Hale & Twomey

Enabling Biofuels

Biofuels Distribution Options

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Thinking Energy

Executive Summary

Analysis of the petroleum fuels distribution system shows that while there are no operational constraints that would prevent the introduction of biofuels in New Zealand, there are some key issues which currently impede the introduction. In addition, physical constraints in the distribution system will limit the likely volume of biofuels that can realistically be sold in the New Zealand market over the planning horizon of 2008-2012 and beyond.

The first significant issue is the specification of petrol. Ethanol blended with petrol will normally cause the blend to exceed the RVP and possibly E70 properties of the petroleum specifications. To ensure the current specification limits are met, special petrol blendstock with low RVP will be required. This greatly increases the distribution cost which is likely to make ethanol blends uneconomic until companies can convert complete grades to ethanol blends. For most companies this is impossible in the short to medium term, due to customers who need petrol without ethanol and service stations that are not suitable for ethanol blends. Many countries such as the USA and Australia allow a waiver for the final blend when the base components of ethanol and petrol meet the respective specifications. This approach is not expected to cause drivability issues for the New Zealand car fleet as the RVP increase is expected to be less than the recent reduction in RVP. We recommend that New Zealand takes a similar approach to facilitate the introduction of biofuels.

The second major issue for ethanol petrol blends is that they must be stored in tanks with double containment (ERMA[1] decision). Our information is that this decision will not be reviewed although it is not required in many other countries (e.g. Australia, USA). Therefore, the gradual introduction of double containment tanks at service station sets the pace that ethanol blends can be marketed. Currently in New Zealand there are just over 1300 service stations and about 300 (22%) of these sites currently have double containment in place. These sites service about 29% of petrol demand. The cost of accelerating the replacement of service station tanks is prohibitive (NZ$215-275 million), although there is a constant replacement going on which means by 2020 80-90% of fuel sold will be through double containment tanks.

If the double containment restriction was relaxed, it would allow for much greater volumes of ethanol to be sold sooner. From our analysis we expect ethanol to only increase from around 17 million litres to 40 million litres (1.2% of petrol) by 2012, assuming economics favour its use.

The third major distribution issue with ethanol is its affinity to water. This means that ethanol has to be transported separately and blended as late in the supply chain as possible. We expect ethanol to be blended in terminals directly into tank trucks as is standard practice in most countries where ethanol blends are sold. The cost of these terminal facilities and the relatively small quantity of ethanol throughput means conversion of terminals will only happen gradually, initially at high volume locations (like Wiri in Auckland).

By contrast there are few distribution issues with biodiesel. It can generally use the same infrastructure which gives it the option of being blended well up the supply chain (at the refinery) if desired[2]. The most significant issues is that the cold flow properties of biodiesel are not as good as mineral diesel, with tallow based biodiesel having a CFPP of 10-14ºC. Biodiesel will require heated storage in its pure form and to ensure the biodiesel is at least 6ºC above its cloud point to ensure that proper mixing occurs when blending. Blended

[1] ERMA: Environmental Risk Management Authority

[2] There is currently some concern over use in multiproduct pipelines which is discussed in the report.

biodiesel is unlikely to require heating as the storage conditions tend to be well above the resultant cloud point.

Most international experience is with biodiesel made from rapeseed or soy. These both have better cold properties than tallow based biodiesel so we expect the New Zealand oil industry to be relatively cautious with the introduction of biofuels blends, until they are confident there are no adverse affects when used by consumers. There is some work being undertaken on tallow based biodiesel and appropriate additives to help with its cold flow properties so it may be that there is more international experience by the time New Zealand begins to roll out biodiesel blends.

We expect the industry will concentrate on the north of the North Island initially, gradually rolling it out to the rest of the country. The main concern will be how it behaves in winter conditions.

Many countries allow up to 5% biodiesel in blends without labelling. This has a lot of advantages for the industry as it gives a lot more flexibility if there are biodiesel supply disruptions. This approach means the supplier has to ensure the blend meets the regulated diesel specification and is fit for purpose.

While economies of scale can be achieved with larger biodiesel production plants, these savings can be offset by the distribution costs of the New Zealand supply chain. Tallow will be very expensive to transport in New Zealand relative to biodiesel. Our analysis gives similar total cost for a large plant at Marsden Point versus two to three medium sized plants around country (with biodiesel either transported to Marsden Point for blending or to various ports). It may be other factors (like the ability to import alternate feedstock) that end up favouring one approach over another. It is worth highlighting that tallow based biofuels plants are relatively new technology, and although a plant is designed to produce 100 million litres, it may take a few years before it gets up to producing that volume on a consistent basis.

With respect to volumes, our expectation is that initial biodiesel demand will be about 25 million litres, which will increase in steps up to about 125 million litres. The pace of this increase will depend on how the blends perform in the winter period.

Overall the distribution system is expected to set limits around the amount of biofuels that can be sold. Our expectation for maximum volumes is as follows with the proviso that there may be limited time between the Government making decisions on targets and the normal investment timeframes to achieve a 2008 target.

Demand	2008	2010	2012
Max Ethanol (mln litres)	17	27	40
Max Biodiesel (mln litres)	36	70	122
Max Biofuel (mln litres)	53	97	162
Max Biofuels (energy PJ)	1.7	3.1	5.2
Min Target (mln litres)	12	-	60
Min Target (energy PJ)	0.4	-	2
Max Target (mln litres)	60	-	240
Max target (energy PJ)	2	-	8

Contents

1.0 Introduction

The biofuels distribution options report covers how biofuels distribution could be integrated with the distribution of petroleum products. The objective is to build a picture of likely decisions that will be made by industry participants for the introduction of biofuels, along with a high level assessment of the costs involved.

In reality, petroleum marketers will not be able to make distribution decisions until government decides on some key biofuels policies. We discuss these issues in Section 5.0 along with the implications of the various options.

The structure of this report is to run through the infrastructure by component, discussing what is required to make it suitable for distributing biofuels. From this we identify key issues which are then discussed in more detail. A table then summarises the infrastructure changes required before moving on to sections discussing blendstocks for biofuels and monitoring.

Commercial issues applicable to particular infrastructure is included as part of the infrastructure discussion. Oil industry participants are not expecting any Commerce Act issues with the introduction of biofuels, however this Act may slow the introduction when investment at joint terminals is required.

The distribution report concludes by deriving expected volumes and likely decisions that will be made by industry participants.

2.0 General Discussion

2.1 New Zealand's Distribution Infrastructure

New Zealand's petroleum fuels distribution infrastructure is similar to that found in most parts of the world – a mixture of refineries, ships, pipelines, terminals with trucking to final customer or service station sites. There are however some relatively unique features to New Zealand's distribution. These include:

- Single refinery - there is only one refinery in New Zealand
- Joint distribution - the main wholesalers who serve more than 95% of the market share a common distribution system from refinery to port storage terminals
- Shared infrastructure – many of the key distribution assets are jointly owned by the same four wholesalers, or by independent companies who contract capacity to those companies
- Import dynamic – imported product makes up a significant proportion of the fuels mix
- Long thin distribution system – New Zealand has a large number of port distribution terminals relative to population because of the long thin geography and the relatively wide distribution of population (therefore many terminals have quite low throughputs compared to other countries)
- Long distance from alternate supply centres (internationally) if there is disruption to the supply or distribution system

As biofuels have been successfully introduced in many countries around the world there is no reason why it is not possible with New Zealand's distribution system. However because of the particular nature of the New Zealand system there are some issues, including the many low throughput locations, which mean investment in biofuels distribution infrastructure could be high on a cost per unit sold basis.

