficult to draw conclusions about the impact on demand for NZ tallow, industry sources indicate that export outlets regard New Zealand and Australian production as premium products because of the absence of issues associated with BSE.

2.1.2 Pricing

Tallow trades as a commodity although not in a readily accessible way as for petroleum fuels. Price reporting agencies such as Jacobsen quote local free on board (FOB) prices[6] for the US, Australia and New Zealand for a range of grades. Five grades are quoted ranging from highest (1% FFA) to lowest (21% FFA). Price history indicates the grades trade in a strict hierarchy according to their quality.

Palm oil prices are also a reasonable proxy[7] for tallow prices in Asia/Pacific because of similar uses for the two commodities. Palm oil is one of the largest edible vegetable oils produced in the world today with 31.8 million tonnes produced in 2004/5[8]. World palm oil production is concentrated in two major Asian countries, Malaysia (~47%) and Indonesia (~36%). Palm oil plants have a high productivity with average palm oil yields of 3-4 t/ha and with mature well tended plants achieving average yields of 6-7 t/ha, up to eight times greater than for other oil seed crop yields[9]. A combination of US and European tallow and palm oil prices indicate a good correlation since 2000. New Zealand 4% FFA prices from 2003 indicate a similarly good correlation (price lower as FOB price).

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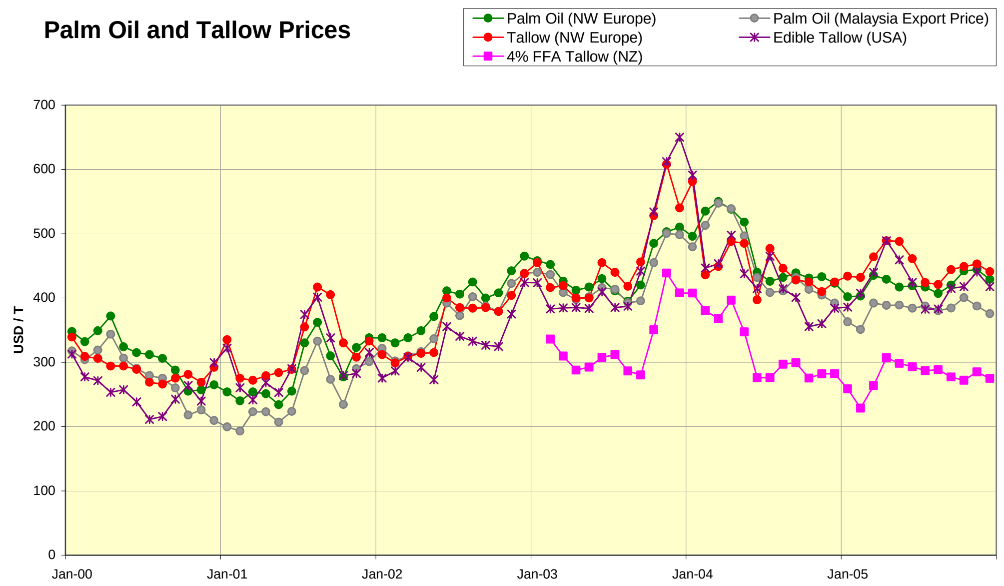
[5] http://www.aginfo.com.au/news_page.php
[6] http://www.thejacobsen.com/index.htm
[7] Personal communication, Gard'ner Smith
[8] USDA, Oil Crops Year Book 2005, Table 47
[9] Page 3, Oil Palm – Achievements and Potential, Mohd Basri Wahid - Malaysian Palm Oil Board

Figure 2



Source: Oil World, + Malaysia Palm Oil Board, +US Department of Agriculture

2.1.3 Growth Outlook

The growth outlook for New Zealand tallow production is considered to be reasonably static to 2009. The 2005 Situation and Outlook for Meat and Wool indicated that total cattle slaughter in June 2006 is forecast to increase by 0.4% as farmers move from beef to sheep farming, with beef numbers predicted to decline as a result. Projections for slaughter indicate a flat to slightly declining profile.[10]

Although domestic tallow volumes looking forward may be relatively static it has been suggested that changes in consumer preference away from saturated to unsaturated fats for health reasons may see a downturn in demand for feedstocks such as tallow with potential for downward influence on tallow price. Whether this would be an outcome for New Zealand produced tallow is difficult to say, particularly given the relatively small domestic demand and continuing demand in export markets.

2.1.4 Logistics

Typical logistics for handling tallow volumes consists of a mixed of bulk shipping and small packed volumes (Isotainers). Logistics would include trucking to bulk storage at ports, storage at ports and shipping to export locations. Of the ports mentioned in Table 1 typical port storage capability would be approximately 7-8,000 tonnes of heated storage. Typical shipping parcels would be in the order of 10,000 tonnes, involving multiple port calls to make a full parcel. Freight rates for tallow shipping are indicated at about $US 65-80/metric tonne for exports to Asia/Pacific. We estimate they could be $US 50-65/metric tonne for a voyage to Australia and could be with in the range $US 35-50/metric tonne for voyages within New Zealand.

2.1.5 Methanol

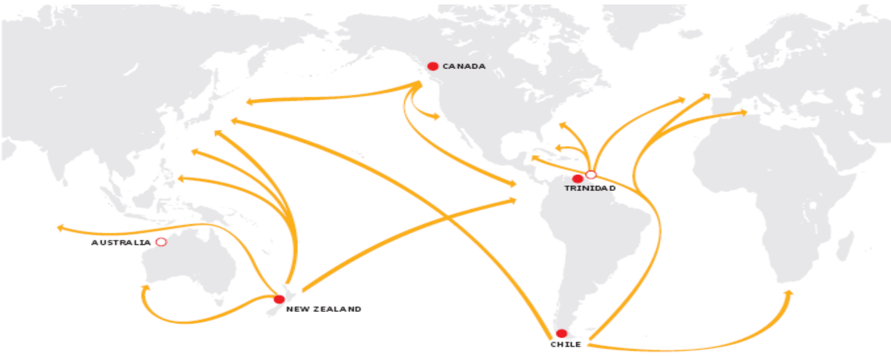
Methanol is an internationally traded commodity produced from a process using natural gas as a feedstock. Methanol is primarily used as feedstock to the chemical industry and as an oxygenated fuel component. Occasionally it is used directly as a fuel and is being investigated as a suitable fuel source for onboard reforming in fuel cell vehicles. There is a growing worldwide demand for methanol.

[10] http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2005/06meatandwool.htm

Methanol is used in many applications (e.g. sports equipment, MDF plywood, paint and adhesives) including MTBE manufacture (a high-octane component used for gasoline blending). MTBE use is however expected to decline because of growing concern about the risk groundwater contamination[11]. Fuel cells are a possible future use for methanol and could significantly increase worldwide demand.

Figure 3 shows the global methanol flows for Methanex, the world's largest producer. Methanex owns two methanol plants in Taranaki, significant scale by international standards (capacity to produce 10% of the world's methanol demand) but lack gas supply. Only the smaller Waitara plant is currently operating and larger Motunui plant has shut down.

Figure 3: Methanex Global Methanol Flows



Source: www.methanex.com

Historically methanol prices have cycled reflecting the balance between supply and demand. High prices caused by lack of supply have encouraged new investment which has lead to a product surplus and a price fall, but with this capital intensive industry with a relatively low cash cost and natural gas offtake commitments it is difficult to subsequently reduce supply. Lately years methanol prices have been above average as shown in Figure 14 (section 6.1.3). For much of the 1990s (and as recently as mid 2001) prices were below US$150/tonne.

The driver of this price has been strong demand and growth, coupled with continued closure of North American plants which has not been fully offset by the new plants commissioned in lower cost countries. Reduction of New Zealand's production with lack of gas availability has added to the strong market dynamics.

Methanol production also competes with other uses of natural gas, such as Urea and/or Liquefied Natural Gas (LNG). LNG use and demand is growing rapidly with a large number of projects worldwide being actively marketed for development. The rise of natural gas prices in the major consuming markets (North America, Europe and Asia) are feeding back through into resource value. This increase in natural gas resource value (also linked to crude oil price increases) is likely to support methanol price to some extent.

2.1.6 By Products

Glycerine is a key by-product from biodiesel production and the current glycerine markets are limited. Although the terms glycerine, glycerin, and glycerol often are used interchangeably there are subtle differences in their definitions. Glycerine is a commonly used commercial name for products whose principal component is glycerol. Glycerin refers to purified commercial products containing 95 percent or more of glycerol. Glycerol is the chemical compound 1,2,3-propanetriol.

[11] MTBE use is currently being phased out in the US.

Glycerine prices in Europe range from $500 to $1 000 per tonne[12], depending on quality and supply availability at the time. Under a scenario of large-scale worldwide production of biodiesel, the excess supply of glycerine could cause its price to fall significantly.

Since glycerine is typically produced at a ratio of 1:10 with methyl ester, the by-product credit of glycerine is on the order of $0.05-$0.10 per litre of biodiesel produced. Biodiesel production costs typically include the glycerine credit. If the market for glycerine becomes saturated and the price of glycerine drops this will have an unfavourable impact on biodiesel production economics.

2.2 Waste Oil Availability

There is limited information available about waste cooking oil availability and price in New Zealand. According to Judd[13] there is likely to be 3,000 to 5,000 tonnes of waste cooking oils available per annum. The report also suggests that the average price could be in the region of $480/tonne (currency unclear) FOB Napier. However this is significantly more generous than a report by the Australian Department of Industry and Tourism[14] which suggests the average price for waste cooking oil in Australia to be $A 170/tonne.

One of the key issues with biodiesel is its cold flow properties (this is discussed further in the Distribution report). It is worth noting that biodiesel produced from Yellow Grease (waste cooking and frying oils) has a wide range of cold flow properties with a cloud point ranging from 8°C to 42°C[15] depending on quality. Its CFPP properties are similar or better than tallow although with a range of 1°C to 11°C[15].

It would seem highly unlikely for stand alone biodiesel plants to be built using cooking oils in New Zealand due to the very small volumes, complex logistics given our sparse population base and also the potentially poor cold flow properties of the resultant biodiesel. However there may be localised opportunities to integrate this feedstock into larger biodiesel plants (e.g. tallow based plants). We would expect pricing to reflect its competitive value as a competing feedstock to tallow, subject to any adjustments reflecting the logistics costs of collection.

2.3 Bio Ethanol

Ethanol is generally produced from the fermentation of sugar or materials that can be converted into sugar such as starch or cellulose. Commonly the process involves the conversion of biomass or starch crops into sugars, fermentation of the sugars into ethanol with the ethanol extracted in its final form by distillation.

Currently the only commercial production of ethanol in New Zealand is undertaken by the Fonterra subsidiary, Anchor Ethanol, using whey. Anchor Ethanol operates ethanol production at three milk processing and casein production locations in the North Island, being Tirau, Reporoa and Edgecumbe (Details of the Process are in Appendix B).

About 15-16 million litres is produced annually, of which 6 million litres are sold for domestic potable use (alcohols etc) and solvents, with the balance 9 million litres being exported to potable and industrial markets. Exports are in both hydrous and anhydrous form. Anchor Ethanol indicates that it has the capability currently to produce 2-2.5 million litres of anhydrous (> 99.8%) for biofuels applications.

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[12] Page 81, Biofuel Costs and Market Impacts, IEA

[13] Biodiesel from Tallow, Barry Judd 2002

[14] Page 55, Appropriateness of a 350ml Biofuels Target, Australian Department of Industry and Tourism

[15] Page 18, Biodiesel Handling and Use Guidelines 2004, US Department of Energy

The possibility exists to increase production capability (in the order of 30 million litres per annum) assuming continuous plant processing (not dependent on seasonal milk production). This would be dependent on receipt of suitable fermentable substrate delivered to the plants. Anchor Ethanol would still expect demand for its ethanol to continue for high value, non fuel use, and would view the availability to the fuels market as an incremental 14-15 million litres.

An emerging factor in Anchor Ethanol's decision making has been the recent strength in international sugar markets (see Section 5.6), which now improves the value to Fonterra for production of lactose sugar. Current international spot prices for ethanol (based on supply from Brazil) could see imports of fuel ethanol costing around $NZ 1.10/litre. At current realization some 2-4 million litres of Anchor Ethanol's current production could be attracted to fuel ethanol, although this would still be unacceptable against the alternative of lactose. For additional production, i.e. diverting whey from edible lactose production, the capital and operating costs are about the same for both lactose and ethanol production, so ethanol would need to compete against the international price of lactose (US$800/tonne). This is equivalent to US$1.60/litre of ethanol (1 tonne of lactose makes 500 litres of ethanol).