2.2 Ethanol

The main property of ethanol that affects its distribution is its affinity for water (unlike petroleum products), which means ethanol blends are more likely to suspend moisture and carry it into the fuel system than non-oxygenated fuels. If there is too much water in an ethanol blend, the water and most of the ethanol (around 60% - 70%) will separate from the petrol and the remaining ethanol; this is known as phase separation. The amount of water that can be absorbed by ethanol blended petrol without phase separation varies from 0.3% to 0.5%, depending on temperature, aromatics and ethanol content.

While good practice is to keep petroleum distribution systems as dry as possible, in general there is water in the system. This can come from:

- Crude oil (although generally this is removed during refining)
- Steam stripping in refineries (although largely removed to meet product specifications)
- Storage tanks – especially petrol storage tanks which often have floating roofs (therefore opportunity for water to enter)
- Shipping – water is used for tank cleaning

Good practice is to remove water from tank bottoms regularly and this method is used to keep final product 'dry' at storage locations (water readily drops out of petroleum product). However that does not stop some water remaining in parts of the distribution system (especially terminals and shipping).

As a result of ethanol's solubility in water, the recommended best practice is to blend the ethanol and petrol as close to the end use as possible.[3] This is also the recommended practice for New Zealand as ethanol blends will not be able to be transported via the RAP pipeline and coastal ships (further discussion in Section 3.2 and 3.4). Therefore we only consider blending options from the distribution terminals for ethanol distribution.

2.3 Biodiesel

Biodiesel is very similar to petroleum based diesel in most of its properties, and blends well at reasonable temperatures. Most advice is that there is no additional distribution issues with biodiesel blends to those associated with petroleum products although there is recent concern over possible contamination of jet fuel with esters when biodiesel is used in multi-product pipelines[4]. It has been common practice to transport biodiesel in multi product pipelines for a number of years in some countries (e.g. France). It is not known whether the current issue, raised after finding low levels of ester contamination in jet fuel, will cause a reassessment of transporting biodiesel in multi product pipelines.

Biodiesel, depending on source, will sometimes need heating if kept in a pure form. Again this is not something unusual in fuels distribution as fuel oil usually has a similar requirement.

The refinery to Auckland pipeline is a multi-product pipeline so its use for biodiesel blends will depend on finings from the current work on jet ester contamination. We still consider the option of blending biodiesel with diesel at the refinery although if the RAP pipeline can't be used it would undermine this case. Alternatively it could be blended at the port terminals, which has the advantage of more flexibility in blend percentages. Some of the things to consider include in the decision on blend location are:

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3 American Petroleum Institute publication 4261, article 8

4 Conversation with Shell New Zealand regarding March 2006 advice from International Aviation. Issue is esters are surface active which means they are attracted to the pipeline surface and then can be stripped out by a following product (e.g. jet).

If refinery is blend location:

- The biodiesel (or biodiesel feedstock) needs to be transported there
- Additional refinery infrastructure required
- There may be issues if a biodiesel blend and normal diesel is required (more infrastructure)
- If RAP can't be used it reduces amount of diesel available for blending by about 1/3.
- Diesel imports (~20%) go direct to the ports limiting volume available for blending
- Not all marketers use the refinery
- It is more difficult to vary biodiesel blend percentage

If ports are blend location:

- Likely to suit multiple production plants, although plants smaller so more expensive
- Blending facilities required in ports (multiple facilities required so more expensive)
- Allows different biodiesel blend percentages for different customers
- Can blend biodiesel into imported diesel
- No issue with multi-product pipelines
- Less transport required

We analyse both options. General materials compatibility issues with biofuels are discussed in Appendix 1.

3.0 Distribution Infrastructure Requirements for Biofuels

3.1 Marsden Point Refinery

The Marsden Point refinery is owned and operated by New Zealand Refining Company (NZRC). The refinery is a tolling operation where the four largest wholesalers (BP, Caltex, Mobil and Shell) process their crude oil into petroleum products.

The commercial model of the refinery does not prevent NZRC becoming involved in biofuels. If there is a commercial case and customer demand NZRC can make the investment. They have the ability to do this on behalf of one or a number of customers. However to change the general specifications for products (industry specifications) they need agreement of all processors.

However there are some technical issues for the introduction of biofuels at the refinery. Because of its water affinity ethanol would create significant problems for the refinery both on site and from its distribution from the refinery. It is not recommended that ethanol is introduced at this point in the supply chain.

Biodiesel could be blended at the refinery although there remains a possible issue with distribution via the multi product pipeline. Investment in biodiesel storage would be required (at least two tanks – size dependant on distribution option chosen) and possibly a new import line for importing biodiesel (although using an existing line with a gasoil flush after use may be cheaper). If two grades of diesel are required (one with biodiesel, one without) that would also require additional investment in finished product tankage.

In many ways it is much simpler blending biodiesel at the refinery, as then all quality issues are handled in the same way as now – biodiesel is just another intermediate component the refinery uses to blend on grade diesel. The main issue is that not all diesel is produced at the refinery, which may result in high biodiesel blend ratios for diesel produced at NZRC if targets are based on total diesel demand or additional cost of also providing blending facilities in import ports.

Refinery issues dealing with producing blendstocks to blend with biofuels are covered in Section 4.0.

3.2 Silver Fern Shipping (SFSL)

SFSL is responsible for shipping petroleum products produced at the refinery to ten ports around the country. In addition they lift crude oil and condensate from New Plymouth and take it to the refinery. They operate two ships and on occasions if there is spare capacity they charter a ship out in the commercial market for a period (usually used for crude or product export and/or a product import).

SFSL is owned by the same four companies that use the refinery. Although it is a cost recovery operation it is designed to run on commercial lines and its owner-users expect it to be competitive against alternative shipping options. SFSL advise that while they largely transport product as part of the 'industry distribution system', they also transport product at times for individual shareholders (i.e. non industry product). The crude oil and condensate lifting's from New Plymouth are done for individual users on a commercial basis. This additional business can be done as it is commercially justified (i.e. makes money) and doesn't interfere with the core business of transporting product from the refinery to ports.

SFSL could carry product for non-shareholders on the same basis (they have carried product to non-shareholders but typically a shareholder has still owned the product while being transported). This is effectively what happens when the ships are chartered out on a commercial basis when there is spare capacity (they have only been chartered for offshore voyages when there is no suitable charter work available purely in New Zealand waters).

Therefore commercially there should not be any impediment to SFSL transporting biofuels as long as this doesn't interfere with their core business functions. However there are some feasibility issues. These include:

- Pure ethanol cannot be carried as the ships are not suited – a chemical carrier is required
- Ethanol blends cannot be carried because of the water solubility issue
- Tallow cannot be carried as the ships don't have suitable tanks to carry it at the required temperature (needs 60 ºC min and the SFSL ships heated tanks are 60 ºC max and cleaning would create major product contamination risks).

Biodiesel both pure and in blends is suitable for carriage. However biodiesel is a generic term rather than a specific product name and is not classified by IMO as valid cargo, this prohibits their carriage when shipping under MARPOL Annex II. Three fatty acid methyl esters (biodiesel) derivatives are currently classified by IMO; these are the palm oil, coconut oil and rapeseed oil. Soybean oil derivatives have a tripartite agreement which also allows their carriage. IMO classification for other biodiesel derivatives is expected in due course. The ability to use SFSL ships is important as they are larger, more efficient and because they are already on the coast, more readily available than the chemical tankers that would be required otherwise. We would estimate chemical tankers to cost about four to five times as much as a movement on a SFSL vessel on the coast of New Zealand.

3.3 Product Imports

Product imports currently meet about 30%[5] of the countries petroleum demand and are expected to continue to meet a significant part of the demand even with a refinery expansion. Product imports come from a variety of countries including Singapore, Australia, Korea, Taiwan and Japan. They primarily come on MR sized ships carrying between 35-40kT. In most cases these ships need to go to two or three ports to fully discharge their cargo.