3.0 Biofuels from Crop Sources

3.1 Feedstocks

Biofuel feedstocks may be either "residues" (i.e. waste products from other activities) or "purpose grown". Residues have negligible production costs, as they are a by-product of other activities. However, they can have high collection and sorting costs if they are dispersed over a wide area. Some residues have alternative uses that could compete with biofuels.

Purpose grown feedstocks have costs associated with growing and harvesting the crop. However, purpose grown crops can be specifically bred to have desirable properties for biofuel production and may be less dispersed than some residues.

Table 2 shows examples of feedstocks for bioethanol and biodiesel production.

Table 2

Bioethanol	Biodiesel
Residues Whey Crop residues Forestry residues Gorse (?)	Residues Tallow Recycled cooking oil
Purpose grown Crops (e.g. maize, sugar beet, fodder beet) Short rotation forestry (e.g. salix, eucalyptus) Switchgrass, Miscanthus	Purpose grown Oilseeds (e.g. rapeseed, soya, sunflower) Algae (still experimental)

In New Zealand the only commercially produced ethanol is from whey (see section 2.3).

Internationally production of ethanol from crops with starch (or sugar) contents is well-established. In Brazil (currently the largest producer of ethanol) sugar cane is the main feedstock. The next largest producer of ethanol is the USA where grain crops (predominantly maize) are the major feedstock. However, in both countries there are significant subsidies available.

New Zealand is not well-suited to growing sugarcane but maize is currently grown, primarily as animal feed. So there is data available on the productivity of maize in New Zealand conditions. Maize growing is assessed in further detail in section 3.3.3 as an example grain feedstock that could be converted to ethanol using long-established technology.

The Canadian based company Iogen have developed an enzyme process for converting cellulose to ethanol. They have a pre-commercial demonstration plant that can produce ethanol from wheat, oat and barley straw. An earlier report to EECA[16] assessed the potential for ethanol production from putrescible waste in New Zealand. This assessment included ethanol production from whey, waste paper, straw and fruit and vegetable waste.

New Zealand also has a large area in exotic plantation forestry (predominantly radiata pine). Residues from forestry represent a large potential feedstock for ethanol production. However, the technology required for this conversion is not yet commercially available. The potential for ethanol production from forestry waste is examined in section 3.3.1

There has also been research into developing fast growing, high energy density crops specifically for energy applications. These include switchgrass, miscanthus and short-rotation coppicing. A project using salix (a type of willow) is underway in the Taupo region for the production of ethanol and the promoter believes that they could have a commercially viable product within the next five years (see Section 5). In section 3.3.4 we use published data from trials of short-rotation eucalypts in New Zealand as an example of energy farming potential.

Tallow is currently the most promising feedstock for biodiesel production in New Zealand as there are large quantities produced by our meat industry. Internationally vegetable oils from crops such as soy beans and rapeseed are the most commonly used feedstocks for biodiesel production. Rapeseed trial for biodiesel were conducted in New Zealand in the 1970s-1980s.

An Australian company Ozmotech[17] is manufacturing plants to convert plastic waste to diesel (although this is not strictly “bio” diesel). There is also research and development underway at a number of institutes to produce fuels from algae (see Section 5).

3.2 Oil crops

Rapeseed oil is the most common feedstock for biodiesel production in the European Union while in the United States soybean oil is more popular. In both cases there are significant government subsidies. Esters derived from rapeseed oil are referred to as Rapeseed Methyl Esters (RME). When the oil is extracted from an oilseed the remaining cake can be used as animal feed.

It would also be possible to produce ethanol from the residues from vegetable oil production. Vegetable oil also has value as a food product so biodiesel producers would have to offer competitive prices for feedstocks.

Currently there is only a small amount of oilseed produced in New Zealand. In the Agricultural Production Census[18], oilseed production was included within the more general “grain growing” category. For the year ended June 2002, there were 7 384 ha of grain growing farms were planted in “other crops”, oilseed would have been a subset of this area. Therefore it is reasonable to assume that there is < 7 400 ha of oilseed crops planted in New Zealand.

Trials of rapeseed in New Zealand produced 0.8 tonnes oil per hectare planted[19]. Later studies in other countries have found yields of up to 1 tonne rapeseed oil per hectare are

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[16] Waste Solutions Ltd. (2005) Estimate of the Energy Potential for Fuel Ethanol from Putrescible Waste in New Zealand. Technical report prepared for the Energy Efficiency and Conservation Authority.

[17] http://www.ozmoenergy.com/technology

[18] Statistics New Zealand, 2002

[19] Liquid Fuels Trust Board, (1982) – Yields, Costs and Availability of Natural Oils/Fats as Diesel Fuel Substitutes – Report No. LF 2021

possible. 1.0 tonne of vegetable oil or tallow produces approximately 0.9 tonnes biodiesel[20]. Therefore, growing rapeseed in New Zealand could yield a conservative estimate of 0.72 tonnes RME/ha up to 0.9 tonnes RME/ha.

Currently there is not a large area planted in oilseed crops in New Zealand, but there are areas where oilseed crops could be grown if it became economically advantageous. The availability of tallow will limit the price paid for biodiesel feedstocks, while vegetable oils can also be sold as foodstuffs.

3.3 Bioethanol

3.3.1 Residues (Crop and Forestry)

Cropping and forestry typically use only part of the total biomass produced. For example, in forestry the bark and small branches do not become timber. In grain production there is also straw formed.

The Waste Solutions (2005)[21] report estimated the cost of ethanol production from a number of putrescible waste sources – whey, waste paper, straw, kiwifruit, potato and pip-fruit waste as potential ethanol feedstocks. The total ethanol potential of all the major putrescible waste sources was estimated to be 275 million litres/annum.

New Zealand also has a large area in exotic plantation forest (mostly radiata pine). In the year ended March 2004, 40 800 ha of plantation forest was harvested. When a forest is harvested a substantial fraction of the tree biomass is left behind. These residues could later be collected and used for energy. If all the residues from the harvest for the year ended March 2004 were collected there would be over 1 million tonnes of dry matter. Assuming that this could be converted to ethanol at a rate of 252 litres/tonne DM[22] then the ethanol potential of forestry arising would be over 250 million litres. However, removing all the residues from the forest could result in depletion of soil nutrients so in practice the full amount would not be recovered.

Table 3 shows the costs (at farm gate) and productivity for forestry residues compared with cereal straw. The costs have all been converted to 2005 terms using the Consumer Price Index. The costs listed are the additional costs incurred by collecting the residues, the ordinary costs associated with cropping and forestry are not included. Note that the conversion of forestry residues and cereal straw to ethanol depend upon different conversion technologies.

Table 3

Feedstock	Productivity (tonnes DM/ha)	Farm Gate Cost / tonne DM (2005, $)	References
Plantation forest residue	26.6[23]	44	East Harbour Management Services (2002), Hall (2003)
Cereal straw	2[24]	28	Waste Solutions (2005)

[20] Judd, B. (2003) - Feasibility of Producing Diesel Fuels From Biomass in New Zealand. Report to Energy Efficiency and Conservation Authority

[21] Waste Solutions Ltd. (2005) Estimate of the Energy Potential for Fuel Ethanol from Putrescible Waste in New Zealand. Technical report prepared for the Energy Efficiency and Conservation Authority.

[22] Based on near-term yields from NREL 2-stage dilute acid experiments and models using forest slash/thinnings. Reported in table on page 18 of Wastes Solutions (2005) report.

[23] This assumes that all residues are removed from the forest.

[24] It is assumed that an equal amount remains on the farm as animal feed or in the field.

3.3.2 Purpose grown

Crops can be grown specifically as ethanol feedstocks. While waste feedstocks cost very little to produce they may be expensive to collect and there is a limited supply of economically available wastes.

Maize is chosen as an example feedstock from cropping as it is the major feedstock used in the United States for ethanol production[25] and is already grown in New Zealand. Maize will then form a base-line against which new crop types can be assessed.

The disadvantage of arable cropping is that it requires high quality land that will have a high opportunity cost with regards to alternative land uses. Environmental risks associated with cropping include increased fertiliser usage (which can lead to nitrate leaching) and increased erosion risk from the removal of land cover.

With new technologies that can process ethanol from cellulose and likely advances in ligno-cellulose ethanol technology it becomes possible to consider growing high producing grasses and fast growing trees as ethanol feedstocks. These feedstocks can be grown on less productive land and produce high yields of biomass.

3.3.3 Crops

In this section we examine maize as an example of ethanol production from grain crops. Ethanol production from maize is mature technology and is widespread in the United States. Maize is also an existing crop in New Zealand which means that there is existing expertise in maize production.

Table 4 shows maize productivity and costs for the Waikato/Bay of Plenty region. The productivity of a farm can vary significantly from year to year due to weather conditions, there are also significant variations between farms. As the production costs are not reduced in years of poor yield, the gross margin per hectare varies significantly between years.

Table 4

Crop	Productivity (tonnes DM/ha)[26]	Farm gate cost of production[27] ($/ha)	Price received ($/tonne DM)	Gross margin ($/ha)
Maize grain	10.5 – 12	2 263	280	677 – 1097
Maize silage	18 – 22	3 171	210	609 – 1449

Source: Ministry for Agriculture and Forestry

The IEA[28] uses an ethanol yield from maize (corn) of 347-480 litres/tonne. We have used a yield of 408 litres/tonne:

Table 5

Maize (grain)	
Total yield (year ended June 2002)	148 847 tonnes
Total area planted (year ended 2002)	14 166 ha
Ethanol yield (litres/ha)	4284
Ethanol potential of maize grain harvested in year ended June 2002	60.7 million litres
Ethanol feedstock cost ($/litre)	0.69

[25] This will, at least in part, be due to the fact that the US has a large and highly subsidised maize industry.

[26] Average values for the Waikato/Bay of Plenty region for the years 2001/02 to 2004/05

[27] Based on MAF monitoring farms costs for 2004/05. Costs included are: cultivation, base fertiliser, sowing, seed and treatment, starter fertiliser, weed control, nitrogen (sidedressed), harvesting, inoculant (silage only), cartage, stacking/covering (silage only), drying (grain only), and interest on inputs.

[28] Fulton, L., Howes, T., and Hardy J (2004) Biofuels for Transport, An International Perspective

The ethanol feedstock cost is based on the alternative price of $280/tonne DM that a grower could receive for maize grain.

To produce 100 million litres of ethanol would require just over 23 300 ha planted in maize (assuming an average productivity of 10.5 tonnes DM/ha). However, actual productivity varies significantly from year to year and with location.

3.3.4 Forestry

Radiata pine is widely grown in New Zealand plantation forests. It is relatively easy to convert pasture to forestry, although more work is required to convert land from forestry to pasture. Existing forestry production could be used or additional forestry area could be planted to provide biofuel feedstocks.

However, if forests are to be planted specifically for energy, yields can be obtained by planting fast growing species that can be harvested on a shorter rotation (4-10 years; see Section 5).

Field trials of short rotation eucalyptus have been conducted in New Zealand. Table 6 shows the potential of short rotation eucalyptus (assuming a 4 year rotation). Similar results should be possible for other short rotation forest systems.

Table 6

Short-rotation Eucalyptus (4 year)	
Productivity (tonnes DM/ha/year)	20[29]
Farm gate cost ($/ha)	512
Farm gate cost ($/tonne DM)	25.6
Ethanol yield (litres/ha)	4980[30]
Ethanol feedstock production cost ($/litre)	0.10

Source: Sims, Venturi (2004) *Biomass and Bioenergy* (26), 27-37; East Harbour Management Services (2002) Drivers of Woody Bioenergy in New Zealand.

Short rotation forestry is not yet commercially established in New Zealand. So the feedstock cost has been set equal to the cost of production rather than the current market price for the feedstock.

To produce 100 million litres of ethanol from short-rotation eucalyptus coppicing would require just over 20,000 ha. This is about 1.1% of the current plantation forest area in New Zealand.