Biofuel is unlikely to have a significant impact on the current product import dynamic, unless blendstock components are required (refer Section 4.0).

3.4 Refinery to Auckland Pipeline (RAP) / Wiri

NZRC operates a multi product pipeline that transfers product from the refinery to the Wiri terminal in South Auckland. Two grades of petrol, jet fuel and diesel are transferred through this pipeline. Looking at the worldwide pipeline systems there are a few dedicated ethanol petrol blend pipelines, but no multi product pipelines that carry ethanol petrol blends due to ethanol's affinity to water and the risk of product contamination. In addition ethanol is very good solvent and strips dirt and solvents in systems such as pipelines causing problems both for the ethanol/petrol blend and other product. Where these pipelines carry jet fuel as well there is additional concern because of the high quality standards required on jet.

As a result ethanol/petrol blends are never transported in multi product pipelines and would not be in the RAP. Any ethanol blends servicing the Auckland market would be blended at Wiri. The issues for the Wiri terminal are similar to other terminals and covered in that section.

As discussed in Section 2.3 there may be an issue with biodiesel blends in the pipeline although work is still in progress. If it is okay the biodiesel would be blended to specification at NZRC and no further work would be required at Wiri (assuming that Wiri continues to operate with a single grade of diesel). If Wiri was the blending location additional facilities would be required. These are similar to those required in other terminals (although more expensive because of the greater volumes and number of loading bays) which are covered in Section 3.5.

Wiri itself is operated by a joint venture company owned by the four companies who use NZRC. In general any developments (such as biofuels) at Wiri would require all four shareholders to agree. However companies can, and do install their individual additive equipment (at their own cost) for special additives they want to use. It is conceivable that a similar model could be used for biofuels where one (or some) of the companies put in facilities for biofuels rather than all four needing to agree.

Note: There is also a short pipeline from NZRC to a distribution terminal used to distribute products to the Northland region. The infrastructure required to blend biofuels at this terminal is similar to other terminals, except where biodiesel is blended at NZRC (assuming this terminal continues to operate with a single diesel grade).

3.5 Terminals

Along with the two pipeline supplied terminals there are ten marine ports around the coast, some with multiple distribution terminals and some with a single terminal used by all companies that distribute from that location.

[5] Energy Data File – average March 2004/2005 years

SFSL classifies the ports into three grouping as follows:

Major Ports	Ports with high throughput where petrol and diesel are largely supplied by direct imports (Mt Maunganui, Wellington, Lyttelton)
Medium Ports	Ports with average throughput largely supplied by SFSL from refinery production (Napier, Nelson, Dunedin)
Minor Ports	Ports with lower throughput largely supplied by SFSL from refinery production (Auckland[6], New Plymouth, Timaru, Bluff)

For the purpose of this analysis we have two groupings, major ports and the rest (medium and minor ports together). Wiri is in a category of its own because of much higher throughputs compared to other locations. The distribution terminal next to the refinery is an equivalent volume to a minor port.

The Gull terminal is at Mt Maunganui so is part of the throughput at a major port.

Typical monthly port throughputs and number of terminals for each category of port are shown in Table 1.

Table 1

	Number	Typical number of terminals	Petrol (000 litres/month)	Diesel (000 litres/month)
Wiri	1	1	100,000	50,000
Major ports	3	3	30,000	30,000
Other ports	7/8[7]	1.5	10,000	13,000

Source: Derived from SFSL, NZRC annual reports, Energy data file

Petrol is typically 75-80% regular grade (currently 78%)[8] with the rest premium grades. While throughputs at the larger ports are much higher in general, there are more individual company terminals. On average major ports have three individual terminals whereas the other ports only have one or two (i.e. companies are more likely to use another company's facility in a smaller port and have their own facility in a major port). This means that the actual volume through each individual terminal is similar. For this analysis we assume the major ports have three individual terminals and the other ports on average 1.5 giving a total of 21 petrol terminals and 22 diesel terminals.

Much of the existing terminal infrastructure is expected to be suitable for use with biofuels (see Appendix 1), with the main emphasis on materials compatibility and some minor upgrades to smaller plant items. There will be some new infrastructure requirements, these are discussed below. Ethanol and biodiesel will require separate facilities due to product incompatibility issues and to avoid contamination.

3.5.1 Ethanol

The normal way to blend ethanol in a terminal is to store the ethanol in its own tank and have an in-line blender that blends it with the petrol (either a special blendstock or on grade product) as it is delivered to the fill stand where trucks are loaded. It is not normal practice to blend into a separate tank and recertify the blend (very expensive option). Quality is

[6] Note Auckland terminal does not distribute petrol and its diesel distribution is primarily used for marine users (about ½ typical small port volume).
[7] Includes Marsden Point Road Loading – petrol is in 7 and diesel in ports
[8] Energy Data File to March 2005

maintained by having quality systems in place that ensure both the petrol blendstock and the ethanol meet the correct specifications. On some specifications (e.g. RVP) a daily test may be done to ensure the resultant blend is as it should be.

Some countries allow splash blending of ethanol (separately delivering the ethanol and petrol base-stock into the truck) but this is not recommended practice as mixing can not be assured[9].

For our analysis of ethanol facilities we look at the tank size necessary to hold one to two months supply of ethanol if supplying up to 10% of at least one of the grades of petrol. This would be sensible to provide adequate cover where re-supply is by imports, although a smaller tank is possible if assured of a consistent domestic supply. However tank size is not a major driver of the cost involved.

The use of existing wharflines (pipeline from jetty to terminal) is an issue for ethanol imports. Ethanol may not be able to be imported through the current petroleum wharfline especially if it rests on water (still done in one or two ports) or jet is discharged through the line. This is not an issue for some ports where there is a chemical line that can be used for ethanol (e.g. Wellington, Lyttelton methanol line, etc.). In the base case we assume no new wharfline but it could easily add $1 million to the cost of ethanol facilities if a new line were required. A truck discharge facility for delivering ethanol into a tank is included in the cost estimate.

The ethanol tank(s) are likely to be expensive as they need to have their own compound separate from petroleum products. This is because the management of water from around these tanks need to be completely isolated. All terminals have separator systems to process and remove hydrocarbons from the site water prior to discharge. However these rely on hydrocarbon/water separation – as ethanol does not separate from water they would not remove ethanol before the water is discharged. This is not acceptable so the systems must be kept separate. This also applies to the truck fill stand where a tank will be required to catch any spills in the fill stand. These are present in some terminals but not all.

Depending on decisions made on finished product specifications, a special petrol blendstock may be required to blend with ethanol. If this is the case one or two larger additional tanks would be required, at least one for storing the low RVP petrol blendstock and possibly one for batching and testing of the blend prior to release. However companies can still choose to directly blend the ethanol with the blendstock into the trucks and avoid the batching tank. This is likely to be cheaper although they will need to have giveaway on the blendstock to ensure the blend is always on specification.

The truck fill stand will also require modification and in many cases upgrade of the control system to manage the blending ratios. This will be quite expensive because of the number of loading arms involved. Some fill stands have more sophisticated control systems that will be adaptable for managing ethanol blends.

Our expectation of the cost involved for a normal terminal for ethanol tankage, associated infrastructure, in line blending and fill stand modification to be about NZ$2 million per terminal. If new wharflines or blendstocks tanks are required this could easily increase by another $4 - 5 million. Some companies have existing chemical storage tanks near their petroleum facilities and/or control equipment on their fill stands suitable for modification. This could reduce the costs involve for those locations (we estimate by about half).

[9] API RP 1626 (2000) Storing and Handling Ethanol and Gasoline Ethanol Blends at Distribution Terminals and Service Stations.