3.3.5 Other sources

There have been some studies on growing high-producing grasses such as miscanthus as energy crops. Gorse is a widespread pest plant in New Zealand that nonetheless represents a significant biomass supply. If gorse-covered land was cleared there would be potential for a short term biofuel source.

3.4 Land area potential

Figure 4 shows a map of New Zealand which indicates suitability of land for cropping based on Landcare Research Ltd’s New Zealand Land Resource Inventory database. These broad suitability classes are derived from climate, soil and topographic data. More detailed analysis is required to identify the most productive areas for specific crop types.

[29] Reported values range from 15 – 25 tonne DM /ha. Note that this is on the basis of productivity per hectare planted, only 1/4 of the planted area is harvested in any given year.
[30] Assuming ethanol yield similar to the theoretical near term yield from poplar (249 litres/tonne DM), quoted on page 18 of Waste Solutions (2005).

Figure 4

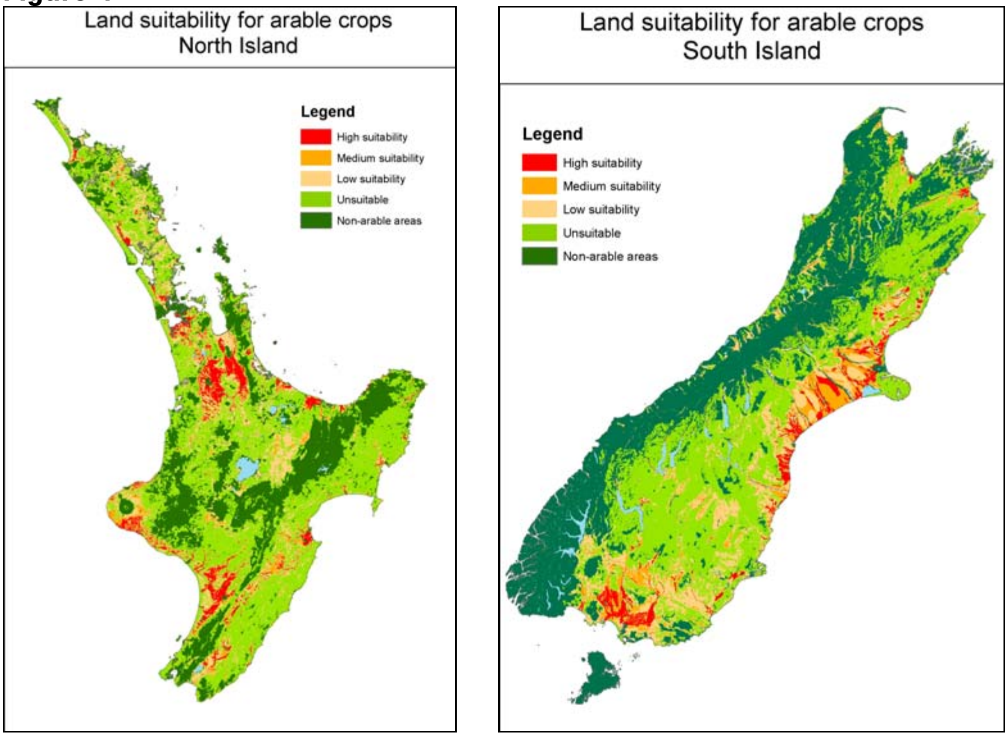
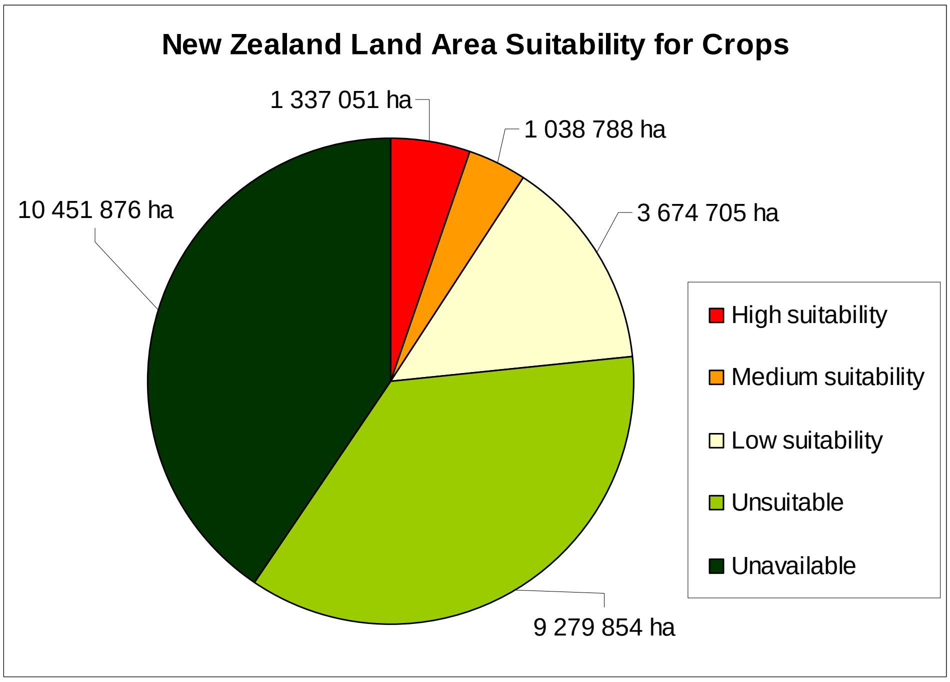


Figure 5 shows the total land area according to the suitability classes in Figure 4.

Figure 5



The suitability for each class is described in Table 7.

Table 7

Suitability Class	Area (ha)	% of total New Zealand land area	Description
High	1 337 051	5.2	Highly versatile land with no (or very slight) limitations to arable use.
Medium	1 038 788	4.0	Land suitable for arable cropping with moderate restrictions due to soil or climate factors (can be managed).
Low	3 674 705	14.3	Severe limitations to arable use. More suitable for pasture or forestry.
Unsuitable	9 279 854	36.0	Unsuitable for cropping. Some areas still suitable for pasture and forestry.
Unavailable	10 451 876	40.5	Land not available for farming. This includes urban areas and areas still in natural land cover.

Note that areas suitable for cropping will also support pasture and forestry.

Table 8 shows the land areas identified by Harris et al. (1979) suitable for selected energy crops:

Table 8

Crop	Total suitable land area (ha)
Maize	2 447 000
Beet	3 089 700
Radiata Pine	7 057 500

Note that there is significant overlap in the land areas suitable for the different crop types. Also in the Harris assessment only cities, boroughs, town districts, national parks, reserves and water supply areas (as of 1979) were excluded as “unavailable”.

Seasonality

Wood can be harvested year round and can be stored. Spring sown cultivars of rapeseed are the most appropriate for New Zealand[31]. These are usually sown in October and harvested in February. Maize is harvested in autumn.

3.5 Alternative land use values

There are opportunity costs involved with growing biofuel feedstocks. The first is that the feedstock itself may have alternative uses as food, animal fodder, fibre or fuel for direct combustion. There are also the competing land uses that need to be considered. All other things being equal, a farmer will want to use his land in the most profitable way possible. However, not all land is suitable for all types of farming.

In this section we compare different farming activities on the basis of their gross margin per hectare. The gross margin is defined as “Revenue – Cost of goods sold”. The gross margins were calculated from data in the Ministry and Agriculture and Farming “Farm Monitoring Reports”.

[31] Liquid Fuels Trust Board, 1982

In order for it to be financially beneficial for a farmer to switch to growing biofuels, the gross margin obtained by growing biofuels needs to be higher than the gross margin for alternative land uses.

The costs included in the "cost of goods sold" for each farm type is listed in Appendix A. Note that costs such as fertiliser and re-grassing are often not included in the gross margins for pastoral farming. However, they have been included in this analysis so that the comparison with crop farming is made on a similar basis.

Table 9

Region	Farm Type	Estimated area (year ended June 2003, ha)	Gross Margin (3 year average, 2005$/ha)
Northland	Dairy	169 000	1 386
	Sheep and beef	315 000	360
South Auckland/ Waikato	Vegetables Broccoli Cauliflower Lettuce Onions Potatoes (table)	Total NZ area[32] 1 786 1 181 1 287 3 700 3 200	 3 578 2 909 5 010 2 991 2 850
Waikato	Maize Grain Silage	2002 data 3 364 5 706	 1 129[33] 1 160
Waikato/Bay of Plenty	Dairy Intensive Sheep and Beef	706 000 651 000	1 905 590
Central North Island Hill Country	Sheep and Beef	Not suitable	304
Gisborne Large Hill Country	Sheep and Beef	Not suitable	201
Hawkes Bay/Gisborne	Vegetables Squash Sweetcorn (process)	Total NZ (02/03) 6 804 7 041	 1 174 1 424
Hawkes Bay/Wairarapa Hill country	Sheep and Beef	Not suitable	380
Manawatu/Rangatekei	Intensive Sheep and Beef	830 000	691
Lower North Island	Dairy	355 600	1 664
Canterbury	Dairy	185 700	2 236
	Mixed arable/sheep	Can't differentiate from hill country	1 077
	Sheep and Beef (Canterbury Marlborough hill country)	Hill country not suitable for cropping	201
	Sheep and Beef (Canterbury/Marlborough finishing and breeding)	Can't differentiate from other types	409
	Vegetables Peas (process) Potatoes (process) Onions	Total NZ (02/03) 10 931	 1 172 4 692 2 992
Southland	Dairy	130 000	1 866
	Sheep and Beef intensive		683
South Island	Sheep and Beef (Merino)	Not suitable	38

The gross margins in Table 9 are a three-year average of the CPI adjusted gross margins from the MAF farm monitoring reports for the year ended June 2003 to the year ended June 2005. Crop yields are very sensitive to climate conditions in a given year. This means that the gross margin/ha for cropping varies significantly from year to year. For example, for the

[32] Vegetable data for all NZ for year ending June 30 2002

[33] This value is outside the range given in table 4 as the price of maize grain in 2002/03 was $320/tonne of DM. In 2003/04 the price dropped to $280/tonne dry matter and remained at this level in 2004/05

year 2004/05 the gross margins for onion growing were negative. Crop yields can also vary significantly within a region.

The land with the lowest gross margins/ha tends to be hill country which is not suitable for intensive farming (including maize growing). However, there is usually less problem with forestry on rolling land, provided the slope isn't too steep.

To produce 100 million litres of ethanol from maize requires approximately 28 000 ha of land. There is plenty of land currently in intensive sheep and beef farms. Unlike hill country these farms may have areas suitable for growing crops. Maize production could be competitive with intensive sheep and beef farming, provided that good yields of maize could be obtained.

Land in dairying would be suitable for maize growing, but these areas are making higher gross margins than would be made from maize growing. Northland has the lowest dairy gross margins that are still over $200/ha more than would have been made from maize. (Harris et al. (1979) identified about 85 000 ha of land in Northland that was highly suitable for maize).

The Canterbury arable land could be used to grow ethanol crops. Ethanol can also be made from the maize stover. However, this requires a different process than ethanol production from grain.

Using cellulose conversion technology allows grasses and woody feedstock to be converted to ethanol. These have less restrictions on the type of land required (slope must still be gentle enough to allow access to harvesting equipment). These could be grown on the gentler hill country. Assuming that woody feedstocks can be converted to ethanol at a rate of 250 l/tonne dry matter then approximately 20 000 ha of short rotation eucalyptus would need to be planted. Short rotation forestry and grasses such as miscanthus have the advantage that they don't require high fertiliser inputs and may in fact be useful for removing excess soil nutrient in regions where this is becoming a problem with dairying.

3.6 Environmental sustainability

Changes in land use can have positive or negative environmental impacts. Quantifying the impacts of land-use change is complex and depends upon local conditions. The following section discusses some of the environmental impacts that could result from land-use change.

Greenhouse gases - reducing New Zealand's net greenhouse gas emissions is one of the reasons for introducing biofuels. Biofuels are ultimately derived from plant carbon. The carbon emitted when biofuels are burnt had previously been extracted from the atmosphere by plant photosynthesis so the net result is that no new carbon has been added to the atmosphere. However, depending upon how the biofuels are produced there could be additional positive or negative impacts on net greenhouse gas emissions.

Indirect emissions – producing biofuels requires energy inputs to grow and harvest the crop, transport the feedstocks and convert them into biofuels. Heavy use of nitrogen fertilisers can produce nitrous oxide, which is a powerful greenhouse gas.

Unsustainable harvesting – if forests are logged and not replanted then the amount of carbon in the atmosphere will increase as it is not reabsorbed by new plant growth.

Carbon sequestration – converting grassland to short rotation forestry does result in a small amount of carbon sequestration from the atmosphere. The average carbon sequestered is less for a harvested forest than for a forest that is not harvested.

Other land use change effects – agriculture produces just under 50% of New Zealand's total greenhouse gas emissions (Climate Change Office 2005). Of this the most significant fraction is methane from grazing animals. Therefore changing land from pastoral farming to short-rotation forestry will result in lower greenhouse gas emissions. However, high use of nitrogen fertilisers also contributes to greenhouse gas emissions, so the benefits of switching from grazed pasture to cropping for biofuels are less certain and would depend upon the management regimes used.

Soil nutrients - fertilisers are often needed to ensure that soils have sufficient nutrients to sustain plant growth. However, fertilisers are expensive and overuse can have negative environmental impacts (e.g. eutrophication of waters ways, nitrous oxide emissions), so it is generally best to minimise their use.

Removal of residues from cropping and forestry systems for biofuel production means removing a lot of the nutrients that are currently returned to the soil, increasing the amount of fertiliser required to compensate. These nutrients are not used in the biofuel production process and remain in the biofuel effluent streams. Therefore it is possible in theory to return these nutrients by applying the biofuel effluent back to the soil. However, this may not be feasible depending upon transport distances.

Some areas have surplus soil nutrients due to years of high fertiliser use. These cause problems by leaching into waterways and encouraging the growth of algal blooms. In these areas planting short rotation forestry crops can help remove the surplus nutrients from the soil.

Soil erosion - in areas where there is a high risk of soil erosion cropping should be avoided. This is reflected in the land use suitability maps.

4.0 New Technology Affecting Biofuel Production

The technologies for current production of biofuels are fairly mature. Costs will likely decline as a function of scale and as technology continues to improve. However the cost of feedstock is a major component in overall cost which may also be influenced by alternative demand factors. Emerging technologies could offer more cost effective production, in particular the technologies to convert cellulosic feedstock to ethanol. It is generally accepted that these technologies are unlikely to be commercial for at least 10-20 years. Nevertheless some concepts are emerging which may have particular relevance in New Zealand. We consider these in the context of the timetable for the sales targets.

Biojoule – This concept involves conversion of cellulosic biomass to ethanol using hardwoods[34]. The company Biojoule believes it is easier to separate the cellulose from the lignin using hard (willow, salix) rather than soft wood. It is suggested that value is enhanced because higher value products derived from the hardwood lignin can be obtained such as substitutes for polymers used in paints, resins etc and xylose, a sugar substitute. Production in the Taupo region is being considered, using continuous rather than batch processing. A pilot plant is being constructed and company believes it could be in commercial production by 2011, with ethanol production initially around 11 million litres. The plant would require 100 dry tonnes of hardwood feedstock per day. Feedstock would come from purpose grown plantations. All up costs are indicated at $NZ 0.40/litre. Biojoule indicated that economics were competitive with gross margins for typical sheep farming operations in the Taupo area.

Convertech – Developed by a Christchurch based company, Convertech, this technology hydrolyses ligno-cellulosic biomass feedstock through auto steam hydrolysis. The technology utilises a series of high pressure reactor loops to sequentially hydrolyse and separate the input biomass into pentoses, levoglucosan and lignin. These products are then subject to secondary fermentation and refinement to realise ethanol, furfural and other biochemicals.

[34] New Zealand Herald (28 February 2006)

Combustion of waste feedstock heats the process whilst steam recirculation and electricity co-generation minimise the energy consumption of the plant. The Convertech technology is applicable to all types of ligno-cellulosic feedstocks (e.g. hardwoods, soft woods, cereal waste etc.) through simple tuning of the operating parameters. The promoters indicate that a 10 tonne per hour plant could process approximately 1 km^2 of forest per year or 8000 hectares of annual crop. They suggest that 23 such plants could satisfy New Zealand's national demand for a 10% petrol blend.

Algae to Oil – this project involves the deriving of biomass from growing or farming algae in pond water and conversion of the recovered algae into liquid oil fuel. Jointly developed by the Christchurch City Council, Solvent Rescue Ltd and University of Canterbury, the project involves construction of a purpose designed and built ponds for high rate algae growth, harvesting and conversion of algae sludge into oil products. The project indicates that conversion of all oxidation ponds available would support production of between 40,000t and 80,000tonnes per annum dry matter, with at least 50% conversion to crude oil liquids.

A company called LanzaTech is developing processes to produce ethanol using large scale industrial and agricultural waste products as feedstock.

5.0 International Supply of Biofuels

5.1 Introduction

Internationally the two biofuels, ethanol and biodiesel account for more than 90% of total usage[35]. However biodiesel production is relatively small compared to ethanol.

Understanding the availability of ethanol internationally is subject to much uncertainty, given it can be used in the production of other products such as beverages, and industrial applications. As well as that feedstocks for ethanol such as sugar cane can have alternative outlets in sugar production which may have a confounding influence on developing a coherent supply picture. Obtaining accurate data is difficult because of a lack of statistics on trade flows.

A number of countries have programs in place to encourage the uptake of biofuels, which is generating significant interest in the demand for and production of biofuels. Commentators generally point to significant growth in production but there are a number of more recent influences which are contributing much uncertainty about actual availability internationally.

5.2 Ethanol

Total global production of ethanol over 2005 is estimated at around 40 bln litres. Various commentators forecast production to grow at significant rates. Figure 6 is an assessment in 2004 by F O Licht of total global production projected to 2012[36]. A study undertaken by the IEA in 2004 indicates similar levels for current production and expected growth rates.

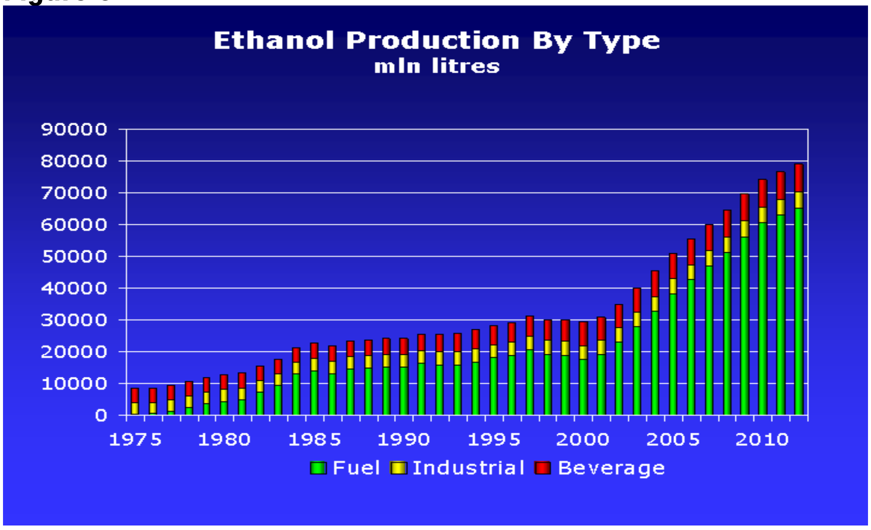
Establishing figures for traded volumes is difficult. Discussions with market participants [37] indicate traded volumes of ethanol internationally are around 2.4 bln litres, of which 1.6 bln litres goes to industrial beverage markets and the balance 0.8 bln litres to the fuels market. F O Licht's analysis would suggest that virtually all of the trade flow came from Brazil.

[35] Australian Biofuels Taskforce Report - http://www.dpmc.gov.au/biofuels/report/report_full.doc

[36] World Fuel Ethanol – Analysis and Outlook by Dr Christoph Berg (April 2004

[37] Personal Communication, ED & F Man, London

Figure 6



5.3 Biodiesel

Production volumes for biodiesel are much smaller at less than 5 bln litres. The bulk of production occurs mainly in the EU and there is little in the way of internationally traded biodiesel. However like bioethanol the impact of various policies supporting biodiesel is expected to see strong growth in biodiesel production as well[38].

5.4 Key Players in Biofuels

Brazil

Brazil is the biggest producer of ethanol, with production volumes in 2004 estimated at 16.9 million m3. Brazil has been a major producer of fuel ethanol since the 1970s following the first oil shocks and its desire to reduce dependency on foreign oil. Over that time the Brazilian government has adopted various support policies to encourage ethanol feedstock plantations based on sugar cane, extend the number of distilleries and encourage the demand through mandated levels of ethanol in petrol and the development of ethanol-fuelled vehicles (flexi-fuelled vehicles). Gasoline blending with 20-25% anhydrous ethanol is mandatory for all gasoline sold in Brazil and regulatory authorities regulate the market through changes within that range. This has enabled vehicles produced to be able to run on these blend levels and virtually all new cars have the capability to safely operate with this level of blend. In 2003 Brazil exported 0.80 million m3 and exports are expected to continue to grow.

United States

The US is the second largest producer of ethanol with production at 12.9 million m3 in 2004[39]. About 95% of ethanol produced comes from corn. Use of fuel ethanol in the US began in the 1970s following the oil shocks but greatly increased in the 1990s following the mandating of defined levels of oxygenates to be contained in gasoline in areas with high levels of petrochemical smog. Although MTBE was the preferred oxygenate initially various US states have moved to ban it because of risk of contamination to underground water. Several initiatives have stimulated the increase in production including tax credits and duties on imports.

A Renewable Fuels Standard has now been promulgated as part of the Energy Policy Act 2005 which requires specific levels of renewable fuels to be sold commencing with 15 million m3 in 2006 and reaching 28 million m3 by 2012. By 2012 this would represent about 4.5% of

[38] Biofuels for Transport, An International Perspective (IEA, page 169)
[39] Australian Biofuels Taskforce (August 2005), p. 58

expected consumption. Targets are not specific to individual market participants and the US EPA has been charged with the task of determining how these targets will be implemented over the period to 2012. Current production levels of biofuels would appear sufficient to meet 2006 mandated levels although there are concerns about market capability to handle the logistical challenges. If planned production capability proceeds, there are suggestions that ethanol production could be in excess of the 2007/08 requirements by the end of 2006. Some market players are speculating that the US could be a net exporter of ethanol.

Europe

Biofuels use in Europe is predominantly focussed on biodiesel. EU directives adopted in 2003[40] encourage the use of biofuels and members have been set non-binding targets to have a 5.75 share of fuels market by 2010. EU production of ethanol is currently around 0.4 million m3 (with Sweden, Spain and France the predominant producers). Biodiesel production which is focussed primarily on production from rapeseed is around 1.5 mln m3 and the bulk of demand is in Germany. The IEA estimates that the EU would require ethanol production to be at 11.4 million m3 and biodiesel production to be at 10.2 million m3 by 2010 to displace 5% of conventional fuels.

Asia

A number of countries have put in place policies to encourage biofuels uptake.

Japan – Japan has proposed an ambitious target of 500 million m3 of target of biomass derived fuels by 2010. A minimum E3 standard has been adopted as it is suggested that a national E10 standard will be proposed for 2010. An ethanol blending ratio at 10% would require around 6 million m3 of ethanol per annum.

India - India has a large sugar cane industry and is producing approximately 0.7 million m3 per annum. Mandatory 5% blend targets are stipulated in 9 states. Bio diesel production is newly emerging. The long term expectation is that India will be a producer of ethanol and a net importer of biodiesel.

China – China is the third largest producer of ethanol with annual production around 3 mln m3 per annum but most is not for fuel use41. China is considering 10% blends for both ethanol and biodiesel. However biodiesel production is minimal. The long term expectation is that China will produce ethanol for its requirements and import biodiesel.

Thailand – Thailand is a major producer of ethanol based on its sugar cane industry. Thailand is proposing targets for biofuel use at 2% of projected energy needs by 2010. Ethanol blending of locally produced ethanol into petrol is strongly encouraged by the government. Currently there is no mandated requirement but MTBE has now been banned from 95 octane. A range of incentives are offered including exemptions on machinery imports and an eight year tax holiday, on the consumer side the Government is expected to impose a nominal excise tax[42] to encourage uptake of Gasohol 95 (a blend of 91 octane petrol with 10% ethanol).