3.5.2 Biodiesel

If biodiesel is blended at the refinery with a single grade of diesel distributed, there is unlikely to be any additional work required in the distribution terminals unless. However if biodiesel is blended at the terminal (essential if imported diesel is to have biodiesel added) then blending facilities are required. Again the most efficient method will be to have a separate biodiesel tank with an in-line blender to blend the two streams together before loading a vehicle.[10] The neat biodiesel tank(s) need heating equipment to ensure the biodiesel remains several degrees Celsius above its cloud point[11] to ensure the subsequent blending operation is successful. This increases the cost of the tank. However it does not have the same separation issues as ethanol.

For this analysis tanks are sized to store enough biodiesel to supply 5-10% of the diesel supply and hold one months storage (storage capacity is lower than ethanol as we assume a continuous supply of biodiesel coming into the facility from the biodiesel producer). A biodiesel truck unloading facility will be required.

If a special blendstock for blending with the biodiesel is needed it would increase costs significantly with additional tankage required. We would expect that companies would only use biodiesel when the base diesel allowed (there was sufficient giveaway on density and cold flow properties) or ensure that the base diesel always had these properties if biodiesel was going into all diesel rather than use a special blendstock.

Again an inline blender and fill stand modification will be required at a similar cost to ethanol. Excluding any blendstock tankage, we would expect the total cost to be around NZ$2 million per terminal, mostly associated with the biodiesel tanks and fill stand modifications.

An option for biodiesel is to blend it directly into the diesel as the diesel is put into the tank (either from pipeline or ship). This is likely to be cheaper (half the cost) as it doesn't require fill stand modification although it reduces the flexibility of providing different percentage blends to different customers.

3.6 Transportation

We would expect dedicated trucks to be used for transporting both pure ethanol and pure biodiesel as it is likely to be a different distribution pattern to the petroleum fuels delivery. Any 'backhaul' options are likely to be optimisations rather than core operation. However transport of the blended product would use the existing fleet. Details of equipment suitability are in Appendix 1.

3.7 Service Stations

This section focuses on the retail operations, particularly double containment requirements. Materials compatibility is discussed in Appendix 1.

As part of the application for ethanol blended petrol, ERMA required that this product (above 1% ethanol) be stored with double containment. The typical method of achieving this at service stations is to use a double skin fibreglass tank with probes that monitor the void space between the two tank skins. Analysis of the market data shows there are currently just over 1300 service stations around New Zealand. Most have three tanks (two grades of

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[10] Splash blending in the tank truck is possible although mixing can not always be guaranteed (Energy Efficiency and Renewal Energy, US Department of Energy, 2004 Biodiesel Handling and Use Guidelines pg 39)

[11] Energy Efficiency and Renewal Energy, 2004 Biodiesel Handling and Use Guidelines

petrol and one grade of diesel) with a mix ranging from small old steel tanks to larger fibreglass tanks with single or double skins. Using data provided by some petroleum wholesalers and data from NZIER's report of independent retailers[12] the number of independent service stations has been extrapolated to be approximately 550 sites.

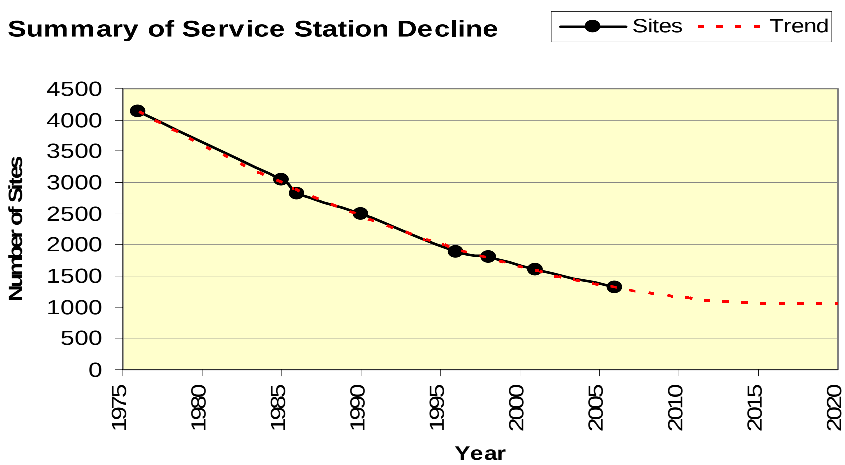
All recent tank installations have double skin fibreglass tanks, with about 750[13] of these tanks now installed in New Zealand. Typical installations at a site would see all tanks (including the diesel tank) replaced at the same time due to their close proximity. At smaller service stations that have been re-tanked single petrol tanks with an internal compartment (to provide 2 grades of petrol) are likely to have been installed.

Using this information there are just over 1,000 service stations that do not meet the current requirement for double containment when storing ethanol blended petrol. We calculate that about 2,650 new tank installations would be required to achieve 100% compliance. Discussions with tank suppliers indicate a typical installed cost of 105,000 NZD per tank. Applying this cost against the 2,650 tanks suggests a cost of approx NZ$278 million.

Looking at this in terms of volume using typical volume demographics data 29% of the petrol volumes sold at service stations is pumped via double skin fibreglass tanks. This is greater than the fibreglass tank penetration of 22% reflecting the greater predominance of double skin tanks at the larger volume sites.

However the proportion of double containment tanks is increasing at a reasonable pace (about 40 sites per year) as new sites are developed and older sites are upgraded or when the supplier is changed. If there was a requirement to replace single skinned tanks prior to the introduction of ethanol based fuel and given the significant cost it is probable that some of the smaller and marginal sites would close. Figure 1 is a summary of service station decline over time with a simple trend line of potential future decline.

Figure 1



Source: Hale & Twomey

This trend suggests that there could be another 260 service station closures with site numbers settling around 1,050 sites by 2020. Assuming these sites were closed instead of being re-tanked we calculate that this would leave about 770 service stations with non complying tanks (about 2,050 tank replacements). Using the same cost per tank this would suggest a cost of approx NZ$215 million.

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[12] The Decline of Independent Petrol Retailing: Rationalisation or Predation, NZIER 2002

[13] Discussion with leading fibreglass tank manufacturer in New Zealand

Steel tank installations at service stations continued into the 1990's at which point they were largely superseded by fibreglass tanks – initially single skins and later double skins. The life expectancy of a steel tank is about 25 years and fibreglass tanks have a 30 year warranty suggesting a life expectancy much longer. Thus using the natural decay, steel tanks may continue to be used in service stations till about 2020, although declining steadily throughout this period. Similarly single skin fibreglass tanks may continue to be used in service stations till about 2030-2040.

The rate of tank replacement at the service stations is one of the key factors that determine the pace at which ethanol blended fuel can be introduced in New Zealand. The volume impact of this is discussed further in Section 7.0.

The spread of double skinned tanks is also not even between companies. Gull with a relatively new network has all double skinned tanks as does Gasoline Alley supplied stations as these all recently had to replace tanks when they changed supply from the major oil companies. For the majors the double skinned sites are concentrated where new sites have been developed or where they have concentrated their redevelopments (Auckland particularly). Our expectation is that provincial centres (and Wellington and Christchurch) would be under represented versus the average (note: not necessarily in rural areas, as many smaller stations have been re-tanked for supply changes such as those associated with Gasoline Alley).

3.8 Commercial Customers

There are two main types of commercial customers, those who use the service station network via fleet cards and those who have fuel storage tanks at their site. This section focuses on the commercial customers with their own tanks.

Predominantly these commercial customers are large diesel users. The key biofuels issue for these customers will be around the compatibility of the biodiesel with their dispensing equipment and their plant and machinery that would use the fuel. These are similar to the service station issues. At low blend levels (i.e. biodiesel content below 20%) this is not expected to cause a problem, Appendix 1 gives more details.