Australia - The Australian government has actively assisted the development of biofuels but has not formally adopted a specific target, although its policy aspiration is to achieve a biofuels production target of 350 million litres by 2010. Current ethanol production capability is about 75 million litres, but recent production has been much lower at just over 20 million litres. Various projects either in development or under consideration could lift Australia's production capacity to 1000 million litres by around 2010. Biodiesel production is only beginning to develop and was estimated at around 15 million litres in 2004-5. However new

[40] Directive 2003/30/EC; 2003/96/EC allowing for preferential tax treatment

[41] Biofuels Taskforce (August 2005), p.64

[42] Page 165, Biofuels for Transport – an International Perspective, IEA

projects have commenced production and a number are proposed (some supported by capital grants), which, if they proceed, could add up to 500 million litres by 2007.

5.5 Financial Incentives Supporting Biofuels

There is a growing consensus that the development of biofuels will deliver social, economic and environmental benefits and that proactive policies supporting development are justified. The range of benefits can be summarised into the following broad categories:

- Encouraging regional development (including provision of agricultural support) – production of biofuels from crops can provide additional markets to farmers and bring economic benefits to rural communities
- Improving urban air quality – biofuels use can provide air quality benefits with lower emissions in key pollutants, such as carbon monoxide (CO) and sulphur dioxide (SO_2)
- Reducing greenhouse gas emissions – studies indicate that biofuels use leads to significant reductions in greenhouse gas emissions (this is more fully discussed in the Economics report)
- Enhancing energy security by replacing petroleum fuels – biofuels can replace petroleum fuels and thereby improve supply security in the event of disruption to energy supply.

The difficulty is in quantifying the costs and benefits of adopting these policies, some of which have interrelated effects. For example while it may be advantageous to encourage production of biofuels from agriculture this may draw crops away from other uses such as food production and increase cost.

Despite these complexities biofuels production internationally is characterised by a wide range of supports and subsidies, reflecting the fact that biofuels has been uncompetitive against petroleum fuels. There a wide range of mechanisms including, subsidies, regulatory preference in the form of exemption from taxes and explicit supply mandates. We discuss the implications of these policies for development of biofuels in New Zealand more fully in the Economics report. A range of support mechanisms are illustrated in Table 10.

Table 10

Country	Size of Biofuels Market	Production Incentives	Demand Incentives
1. Brazil	Ethanol: 12 bln litres m³ Biodiesel: Negligible	Tax incentives, loan assistance, preferential tax rates,	Price controls, incentives for flexible fuels vehicles
2. US	Ethanol: 15 bln litres Biodiesel: 7.9 bln litres	Credit on fuels tax with effective incentive of $US 0.54/gal ($NZ 0.21/litre); ad valorem tariff of 2.5%;	Credit on fuel tax incentive of $US 0.54/gal ($NZ 0.21/litre); ad valorem tariff of 2.5%; state incentives
3. European Union	Ethanol: 0.2 bln litres Biodiesel: 1.2 bln litres	Incentives on plant construction, capital grants	Fuel Tax Exemptions
Excise credits by country ($NZ/litre)			
France			0.71
Germany			1.21
Sweden			1.00
United Kingdom[43]			0.56

[43] Differentiated and varies with vehicle CO_2 emissions

Country	Size of Biofuels Market	Production Incentives	Demand Incentives
4. Asia India China Thailand	Ethanol	Subsidies, tax credits	Fuel tax exemptions
5. Australia	Ethanol: 0.02 mln m^3 Biodiesel: 0.015 mln m^3	Production grants equivalent to fuel tax exemption Production grants equivalent to fuel tax exemption	Fuel tax exemption at $A 0.38/litre[44] for domestic production Fuel tax exemption at $A 0.38/litre[45]

5.6 Prices

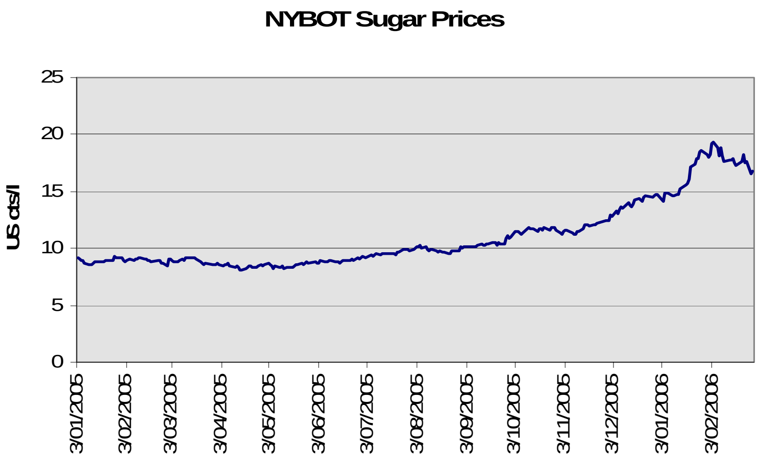
5.6.1 Biofuels Cost

Although biofuels, more particularly ethanol, are regularly traded there is as yet no regularly traded price for ethanol as a commodity in the same way as for oil. Futures markets are beginning to emerge in the US but lack liquidity[46]. Traded ethanol volumes are low relative to total availability. It is therefore difficult to obtain historical price data.

Ethanol prices are currently at high levels historically due to demand pressures from the US RFG program, demand for sugar and climate factors affecting sugar cane yields. Prices ex Brazil are being quoted as high as $US 550m3[47].

International prices for sugar have also increased dramatically (see Figure 8) because of reduced supplies from traditional producers, changes in trade policies e.g. EU reductions in support for domestic sugar and the impact of ethanol demand itself. This is drawing potential sugar cane production away from ethanol production and causing ethanol prices to rise as well. Market players consider that sugar markets may remain tight for the next 2-3 years. This indicates that sugar markets play a key role in the value of ethanol given cane sugar can be used for both sugar and ethanol.

Figure 7



[44] Australian government has announced new arrangements for fuel tax and individual levels will be set based on energy content of the fuel. Current fuel tax exemption for biofuels will reduce in 2015 to $A 0.26 /litre for ethanol and $A 0.19/litre for biodiesel.

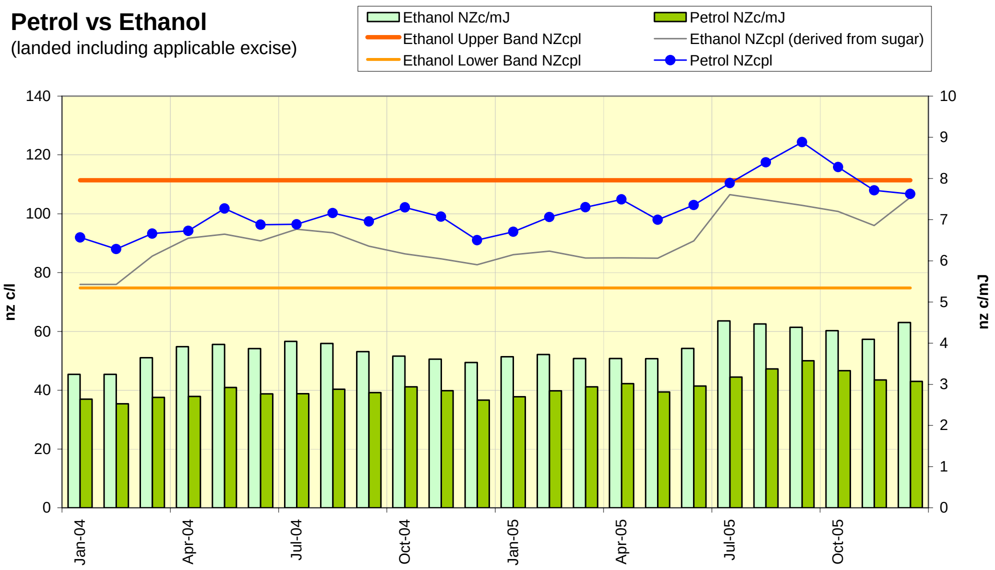
[45] Fuel tax exemption in Australia currently applies to biodiesel imports as opposed to ethanol.

[46] Both the New York and Chicago Boards of Trade have ethanol contracts

[47] Dominion Post (Reuters report), 11 February 2006

The New York Board of Trade (NYBOT) has created an ethanol futures market, derived as a link to sugar contracts, providing a link between ethanol and sugar prices. While there is no direct link between the price of petrol and sugar there may be an indirect link given sugar cane can be refined into sugar or converted to ethanol for subsequent blending into fuel. Sugar markets would need to compete with oil market demand for ethanol as a fuel. In Figure 8 we plot an ethanol price assumed from the price of sugar against the landed price of petrol in New Zealand on a volume basis (NZ cents per litre and NZ cents per megajoule). This shows a reasonable correlation with petrol prices since 2004. As ethanol demand for fuels grows we would expect ethanol prices to more closely correlate with oil markets over time.

Figure 8



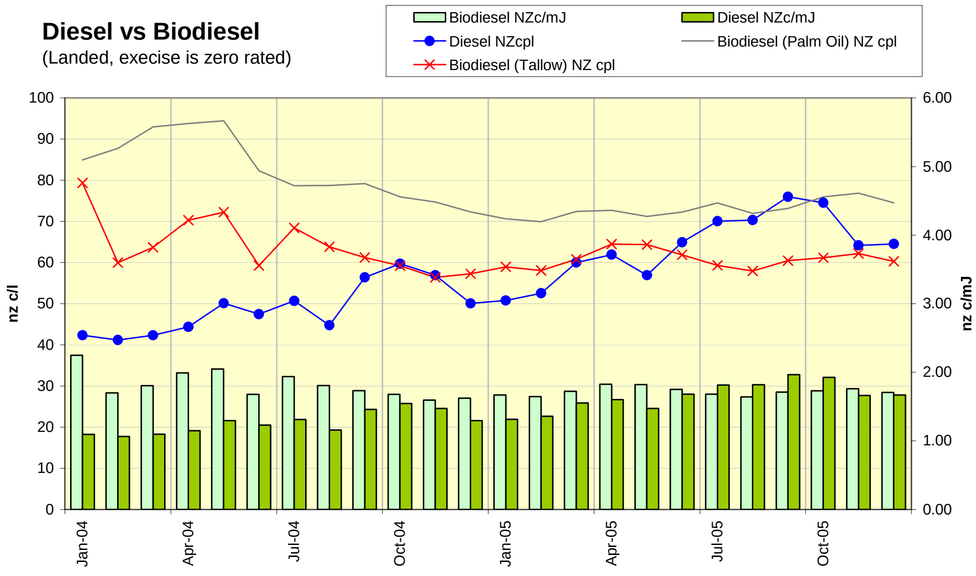
What it suggests is that ethanol prices have maintained a link. Our analysis indicates that a theoretical ethanol price would have tracked on average at about 90% of the landed (excise inclusive) New Zealand petrol price since January 2004 on a volume basis.

Given the lack of ethanol pricing data we have suggested an upper and lower price band to give a possible range of prices. Market feedback indicates that our suggested range is reasonable.

As oil prices have been high over this period is it is reasonable to expect that ethanol prices would become more competitive. However even with high gasoline prices, the data indicates that imported industrial ethanol would need to remain free of duty to remain competitive with gasoline.

Because there is no trade in biodiesel there are no landed prices with which to compare to mineral diesel (as we have done with ethanol above). However to illustrate the influence of prices we have compared diesel prices to the cost of manufacture using commodity prices derived from tallow and palm oil in Section 2.1.2 (Figure 9). Manufacturing costs are discussed more fully in Section 6. The increase in diesel prices, particularly over the last year, indicates that biodiesel has improved its competitiveness. Of note is that diesel prices have been high enough for biodiesel to be greater on an energy basis as well.

Figure 9



5.6.2 Freight Costs

Freight rates for biofuels are a lot more expensive compared to tankers used to carry petroleum products. Because of the inherent product characteristics biofuels and biofuels feedstocks are carried on chemical tankers, which are specialised vessels for the carriage of bulk chemicals, acids, edible oils and other specialty liquids. Tanks are fabricated in stainless steel and ships have the ability to carry multiple parcel cargoes, providing complete segregation from other products.

Freight rates for these sorts of vessels will in general be 2-3 times higher than standard petroleum product tankers (US$ 60-80/metric tonne). However a voyage from Brazil could be two to three times that rate again[48]. If single cargoes could be carried in say 10-20,000 tonnes parcels rates would be lower (around the $US 80-100/tonne mark) but this would depend on the ability to discharge a complete cargo at one port, which is not feasible in the New Zealand context. Carriage of biofuels is a developing area for ship owners and typical voyage patterns are yet to develop. For example Brazilian ethanol could be shipped to Asia/Pacific for bulk breaking to smaller parcel tankers as market dynamics allow. It is difficult to speculate on what this might mean for freight rates. We have assumed ethanol imports at a higher freight rate of $US 200/metric tonne.

Parcel tankers are subject to International Maritime Organisation requirements for the handling of chemicals similar to petroleum tankers. The impact of these requirements is discussed in the Distribution report.

6.0 Manufacturing Costs

The main method currently used in working plants for production of biodiesel involves a transesterification process where glycerine is separated from fat or vegetable oil. The process

[48] Personal communication, Stolt Neilsen Australia

results in two products—methyl esters (the chemical name for biodiesel) and glycerine (a valuable byproduct usually sold to be used in soaps and other products)[49].

As discussed in Section 2.1 because of its availability, tallow is regarded as the chief feedstock source in the short run[50]. Tallow is produced in quantity in New Zealand as a by-product of the meat industry; approximately 30,000 tonnes per annum are used domestically for stock food, soap, and margarine,[51] but a quantity is exported each year. In 2004-05 (the most recent year's data) 133,705 tonnes were exported valued at $NZ 69 million or $516/tonne on average.[52] Thus 130-160,000 tonnes might be readily available; most likely the lower number, assuming that the existing uses would value it more highly.

Blended with New Zealand's current use of approximately 1.6 mln tonnes of diesel for on road vehicle use and 1.8 mln tonnes for all transportation uses (including shipping); the quantity of biodiesel available would represent an approximate 7.4% or 6.3% mix respectively.

Additional quantities of biodiesel might be manufactured from a range of other feedstocks, most likely imported vegetable oils e.g. palmoil[53]. These costs are examined below.

6.1.1 Capital Costs

A number of estimates of capital costs for biodiesel plants are summarised in Table 11. These include two New Zealand studies undertaken for EECA. More recent Australian studies have been included also.

Table 11 Capital Costs - Biodiesel Plants

Plant Capacity ('000 tpa)	mln litres pa	Capital Cost $million	Year of data	2006$mln	$/tpa
116 (1)	133	45.7	2001	50.5	435
70 (1)	80	33.8	2001	37.3	534
4.4 (1)	5	9.1	2001	10.1	2285
20(2)	23	21.0	2002	22.5	1125
40(2)	46	23.8	2002	25.5	637
60(2)	69	28.2	2002	30.2	503
70(2)	80	29.7	2002	31.8	455
35(3)	40	22.1(5)	2001	24.4	686
35(4)	40	29.3	2002	31.4	896

Source: (1) Judd B (2002) Biodiesel from Tallow. Prepared for Energy Efficiency and Conservation Authority; (2) Duncan J (2003) Costs of biofuels production. Prepared for Energy Efficiency and Conservation Authority; (3) Amadeus Petroleum NL (2001) Annual Report; (4) CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources.
(5) The original costs (A$12 million) are assumed to exclude non-plant capital costs, e.g. roads, storage etc. We assume this increase costs by 50%.

Duncan provided an estimate of the cost of a 70,000 tpa plant and estimates from Europe of the costs of 20,000, 40, 60,000 tpa plants. We use the ratio of capital costs for the European plants. The data suggest economies of scale in production, as shown by the econometrically-derived fitted line in Figure 10.[54]

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49 www.biodiesel.org

50 Judd B (2002) Biodiesel from Tallow. Prepared for Energy Efficiency and Conservation Authority.

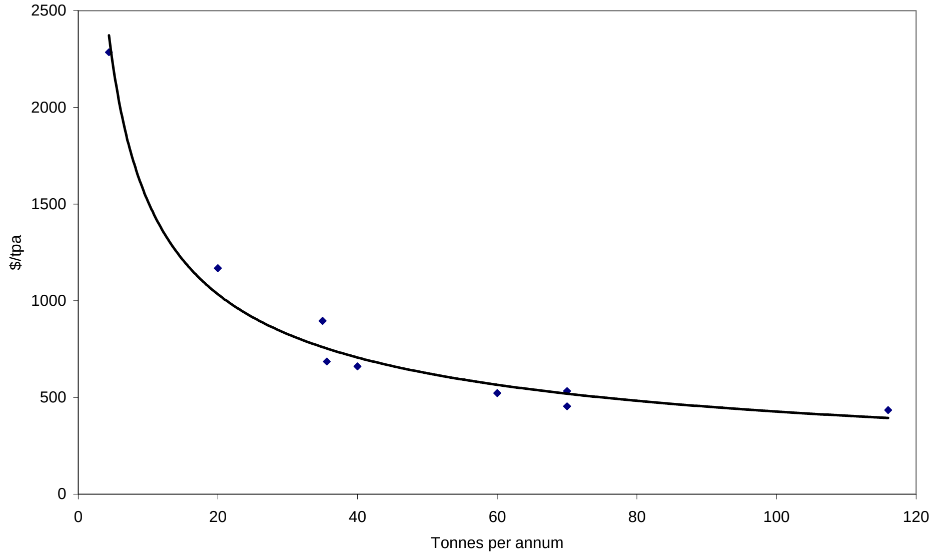
51 Judd B (op cit)

52 Gregory Da'Costa, Meat & Wool New Zealand, personal communication

53 While palm oil is seen as a prospective biodiesel feedstock there is concern that production might be at the expense of tropical rainforests (i.e. rain forests cut to grow palm trees). This may lead to reluctance to use as a fuel because of environmental concerns

54 $\$/tpa = 5349.4 \times capacity (tpa)^{-0.5486}$ (R^2=0.96)

Figure 10 Capital Costs ($/tpa) of Biodiesel Plants



The capital costs of plant are estimated to be similar across the different feedstocks[55]. We assume they are the same.

6.1.2 Operating Costs

Operating costs are defined here as all costs that are not capital or feedstock costs. We do not separate out annual fixed costs (e.g. labour) from operating costs that would vary with output (e.g. chemicals). Judd (2002) provides estimates that range from $117 to $196/tonne ($0.1 to $0.17 per litre) in 2001 dollars; these contrast with the more recent Australian (ABARE) estimates of A$0.05-$0.10/litre (NZ$0.06-0.11/litre).

For analysis we separate out the methanol costs from other operating costs because we have an estimate of quantities of methanol required (see below) and costs. Methanol costs in 2003, the year of the ABARE analysis, were approximately NZ 4 cents per litre, suggesting that the ABARE numbers may have ignored these costs. We assume that the operating costs fall in a straight line from 11 cents per litre for a 5ktpa plant to 6 cents per litre for a 90 ktpa plant and are 6 cents per litre for larger plants.[56]

6.1.3 Feedstock Requirements and Co-Products

Feedstock requirements are estimated from data provided by Duncan (Table 12); he notes that the free fatty acid content of New Zealand tallow is less than 2%. The assumptions used in this study are included in the final column.

Table 12 Feedstock requirements and yields (kg/kg biodiesel produced)

Feedstock	Stochiometric	Energea <4.5% FFA	Energea >4.5% FFA	LFTB	This study
Tallow	0.995	1.0	1.0	1.067	1.0
Methanol	0.119	0.114	0.114	0.121	0.114
Acid	0	0.028	0.035	0.017	NA
Catalyst	0	0.030	0.013	0.012	NA
Glycerol	0.114	0.1	0.09	0.097	0.1
K_2SO_4		0.031	0.023		

[55] CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources.

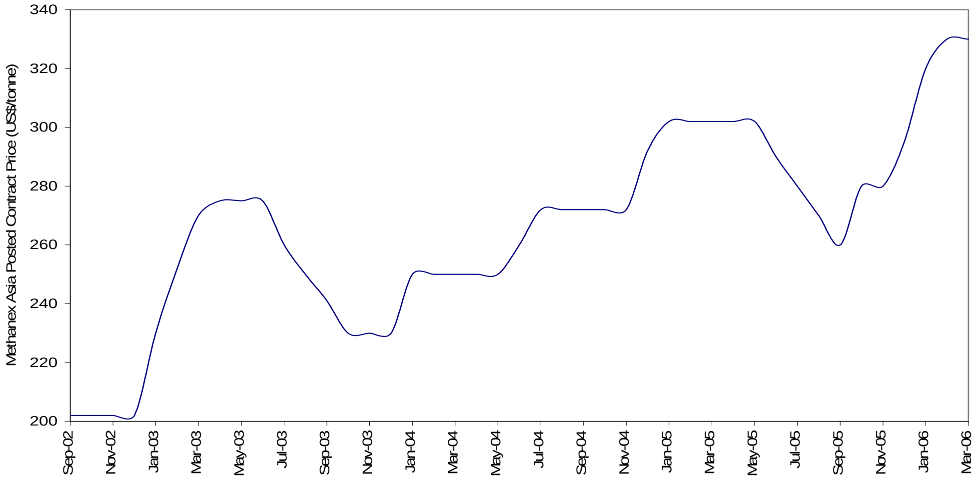
[56] This is based on the plant sizes analysed in the Australian study, ie between 5 and 100 million litres per annum (CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources)

Note: NA = not applicable – simplifying assumptions used
Source: Duncan J (2003) Costs of biofuels production. Prepared for Energy Efficiency and Conservation Authority

Tallow costs are taken as the opportunity costs of use in biofuel production based on the export value of tallow. These values are currently approximately NZ$516/tonne[57]; this is an f.o.b. price; the costs for use in New Zealand will be less transport costs, estimated to be NZ$60/tonne, i.e. a cost of $456/tonne. We assume a requirement of 1 tonne of tallow per tonne of biodiesel produced.

The methanol price is taken from the Asian Posted Contract Price (Figure 11).[58] The current price is high (which is part of the reason that the New Zealand methanol plant is reopening in 2006). At a requirement of 0.114kg/kg of biodiesel, a methanol cost of US$300/t represents a cost of NZ 5cents per litre.

Figure 11 Methanol Price (Asian Posted Contract Price)



www.methanex.com

Glycerol is produced as a by-product of biodiesel production; glycerol output is 10% of the weight of biodiesel output (Table 12). Recent estimates of contract prices for glycerol are in the range of US$800-1000/tonne.[59] Using a price of $900/t and current exchange rates (US$0.65:NZ$1), the credit for glycerol is approximately $156/t or 13 cents per litre. NZIER[60] included glycerol costs as a percentage of tallow costs. However, it is more likely to move in the opposite direction, i.e. increased demand for tallow because of biodiesel demand, set against a fixed demand for glycerol will see glycerol prices falling.

Palm oil is an alternative imported feedstock. Recent prices are US$385 or NZ$585/tonne. The palm oil requirement is 1.25kg for every kg of biodiesel output. Other costs are assumed to be the same.

6.1.4 Distribution and Blending

The components of distribution cost include the costs of delivering feedstock to the biodiesel production plant; and the costs of distributing from the biodiesel facility and blending and distribution to port terminals. These are detailed in the Distribution Report (Table 8, Section 6.2).

[57] Greg da costa
[58] http://www.methanex.com/products/documents/MthlyAvgPrice_Mar2006.pdf
[59] www.icislor.com
[60] NZIER (2004) Mandatory transport biofuels. Costs and benefits of mandatory biofuel blends in transport fuels. Report to the Ministry of Economic Development.

6.1.5 Total Costs

The total costs of biodiesel production are shown in Table 13. This includes production from tallow and from palm oil. For tallow we assume that plants of very different sizes could be built, because sources of local supply would determine size. For palm oil we assume that only plants above 50,000tpa would be constructed based on an imported product, in order to benefit from the economies of scale.

There is also a potential to import biodiesel. Current Malaysian prices of US$650/tonne are cited;[61] with a transport price of approximately US$60/t, this would translate to a NZ price of approximately 92cents per litre.