There are not so many commercial customers with petrol storage. Generally ethanol petrol blends are less suitable for storage as the turnover may be insufficient to ensure quality is maintained. Unlike a service station site which has dedicated staff running the facility, the commercial sites often don't and as discussed previously ethanol petrol blends requires active water removal management to ensure fuel quality is maintained.

Labelling requirements are likely to follow the same direction as service stations.

3.9 Summary of Infrastructure Requirements

Table 2 summarises the infrastructure requirements for biofuels by component of the distribution system.

Table 2

Component	Ethanol/ blendstocks	Biodiesel
NZRC	Not applicable as ethanol won't be blended at refinery. Production of a special blendstock will require new infrastructure to mange different grades.	If blended at refinery there will need to be two heated tanks (size dependant on location of plant), modification to blending system and a means of getting biodiesel into refinery (e.g. pipeline from plant, line (or modification) of line from jetty, truck unloading)
SFSL	Not applicable, as ethanol or ethanol blends will not be transported. Transport of a blendstock will increase cost.	Capable of transporting biodiesel or biodiesel blends (not tallow) once MARPOL approves.
Imports	Blendstock available at similar cost	Blendstock available at higher cost
Refinery Auckland Pipeline	Will not be used for ethanol/petrol blends	Uncertain whether it can transport biodiesel blends
Wiri	Expected cost of infrastructure ~ NZ$4 million	Expected cost of infrastructure ~ NZ$4 million if blending at location
Other terminals	Expected cost of infrastructure ~ NZ$2 million/terminal (NZ$40 million for all other terminals)	Nothing required if blended at NZRC - expected cost of infrastructure if blending required~ NZ$2 million/terminal (NZ$42 million for all other terminals)
Transport	No significant issues	No significant issues
Service Stations	Only those with double containment can be used – currently 29% but increasing over time. Would cost over NZ$200 million to convert earlier and speed rationalisation of service stations (early closures).	No significant issues

4.0 Blendstocks for Biofuels

4.1 General

The use of blendstock for biofuels is dependant on the specification requirements of biofuels. When ethanol is blended into petrol the RVP, E70 and octane of the blend increases and in the case of RVP and E70 may put blend out of specification. There are three ways of managing this:

- Get a special petrol blendstock so the blend is on specification
- Adjust the specification on all petrol so both the petrol and blend is on specification
- Allow a waiver for the blend on RVP and E70 specifications

This issue is more fully discussed in Section 5.0. In this section we discuss issues around the supply of the blendstock.

There is a similar issue with biodiesel blends in this case with the cold property specification and the maximum density specification. This could be managed a number of ways

- Blending at refinery so product is issued meeting specification
- Enough giveaway on base diesel to allow biodiesel to be added
- Allow a waiver on density and cold flow specifications
- A special blend of diesel basestock for blending

For biodiesel it is expected only one grade would be marketed nationally – i.e. all customers can use up to 5% biodiesel. Given this, the option of enough giveaway and a special blend of diesel are essentially the same.

4.2 Marsden Point Refinery

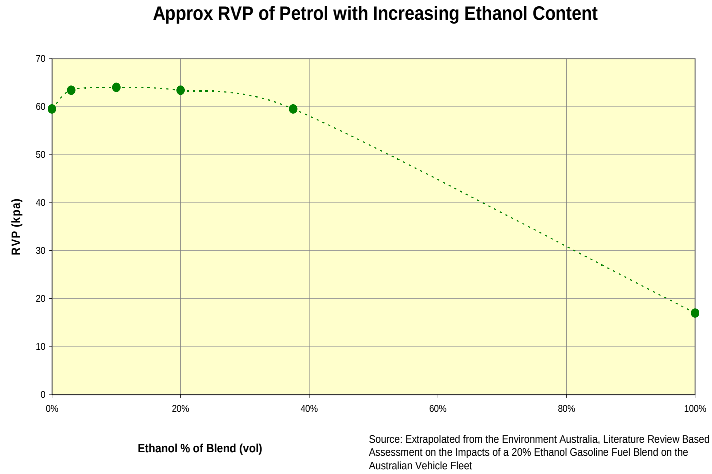
The refinery would be capable of producing a special blend of petrol for use with ethanol if its customers required. There are however a number of issues including:

- They would need to invest in more petrol tanks as they would need to produce blendstock as well as the existing grade
- Reducing the RVP would make it more expensive although this could be offset by savings from reducing the octane
- If octane of petrol is reduced, less fuel gas and hydrogen will be produced in the refinery – currently the balance of these fuels is a key refinery operational restriction (especially hydrogen). It may be the refinery needs to maintain octane levels in order to produce enough fuel gas and hydrogen for the rest of the refinery so cannot get a benefit.

Without detailed modelling on refinery balances (which would require a lot of refinery work) our assessment is that the base cost of a petrol blendstock would be equivalent to the petrol grade excluding the need for additional infrastructure.

The petrol blendstock will be similar whether it is for a 3%, 5% or 10% ethanol blend as the RVP increase happens with the addition of only 3% ethanol (non-linear). If the supplier wants to capture the benefit of a lower octane then a specific amount of ethanol will be required as that does blend linearly. A graph showing this effect with an approximate trend line is shown in Figure 2.

Figure 2



If biodiesel is blended at the refinery, other than the investment required covered in the Section 3.1 no additional investment is required. Current blend tanks will be used and the blended product would meet the finished specification and be distributed by current methods. This is the simplest operation as all quality systems are set up to monitor quality at this point now.

If blending in terminal, companies may ask the refinery to build giveaway into the base fuel in order to ensure a blend is on specification. This is likely to involve a tighter upper density specification (0.8485 maximum for 5% biodiesel rather than 0.850) and 1-2ºC lower on the CFPP. The main cost of this would be the cloud – our estimate is about US$0.10/bbl/cloud number so the incremental cost would be about US$0.20/bbl (0.2 c/l). Note this assumes all diesel going to a destination will be produced to this specification, not two different grades.

Information for the US[14] shows that a 10% tallow based biodiesel blend raises cloud point by about 6ºC (from a very low cloud base diesel). New Zealand diesel does not have such a low cloud so the increase may be less, however it will still be significant. A 5ºC rise would mean the base diesel would need to be blended lower costing about US$0.50/bbl or ~0.5 c/l. At 20% blend the cloud point rise is even more significant (up to 10ºC higher). However it could be the higher percent blends are only used for certain customers where cold flow properties were not an issue (i.e. not meet the regulated specification). However different percentage biodiesel blends are only feasible when blended at the terminals not refinery.

4.3 Blendstock Imports

Blendstocks suitable for blending with ethanol could be imported. The tighter RVP/E70 specification may increase the cost whereas the ability to reduce octane could reduce cost. However the specifications for New Zealand petrol are tight compared with other countries in a number of areas (e.g. sulphur/olefins). The relaxation in octane may not allow refineries to use cheaper components because of other specifications (e.g. sulphur limits the use of cracked gasoline which is normally a cheaper component). As a base case assumption it is assumed that blendstock will be available from similar locations as the current imports but no significant cost difference is involved.

Diesel can be obtained with lower CFPP properties on the international market but that will increase the importer's cost. We assume this will be a similar level to that estimated for NZRC (0.2 c/l for blending with 5% biodiesel).

[14] Energy Efficiency and Renewal Energy, 2004 Biodiesel Handling and Use Guidelines

4.4 Other Distribution Issues

Anything that involves a new/extra product grade increases the complexity of the distribution system. For SFSL costs will increase due to the greater number of small parcels of product to transport (and less flexibility to shift between them). Costs within the distribution terminals are likely to be substantial as identified in Section 3.5. This is a particular issue for ethanol petrol blends where two grades would be required (i.e. blendstock + existing grade). An option would be to blend all petrol with suitable giveaway but as ethanol volumes are likely to be small this cost could be very high as it would apply to all petrol. For instance if all regular petrol was produced with a lower RVP to allow for the possibility of blending with ethanol, we would expect the additional cost to be between US$0.30-0.50/bbl (0.3-0.5 c/l) which would be an annual cost of NZ$6-10 million. If only 40 million litres of ethanol is sold annually this increases the cost of including that ethanol by $0.20/litre of ethanol, a very substantial increase.

4.5 Blendstock Summary

The use of blendstocks is expected to increase costs substantially. This can make a very big impact on the cost of introducing biofuels to a market. Because of this we recommend other approaches are taken that avoid the need for special blendstocks. This is discussed further in the Section 5.0.

5.0 Key Issues and Decisions

This section outlines the key distribution issues and the decisions required, some of these are policy decisions for government to consider, whereas others are economic decisions which will be determined by the market. The Government policy decisions will influence the uptake of biofuels in the New Zealand market.

5.1 Ethanol specification

Ethanol blending effects and the resultant impact versus the petrol specifications, as well as associated infrastructure issues are discussed in Table 3.

Table 3

Option 1: Allow blending of on-grade petrol and ethanol without requiring final blend to be on-grade.	Option 2: Require final blend to be on-grade (i.e. special petrol blend required).
Blending of on-grade petrol with on-grade ethanol causes the Reid Vapour Pressure (RVP) and octane of the petrol to increase. RVP increases quickly reaching maximum effect with only 2-3% ethanol blends and then slowly declines[15].	Requiring the final blend to be on-grade maintains the current regulatory requirements, however to achieve this, a special blendstock of petrol with lower RVP and possibly lower octane (to capture the octane giveaway) will be required to ensure the final blend is on-grade.
RVP is likely to increase ~ 4.5kpa[16] with ethanol blends. Thus RVP is likely to exceed the current RVP limits for NZ petrol. The likely increase will be less than the pre 1 Jan 2006 level, thus drivability issues are not expected. However evaporative losses may increase with the higher RVP.[17]	The ability to supply a special blendstock of petrol is not expected to be difficult although there is not expected to be a price advantage from this due to the specialized nature of the blend. However additional infrastructure costs will be substantial.
Octane will also increase due to the higher octane level of the ethanol. As this increase is favourable this will not cause any drivability issues. However for a company to market this extra octane they would need to test the resultant blend to assess the quality of the blended fuel.	It will become difficult to swap between ethanol based petrol and a standard grade of petrol at terminals and service stations as the resultant mixture is likely to be off-grade for RVP, despite both mixtures being on-grade prior to mixing. It may be more economic to adjust base petrol grade rather than have to duplicate infrastructure.
Monitoring may be more complex, unless it was managed by a limited waiver if ethanol is present.	Monitoring would remain the same as today.
New infrastructure requirements at each terminal would include a raw ethanol tank, an inline blending system at the fill stand plus upgrades to the water separator system and fire protection system. This option has lower infrastructure costs than option 2.	New infrastructure requirements at each terminal would include a raw ethanol tank, a raw petrol blendstock tank, an inline blending system (or possibly a blending tank to allow blending plus certification prior to release) plus upgrades to the water separator system and fire protection system.
With this approach there more flexibility for viable supply including seasonal swings. This will also allow flexibility for varying levels of ethanol in the petrol blend.	Guaranteed supply of ethanol is required as the petrol blendstock may not be suitable for supplying the market. This reduces the flexibility of supply.

[15] Department of Environment and Heritage, Setting a Quality Specification for Fuel Ethanol

[16] Environment Australia, Literature Review Based Assessment on the Impacts of a 20% Ethanol Gasoline Fuel Blend on the Australian Vehicle Fleet

[17] There is some debate about the actual impact. NSW Government did testing before allowing a wavier and the findings are summarised in the Australian Report of the Biofuels Taskforce to the Prime Minister (2005), pg 81

The cost of infrastructure for ethanol is analysed in Section 6. Even if the simpler option 1 is followed, the costs of the ethanol infrastructure are significant especially as volumes are expected to be low. If the ethanol/petrol blend has to meet the same specification as the petrol we expect the infrastructure costs for ethanol blends introduction may well be prohibitive and unlikely to happen in the short to medium term. Many countries have allowed a waiver for the RVP specification as proposed in option 1 (e.g. Australia, USA) to facilitate the introduction of biofuels.

5.2 Biodiesel Logistics

We have identified three plausible logistics options for biodiesel, each of these options and the associated infrastructure issues are outlined in Table 4.

Table 4

Option 1: Biodiesel is transported from the biodiesel plant(s) to key terminals for blending prior to delivery.	Option 2: Biodiesel is transported from biodiesel plant(s) to NZRC for blending prior to supply to the terminals.	Option 3: Tallow is transported to Marsden Point for processing into biodiesel then blending prior to supply to the terminals.
Assuming tallow becomes the predominant biodiesel feedstock, possible plant locations may be central South Island, lower North Island and upper North Island. Biodiesel delivery costs from these locations would be minimal due to their likely proximity to key terminals.	Biodiesel could be shipped to NZRC on SFSL vessels (or similar) for blending with NZRC produced diesel, for subsequent redistribution to the terminals. Much cheaper to transport than tallow, this may make it more economic.	Tallow can't be transported on SFSL vessels, so expensive specialty chemical carriers would be required. Infrastructure for discharging and storage (probably at Northport) prior to processing would be required. These may offset the scale advantage of plant size.
Issues with plants - other than Wiri, they will exceed requirement of nearest port (at 5%) thus increasing distribution cost. Also South Island unlikely to be suitable for use in winter initially – again this increases distribution cost.	Blending at NZRC is safer for meeting final quality and allows the biodiesel to be distributed to the regions with less severe winter cold properties.	Biodiesel could be transferred to NZRC by truck or pipeline – less tankage required at NZRC. Same advantages as option 2 from blending at NZRC.
New infrastructure requirements at each terminal would include a raw biodiesel tank with heating, an inline blending system at the fill stand and receiving facilities for biodiesel (truck or ship). Allows imported diesel (~20% of market to be blended.	New infrastructure requirements at NZRC may include a new wharfline (flushing may be a cheaper option) and two heated tanks for receiving and using as blending tanks. Biodiesel would be used as a blending component. Adjustments to NZRC blending system would be required. No modification is then required at the terminals.	An import and storage infrastructure would be required for tallow associated with the manufacturing plant. Similar infrastructure required at NZRC to option 2 although tanks can be smaller. Requires RAP pipeline to be feasible for transporting biodiesel blends. No modification required at terminals.
Gives flexibility to adjust blend ratio for different customers, a fleet might use B20.	NZRC would set the ration – virtually no ability to vary for particular customer (unless very large volume)	NZRC would set the ration – virtually no ability to vary for particular customer (unless very large volume)

The costs associated with each of these options are in Section 6.

5.3 Biodiesel Cold Properties

The main issue with blending diesel and biodiesel is the effect on the cold filter plugging point (CFPP), which is a measure of the temperature where fuel lines are likely to block due to crystallisation. CFPP is a measure of fit for purpose rather than environmental impact. Biodiesel CFPP can vary depending on the source, for tallow this is around 10-14 ºC[18] versus a regulated requirement of -6 ºC CFPP in the winter period and a typical fit for purpose practice of -9 ºC CFPP in the winter period.