Table 13 Costs of Biodiesel Production

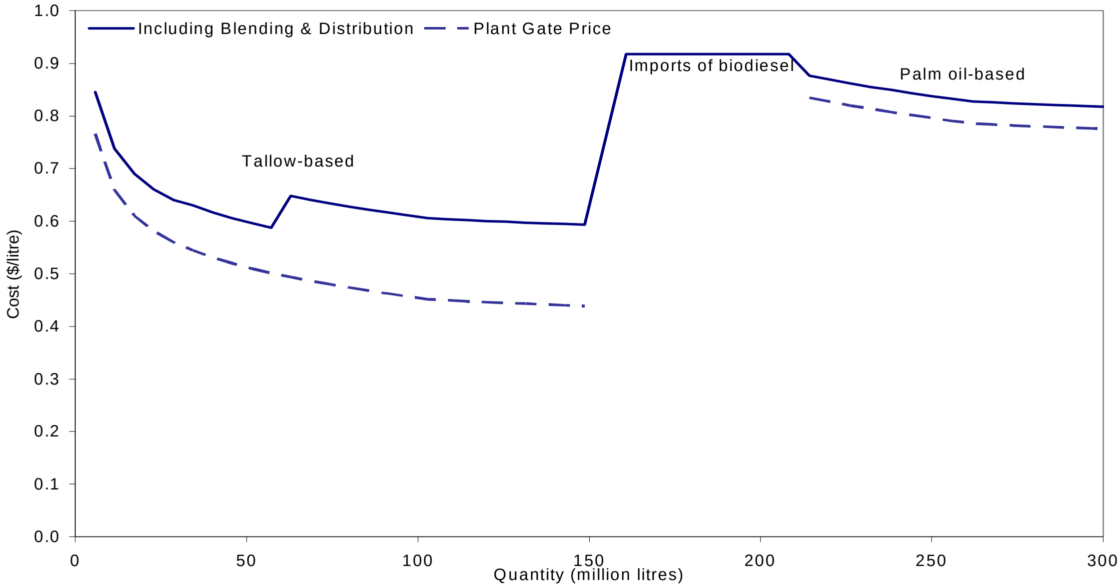
Plant Size		Capital costs	Tallow	Methanol	Other	Total	Glycerol credit	Net	Distribution	Net
Ktpa	Million litres	$/litre	$/litre	$/litre	$/litre	$/litre	$/litre	$/litre	$/litre	$/litre
Tallow										
5	6	0.33	0.40	0.05	0.11	0.89	0.12	0.77	0.08	0.85
20	23	0.15	0.40	0.05	0.10	0.70	0.12	0.58	0.08	0.66
40	46	0.11	0.40	0.05	0.09	0.64	0.12	0.52	0.09	0.61
60	69	0.08	0.40	0.05	0.08	0.61	0.12	0.49	0.15	0.64
120	137	0.06	0.40	0.05	0.06	0.56	0.12	0.44	0.15	0.60
Palm Oil										
50	60	0.09	0.73	0.05	0.08	0.95	0.12	0.83	0.04	0.88
60	71	0.08	0.73	0.05	0.08	0.94	0.12	0.82	0.04	0.86
120	143	0.06	0.73	0.05	0.06	0.89	0.12	0.78	0.04	0.82

Figure 12 shows increasing economies of scale in production from tallow up to approximately 150 million litres for a single plant. Above 150 million litres, supply would need to come from either imported biodiesel or imported biodiesel feedstock for processing. We estimate using palmoil as an example New Zealand based processing to be lower cost.

In practice, production could be from a number of medium sized plants, e.g. 3 plants producing 50-60 million litres. Because the plants are smaller distribution costs tend to be cheaper (less transport cost of tallow and biodiesel). Plants of this scale are expected to have net costs, including distribution, in the order of 60 cents per litre. The analysis suggests that plants of this scale may be optimal, because of the additional costs of distribution for larger plants.

[61] http:// biodieselnow.com

Figure 12 Costs of Biodiesel Production



6.2 Manufacturing Costs — Bioethanol

There are a number of different production methods and feedstocks for bioethanol production. These generally involve converting sugars (in the case of molasses and sugar cane or beet) into a low grade 'beer,' and distilling this to the desired level of bioethanol purity. Starchy products (in practice, corn/maize and wheat, although theoretically from any starchy feedstock) can have their starch converted to sugar, and the same process carried out. Another process, although not currently widespread, is called 'Acid Hydrolysis,' where cellulose and hemicellulose from plant matter (forest residues, etc) are converted to sugars, and then fermented and distilled.

In this study, we have focussed on the following feedstocks and production processes:

- Corn/Maize: Starch conversion to sugars, fermentation and distillation
- Sugar beet: Fermentation and distillation
- Wood: Acid Hydrolysis, fermentation and distillation

Each of the different feedstocks and processes has had their manufacturing costs investigated independently.

6.2.1 Capital Costs

Most of the literature deals with Capital Costs as variable costs, that is a $/l value. This assumes that there are no economies of scale in bioethanol production facilities.

Similar to most production facilities, there are economies of scale in bioethanol production, particularly in reference to capital costs. As output increases, the cost of capital is spread over a greater output, bringing down the average cost of capital.

A recent Australian review paper suggests that the fixed capital costs of ethanol production from grain are around 75-80% higher than those for biodiesel.[62] We have used capital costs for bioethanol production from maize that follow the same decreasing average cost curve, but

[62] CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources.

at a rate 75% above that for biodiesel. At the high-production (relatively efficient) end of the cost curve, this gives variable capital costs comparable to those found in the literature.[63,64,65,66]

We have adjusted the capital cost curve for Wood and Sugar Beet in the same manner, so that at the high-production end of the curve, the variable costs are also comparable to those found in the literature.

6.2.2 Operating Costs

Operating costs are once again defined here as all costs that are not capital or feedstock costs.

The literature contains large variations in the estimation of operating costs. Where there is a range of costs reported in different sources, a mid point has been used. Table 14 shows the operating costs by feedstock/production process.

Table 14: Operating Costs

	Wood[1,2]	Maize[1,2,3,4]	Sugar Beet[2]
Operating Cost ($/l)	$ 0.25	$ 0.11	$ 0.17

Source: [1] Fulton, L., Howes, T. and Hardy, J. (2004) Biofuels for Transport, An International Perspective. Study by the IEA. [2] AEA Technology (2002) International Resource Costs of Biodiesel and Bioethanol. Report to the UK Department for Transport. [3] Shapouri, H. and Gallagher, P. (2005) USDA's 2002 Ethanol Cost-of-Production Survey. [4] CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources.

6.2.3 Feedstock Costs, Availability and Co-product Values

The feedstock cost consists of two parts: the conversion yield (how much ethanol is produced from one ton of feedstock), and the price of that feedstock. Once again, there are large variations in the literature in the estimation of conversion yield. In these cases, a midpoint has been used. Table 15 summarises the feedstock costs used in the analysis.

Table 15: Feedstock Costs

	Wood	Maize	Sugar Beet
Feedstock ($/t)[1]	$ 44.00	$ 280.00	$ 68.70
Transport costs ($/t)	$ 25.00	$ 25.00	$ 25.00
Conversion yield (l/t)	300[2]	408[2]	98[3]
Feedstock Cost ($/l)	$ 0.23	$ 0.75	$ 0.96

Source: [1] Section 6.3 [2] Fulton, L., Howes, T. and Hardy, J. (2004?) Biofuels for Transport, An International Perspective. Study by the IEA. [3] AEA Technology (2002) International Resource Costs of Biodiesel and Bioethanol. Report to the UK Department for Transport.

In section 3.3.3 we have calculated that the upper limit of bioethanol production from maize is 60.7m litres. For production from maize to exceed this level, land would need to be reassigned from the production of other products. In order for market forces to reassign this land, there would need to be an increase in the price of bioethanol relative to the value of the product currently being produced from this land. Table 16 shows the increase in the price of bioethanol required for a range of gross margins of alternative uses, to reassign land use to bioethanol production from maize.

63 Fulton, L., Howes, T. and Hardy, J. (2004?) Biofuels for Transport, An International Perspective. Study by the IEA.

64 AEA Technology (2002) International Resource Costs of Biodiesel and Bioethanol. Report to the UK Department for Transport.

65 Shapouri, H. and Gallagher, P. (2005) USDA's 2002 Ethanol Cost-of-Production Survey.

66 CSIRO, ABARE and BTRE (2003) Appropriateness of 350 Million Litre Biofuels Target. Report to the Australian Government Department of Industry Tourism and Resources.

Table 16: Bioethanol price increase required to switch to bioethanol production from maize

Gross Margin of alternative land use	$/l price increase required
$ 100	$ 0.02
$ 500	$ 0.12
$ 1,000	$ 0.23
$ 2,000	$ 0.47

There is no relevant limit on the amount that can be produced from forest residues, while the amount that can be produced from sugar beet is undetermined.

Co-products of bioethanol production differ by feedstock and production process. Where a range of co-product values have been found in the literature, we have assumed a midpoint value.

Table 17: Co-product Values

	Co-product[1]	Value of Co-products ($/l)
Wood	Electricity Ash Acetic Acid	$0.03[2]
Corn/Maize[67]	Corn Oil Corn Feed Corn Meal	$0.19[2,3]
Sugar Beet	Pulp Animal Feed	N/A

Source: (1)http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_024054-04.hcsp, 16/03/2006. (2) Fulton, L., Howes, T. and Hardy, J. (2004?) Biofuels for Transport, An International Perspective. Study by the IEA. (3) AEA Technology (2002) International Resource Costs of Biodiesel and Bioethanol. Report to the UK Department for Transport.

6.2.4 Blending and Distribution Costs

There are two components to distribution costs: The costs of delivering the feedstock to the bioethanol production plant; and the costs of distributing the bioethanol to the blending facility. We have assumed a constant cost of $25/t over all feedstocks for the first component, and $0.02/l over all ethanol for the second. A blending cost of $0.07/l is assumed.

6.2.5 Total Costs

The production cost information discussed above combines to produce the bioethanol supply curves shown in Figure 13.

A production cost for ethanol produced from whey has been included. This is based on information from Anchor Ethanol. Fonterra currently produces 15-16M litres of ethanol from Whey. Around 3-4M litres of this could be diverted at under $1.10/l, but from this level, prices rise to around $2.00/l. For Fonterra to produce any more ethanol than it currently does, whey would need to be diverted away for edible lactose production to ethanol production. In this case, ethanol would need to compete against the international price of lactose (US$800/tonne). To compete, ethanol would need to be priced around NZ$2.50/l.

[67] Wet-milling of corn has been assumed, as the co-products of wet-milling corn have a greater value.