As CFPP does not blend linearly it is not easy to assess the resultant CFPP of a blend from the raw diesel and biodiesel CFPPs mathematically. Work completed in the USA[19] indicates the impact varies depending on the source of biodiesel although the impact at 5% is small. With some biodiesel (including that sourced from edible tallow) the impact is quite significant at 20% (about half the difference between the source diesel CFPP and that of the pure biodiesel). However the properties are likely to be impacted by a wide range of factors including diesel and biodiesel quality, raw materials used to make the biodiesel and blending method, thus trial blends using actual biodiesel would be required to assess the expected CFPP effects for New Zealand.

Further work by the National Biodiesel Board[20] considered blending of biodiesel and the effect on cold flow properties. This highlighted two key points, firstly that good mixing is important and secondly that the raw biodiesel mixes well when its temperature (at the time of mixing) is ~6 ºC above its cloud point. This suggests biodiesel is more suited to blending in warmer climates / seasons and that raw biodiesel may require heated storage (as it has a 10-14°C CFPP heating of pure tallow sourced biodiesel will to be required in New Zealand).

Normal cold flow additives which are used to depress the cold flow properties of diesel don't work well with biodiesel and blends of both diesel and biodiesel[21]. While additive suppliers are looking at developing additives for biodiesel this will take time and again is likely to be source dependent. New Zealand winter grade diesels often contain cold flow additives so the impact of biodiesel on diesel with additive will need to be monitored.

There is some concern within New Zealand that CFPP test may not always be a reliable indicator for CFPP with biodiesel blends from tallow[22]. Most international work has been done with rapeseed or soy based biodiesel which have better cold properties than tallow based biodiesel.

The New Zealand legal specification requires a minimum of -6ºC CFPP diesel in winter and also requires the diesel to be fit for purpose. Some companies (who market in the colder South Island climates of New Zealand) supply diesel with even better cold properties (-9ºC or -15ºC CFPP) to meet the fit for purpose specification. Until companies are comfortable with biodiesel blends in service and have done some testing on the impact on diesel with additives they are likely to take a precautionary approach to biodiesel blends using it only in Northern regions and/or warmer seasons.

[18] Energy Efficiency and Renewal Energy, US Department of Energy 2004, Biodiesel Handling and Use Guidelines

[19] Energy Efficiency and Renewal Energy, US Department of Energy 2004, Biodiesel Handling and Use Guidelines pg 38

[20] National Biodiesel Board, Biodiesel Cold Weather Blending Study

[21] Energy Efficiency and Renewal Energy, US Department of Energy 2004, Biodiesel Handling and Use Guidelines pg 35

[22] Phone conversation with BP

5.4 Biodiesel Labelling

There are two options for biodiesel labelling requirements and the issues are discussed in Table 5.

Table 5

Option 1: No requirement for blends of up to 5% biodiesel to be labelled.	Option 2: Require all blends containing biodiesel to be labelled.	
	With labelling comes the option to allow biodiesel to be a blend of on-grade diesel and on-grade biodiesel without requiring the final blend to be on-grade, or a requirement for the final blend to be on-grade.	
The blend must meet the legal specification for all properties including CFPP requirements as the fuel is not distinguished from standard diesel. This approach would be consistent with the NZS 7500:2005 Automotive Biodiesel Specification for Manufacture and Blending. Currently NZS 7500 limits retail blends to 5%, but allows blends up to 100% for non retail use.	**Option 2a: Allow blending of on-grade components.**[23]	**Option 2b: Require the final blend to be on-grade.**
	Using this approach CFPP is not guaranteed, however typical levels in the market are greater than the current regulated levels. The other fit for purpose requirements like FBT are also not guaranteed, however there is still the requirement to be fit for purpose.	Like option 1 the final grade would need to be on-grade for all properties including CFPP and FBT.
It is likely that some companies may choose to market their fuel as biodiesel. If they do so they will be responsible for ensuring the blend contains the components they say it does.	Similar to option 1 a minimum level of biofuel maybe required to ensure the fuel contains a reasonable level. There would need to be some way of differentiating various levels of biodiesel, particularly below or above 5% to allow the consumer to be aware of the level of biodiesel in the fuel.	
There is more flexibility of supply as the biodiesel content can vary. This reduces the requirement for biodiesel to be always available which would give the more supply flexibility.	There could be less flexibility of supply as changing biodiesel content could require a change in labelling on retail sites to avoid misrepresenting what is being sold. The need to change labels could also hinder a supplier's ability to use seasonality.	
Monitoring would remain the same as today.	Monitoring would need to cover for a waiver on certain properties.	Monitoring would remain the same as today.

It is worth also noting that biodiesel quality does vary depending on the source of the raw materials and the manufacturing process, thus unlike petrol ethanol blends the resultant blend result is less certain.

5.5 Biodiesel Specification

Biodiesel is typically denser than mineral diesel and when blended with diesel the resultant blend can exceed the density limits as set out in the Petroleum Regulations. Upper density limits are imposed on mineral diesel to restrict the heavy aromatics and paraffin's as these heavy molecules tend to generate higher particulate matter emissions, particularly in older vehicles. However biodiesel's higher density is not due to these heavy molecules and does not suffer the same particulate matter emissions[24].

[23] Note NZS 7500:2005 Automotive Biodiesel Specification for Manufacture and Blending currently does not permit this option.
[24] NZS 7500:2005, Automotive Biodiesel Specification for Manufacture and Blending

The other important consideration is that diesel injection systems work on volume not mass. By tightly controlling the upper and lower density limits the air to fuel ratio is likely to be more optimal. However as biodiesel contains oxygen, optimal combustion can be achieved with a lower air to fuel ratio, which helps to compensate for biodiesel's higher density.

6.0 Summary of Cost

Using the cost information discussed in Section 3 along with the volume assumptions in Section 7 we build up expected blending and distribution costs in c/l, using current typical construction costs. Capital costs are concerted to c/l using the same assumptions used in the Economics Report (15 year life, 15% return on capital).

6.1 Ethanol

Expected throughputs of ethanol are relatively low because of restrictions on service stations that can be used and customers who can use it. We assume at most volumes will increase from 24 to 57 million litres between 2008 and 2012.

As port terminal infrastructure is quite expensive this translates into an expensive per litre rate (assuming the volume of 2011 as divisor). These costs assume there is a waiver on RVP and additional tanks are not required for a special petrol blendstock. This is outlined in Table 6.

Table 6

Infrastructure	Cost (NZ$M)	Throughput (million of litres)	Cost (NZ c/litre of ethanol)
Wiri	4	16.7	4.1
Other Terminals	2	1.6	21.7

Other than Wiri, the cost on a per litre basis is excessive. This means ethanol is only likely to be done where throughput through an individual terminal is much higher (e.g. shared terminals in major ports) or the investment in infrastructure is cheaper because of existing facilities available. Increased throughputs can be achieved by supplying petrol/ethanol blends to a wider region to that normally supplied from a terminal. However as 90-95% of what is transported in a truck is petrol, the economics of distributing too far outside normal distribution (i.e. closer to the terminal normally used for that region) is expensive. We expect the cost per litre of ethanol supplied will need to be under about 10 c/l before it becomes viable to put ethanol facilities in a new port.

If the costs were increased by the need to hold blendstocks (up to three to four times this cost) they would be prohibitive on a per litre basis.

Note this is a generic analysis across industry. For some companies (especially Gull) where one terminal supplies all their volume and all sites can take ethanol the costs are likely to be much cheaper.

6.2 Biodiesel

The biodiesel infrastructure was analysed with three options. These are shown in Table 7.