Figure 13: Supply Curve for Ethanol

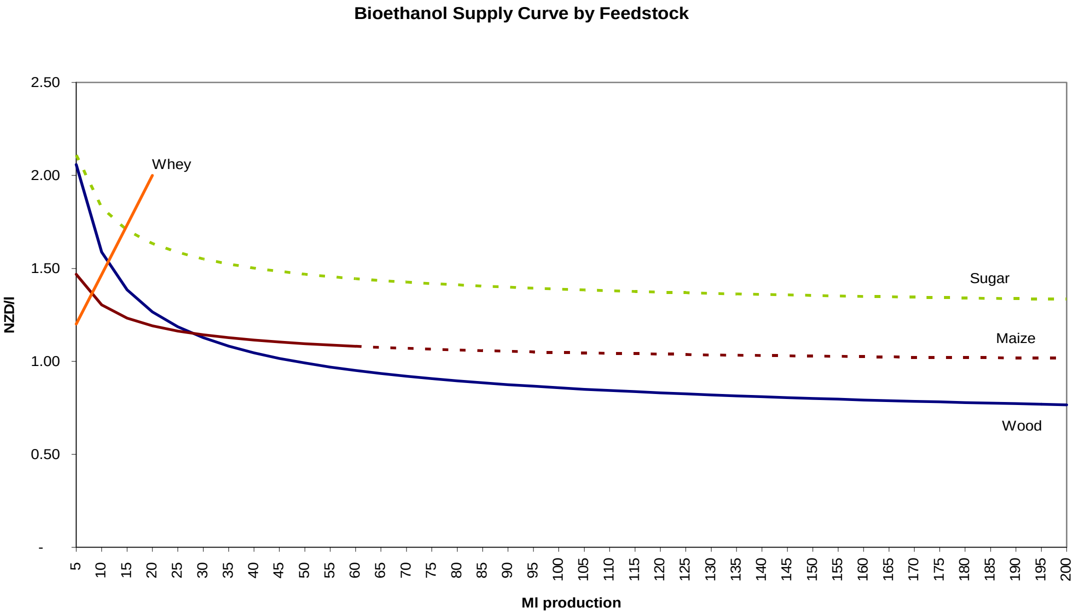
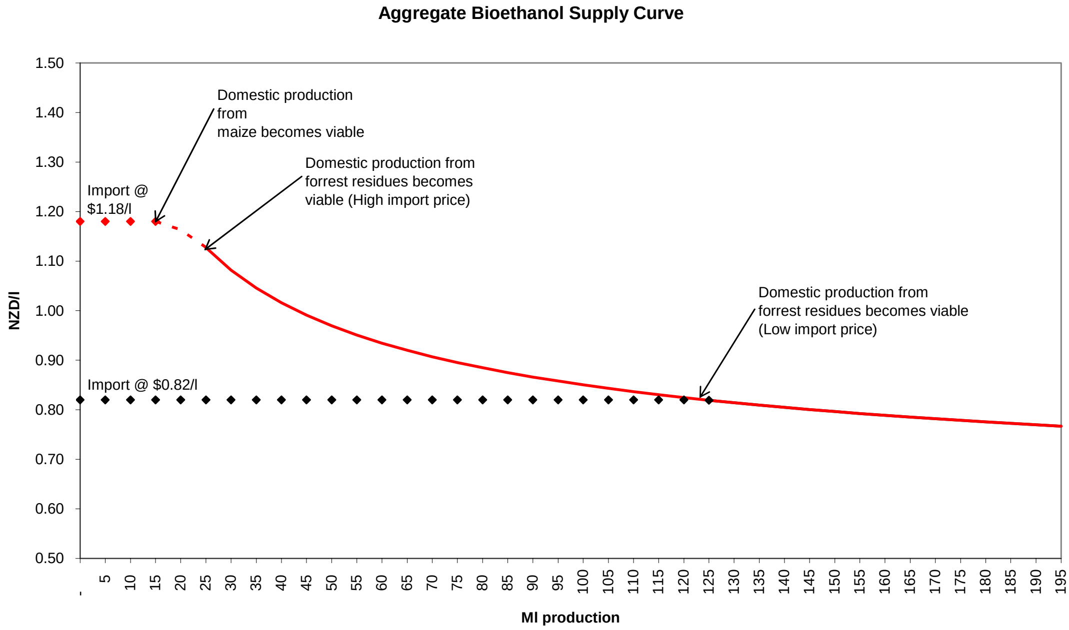


Figure 13 indicates that the most economical feedstock/process for bioethanol is dependant on the quantity being produced. At very low levels, (less than 5m litres) production from whey is the most economic option. However, from this level, production costs for whey rise very quickly, and it is quickly uneconomic. Production from wood has relatively high capital costs, so it is quite expensive at small production quantities. However, for production levels of more than 30 million litres, the low feedstock cost of wood becomes the dominant influence, and wood becomes more economic to use than maize. The amount of bioethanol that can be produced from maize is constrained by the land availability. Sugar Beet is an uneconomic option, costing between $2.11 and $1.33 per litre. The availability of land for Sugar Beet is yet to be determined.

When the option of importing bioethanol from Brazil is taken into account, the aggregate New Zealand supply curve gets more complicated. In this analysis a world price of bioethanol is assumed at between $0.51 and $0.88/litre, and a shipping cost of $0.23/litre added. A blending cost of $0.07/litre is assumed, giving a total cost of importing bioethanol of between $0.81 and $1.18/litre.

The aggregate New Zealand bioethanol supply curve is shown in Figure 14.

Figure 14: Aggregate bioethanol supply



At high-end import prices, the most economic method of supply for quantities below 15m litres is importing. For production levels greater that this point, production from forest residues becomes an economic option, with costs decreasing to a level of $0.77/l for 200m litres of production.

At low-end import prices, importing bioethanol is the most economic method of supply until a quantity level of 125m litres. From this point of, forest residues would be used to produce bioethanol.

The aggregate bioethanol supply curves shown in Figure 14 show the marginal costs of producing bioethanol in New Zealand. As bioethanol is traded on the world market, these are not indicative of the expected behaviour of the *price* of bioethanol in New Zealand. It is expected that the price of bioethanol produced in New Zealand will mirror the world price. This has been calculated above as between $0.81 and $1.18/litre, including shipping and blending/storage.

7.0 Adequacy of Supply

As indicated sufficient volumes of tallow are available to support domestic biodiesel production up to a level of 150 mln litres, assuming the tallow is attracted to biodiesel use. Domestic manufacture of biodiesel using tallow is competitive with current oil prices and in production cost terms would appear to be more attractive than ethanol. Sufficient volume based on domestic manufacturing is available to meet likely volume scenarios over the period 2008-2012.

Above 150 mln litres biodiesel however there are no likely domestic availabilities of biodiesel or feedstock to meet demand within the timeframe set for the targets. Any further supply requirement would need to come from imports of finished biodiesel, or alternatively further manufacturing based on, for example, palmoil imports. While biodiesel imports are being talked about it is not clear at this stage that these would be significant enough to allow for gradual increase in the amount of biofuel availability based on biodiesel. Furthermore it may be that in the absence of supports or subsidies biodiesel may be more attractive in other countries, potentially attracting biodiesel produced in New Zealand.

Until such time as new and emerging technologies provide other possible avenues for biodiesel manufacture New Zealand's availability of domestically produced biodiesel will be capped by the availability of feedstock.

On the other hand domestic availability of ethanol is very limited when compared with potential volumes available from domestic manufacture of biodiesel. Current manufacturing capability is relatively small and high level analysis of current agricultural practices suggests we are unlikely to see a significant shift toward purpose grown crops for biofuels in the 2008-12 period, except where new technologies may provide opportunities to improve on existing returns. The likelihood of new and emerging technologies contributing to domestic supply capability over the period 2008-12 is speculative at this stage.

However there is likely to be good availability from imports. International availabilities have been growing. While it is difficult to speculate on whether there will continue plans by a number of countries would suggest that ethanol volumes will be available.

Given the cost differences between biodiesel and ethanol the difference in basic supply dynamic between the two options raises questions about how the market could evolve for biofuels depending on how targets were structured. For example the time taken for investment in biofuels production will be a key factor in the timing of mandatory requirements. Our advice is that it will take about 2-3 years between an investor knowing the regulatory decisions (what the mandatory requirements will be) until they have a producing plant. For example once the regulatory decision is made an investor needs to develop a firm proposal, progress design, arrange feedstocks, supply contracts, obtain offtake contracts (e.g. find buyers), arrange finance, obtain resource consents, build the plant and commission operation. Therefore if the Government makes a decision on targets at the end of 2006 supply from the new domestic facilities (both ethanol and biodiesel) is not assured until 2010.

If a mandatory target is introduced early it will force the market down an avenue of what is available in the timeframe rather than what makes most economic sense. Certainly a 2008 minimum is likely to force investment in imported ethanol facilities as that is the only way petroleum marketers will have assurance they can meet the legislated target.

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Appendix A

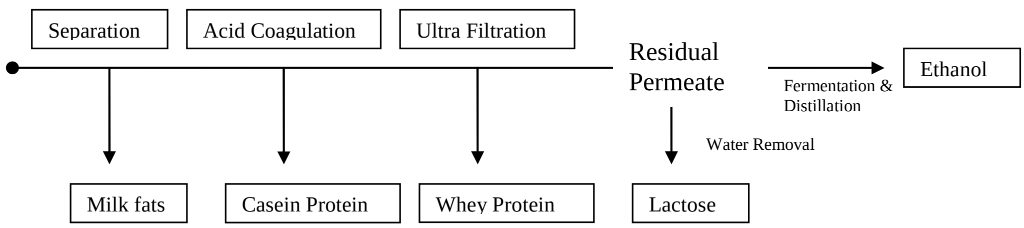
Farm type	Costs considered in cost of goods
Dairy	Cattle purchases, Permanent wages, casual wages, ACC, Animal health, Breeding, Dairy shed expenses, Electricity, Feed (all types), Fertiliser, Lime, Re-grassing costs, weed and pest control, fuel, vehicle costs (excl fuel), repairs and maintenance, water charges (irrigation)
Maize	Cultivation, base fertiliser, sowing, seed and treatment, starter fertiliser, weed control, nitrogen (sidedressed), harvesting, inoculent (silage), cartage, stacking/covering (silage), drying (for grain), interest on inputs
Mixed arable	Sheep purchases, wages, ACC, contracting, animal health, breeding, electricity, animal feed, fertiliser, lime, seeds, seed dressing, shearing, weed and pest control, fuel, vehicle costs (excl fuel), repairs and maintenance, water charges (irrigation)
Sheep and beef	Sheep and cattle purchases, permanent wages, casual wages, ACC, Animal health, Breeding, electricity, feed (all types), fertiliser, lime, re-grassing costs, shearing costs, weed and pest control, fuel, vehicle costs (excluding fuel), repairs and maintenance, water charges
Vegetables	Gross margins calculated by MAF. Cost breakdowns not given.

Appendix B

[Information supplied on Commercial/In confidence basis]
New Zealand's the only commercial production of ethanol is undertaken by the Fonterra subsidiary, Anchor Ethanol, using whey. Annual production is 15-16 million litres. Anchor Ethanol operates ethanol production at three milk processing and casein production locations in the North Island, being Tirau, Reporoa and Edgecumbe.

The volume produced is a function of the seasonality of milk processing together with the way in which individual plants are operated. Some plants are treated as peaking capacity and are closed as soon as the volume of milk available falls below optimum levels. Thus production is highly dependent on the seasonal variation of milk supply. Milk production begins in early August, peaking around the end of October and trailing away through to June. Typically ethanol production begins around September and continues through to February.

The following simple schematic indicates the process steps leading to production of the raw material (residual permeate) which is the feedstock for the fermentation and distillation into ethanol.



The residual permeate can either be processed into ethanol or, subject to water removal, produced as lactose for further processing into lactose sugar. Crystallised lactose can be used in a variety of markets, including sugars used in the production of high value pharmaceuticals. Anchor Ethanol's capability to increase levels of lactose sugar production is dependent on the ability to process and store greater quantities of lactose sugar where logistics requirements are not dependent on the seasonality of processing. Fonterra is considering the value of increasing lactose production by increasing storage capability at other North Island locations, thus enable greater volumes of residual permeate to be processed to lactose.

Anchor Ethanol produces about 15-16 million litres annually, of which 6 million litres are sold for domestic potable use (alcohols etc) and solvents, with the balance 9 million litres being exported to potable and industrial markets. Exports are in both hydrous and anhydrous form. Anchor Ethanol indicates that it has the capability currently to produce 2-2.5 million litres of anhydrous (> 99.8%) for biofuels applications.

It has been suggested that Anchor Ethanol production capability could be in the order of 30 million litres per annum. This assumes current plant processing capability is continuous (not dependent on seasonal milk production) and would be dependent on receipt of suitable fermentable substrate delivered to the plants at a point in the process equivalent to the availability of the residual permeate. Anchor Ethanol advises that, in principle, provided the substrate was presented is a readily fermentable form, plant capability could be extended. It would not be possible to allow two different substrates to be run concurrently. Anchor Ethanol would still expect demand for its ethanol to continue for high value, non fuel use, and would view the availability to the fuels market as an incremental 14-15 million litres.

An emerging factor in Anchor Ethanol's decision making has been the recent strength in international sugar markets, which now improves the value to Fonterra for production of lactose sugar. We discuss the impact of sugar markets in Section 5.6 of this report.

Current spot prices for ethanol supply from Brazil have been indicated at around $US 500/m³ which, when freight is added, could see the alternative of imports of ethanol costing around $NZ 1.10/litre. At current realization some 2-4 million litres of current production could be attracted to fuel ethanol, although that was still unacceptable against the alternative of lactose. For additional production, i.e. diverting whey from edible lactose production (about 20,000 tonnes going this route), the capital and operating costs are about the same for both lactose and ethanol production, so ethanol would need to compete against the international price of lactose (US$800/tonne). This is equivalent to US$1.60/litre of ethanol (1 tonne of lactose makes 500 litres of ethanol).