Table 7

Option	Large Biodiesel Plant (120kT) at Marsden Point	Two or three medium sized plants (50kT) and ship biodiesel to NZRC for blending	Smaller plants and blended in terminals (a) or medium sized plants with ship transport to other ports (b)
Distribution required	Transport tallow to port Tallow shipment to Marsden Pt Biodiesel to refinery Redistribution of blend	Collection of tallow Transport of biodiesel to port Transport of biodiesel to terminals. Redistribution of blend	Collection of tallow Transport of biodiesel to terminals.
Infrastructure required	Tallow storage at port Tallow discharge and storage at Marsden Point. Tanks and blending infrastructure at terminal.	Biodiesel storage at port Biodiesel discharge at terminal Tanks and blending infrastructure at terminal.	Infrastructure in all terminals using biodiesel
Advantages	Scale: large plant cheaper Blending: Refinery easier – quality assured	Shipping: Cheaper easier to ship biodiesel Blending: Refinery easier – quality assured	Can blend imported diesel Invest in locations as required
Disadvantages	Transport: Tallow expensive to transport Imports: doesn't allow for biodiesel in imports	Scale: More expensive plants Imports: doesn't allow for biodiesel in imports	Scale: Much more expensive plants. Other than Wiri no new location has significant demand

The analysis of the above options gives the following output

Table 8 (all NZc/litre)

Option	Large Biodiesel Plant (120kT) at Marsden Point	Two or three medium sized plants (50kT) - ship biodiesel to blend at NZRC	Medium sized plants - blend in terminals with shipping as required	Smaller plants and blended in terminals
Distribution costs+	12.9	6.4	3.0/2.2	1.0
Plant cost: capital & other costs that vary with volume	11.3	17.8	17.8	25.7
Blending and other infrastructure costs	2.5	2.2	7.0/5.0*	7.7/4.2*
Total	26.7	26.4	27.8/25.0	34.4/30.9

+ note distribution cost includes cost of getting tallow to port and storage prior to export (where applicable). Therefore these prices should be used with an ex-plant tallow price not an export price from port tanks.
* Lower number is for Auckland only.

Based on these assumptions, the costs are similar for a medium sized plants blending in terminals or shipping the biodiesel to NZRC, or a large plant at NZRC. The actual decision would come down to a number of factors including feedstock availability/options, the scale curve for the type of plant proposed and firming up investments required under each option. Directionally once plants are smaller than 50kt (~60 ml) the incremental cost of the plant is not offset by distribution savings.

Blending at NZRC has a number of quality advantages for the diesel produced at NZRC. However about 25% of diesel is directly imported and all marketers import (100% in Gull's case). In order to put biodiesel into all diesel, blending facilities would need to be set up in some ports which increase costs. This could favour a wider distribution of biodiesel plants with some shipping of biodiesel between ports.

7.0 Volumes

7.1 Likely Ethanol and Biodiesel Demand

Volume demand for both ethanol and biodiesel is outlined below. The distribution issues covered above set the landscape for the maximum likely volume of each over time. These assumptions are based on current market conditions. Changes in incentives, targets or anything affecting consumer uptake will all affect the actual rate of uptake.

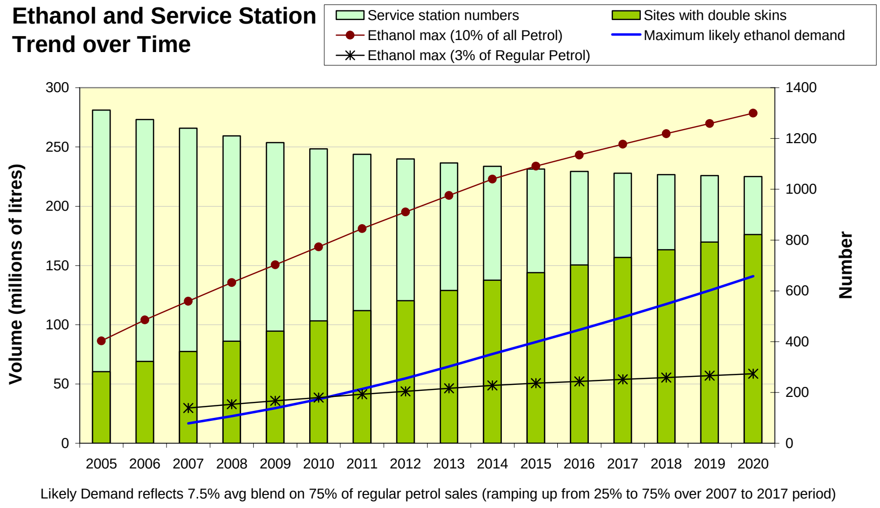
7.1.1 Ethanol

Likely ethanol demand is restricted by the requirement for double containment of ethanol petrol blends[25], by engine manufacturer constraints and by consumer demand. For our analysis we have assumed that ethanol will only be blended into regular grade petrol – this reflects both the engine constraints and the expected marketing realities of offering the consumer a choice of fuel types. Additionally we have assumed that retailer and consumer confidence will start slowly (sales at 25% of possible locations for regular grade petrol) and ramp up slowly, reaching 75% of sales locations by 2017. In addition we have assumed the ethanol blend is a mixture of E5 and E10 (average 7.5%).

Using these assumptions and the expected increase of double containment at service stations over time, less expected site closures over time, the results can be seen for various levels of ethanol uptakes in Figure 3.

[25] Assumption on changeout of single containment tanks is that larger volume sites are changed earlier (i.e. companies take account of ethanol ability in changeout profile).

Figure 3



The graph captures the total number of service stations in the market over time with the growing level of double containment at the sites.

The first key line is the 'Maximum likely ethanol demand' line in blue, which reflects the assumptions above. From this the maximum likely demand is initially expected to be small with only 24ml of ethanol with the potential to grow to 57ml 2012 and continuing to climb to 147ml by 2020.

The second key line is the 'Ethanol max (3% of Regular Petrol)' line in black, which reflects the maximum volume of ethanol that can be blended into all regular petrol going through double containment tanks assuming a 3% ethanol blend in line with the more conservative engine manufacturer recommendations. This shows that the volume increases from a potential volume of 32ml (2008) to 46ml by 2012 and then 65ml by 2020.

Note that these lines are maximums assuming the whole country is covered. Because these volumes are very low, the cost of putting infrastructure in, is high (Section 6.1). Therefore we would expect that smaller throughput terminals will not be converted until volumes that can be throughput have built up considerably. Up to 2012 we would expect at most, Wiri and the three main port locations to be converted (approx. 70% of above volume). Therefore expected maximum volumes (not taking account of supply or economics) are shown in Table 9:

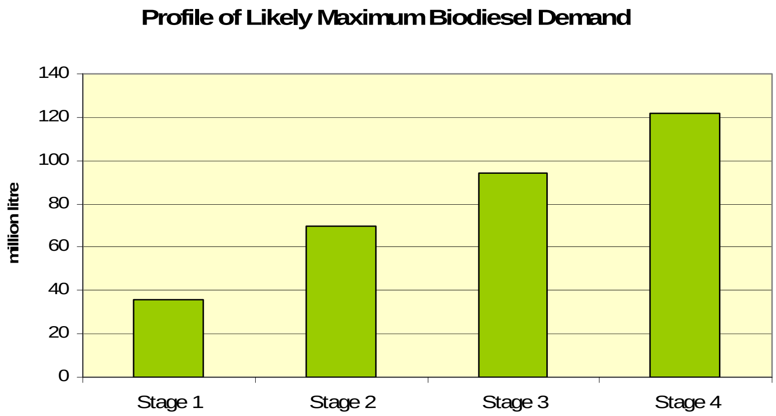
Table 9

Millions of litres of ethanol	2008	2012
Proportion of petrol through double containment tanks	42%	56%
Using H&T assumptions	17	40
3% in all regular petrol	22	32

7.1.2 Biodiesel

Biodiesel's poor cold flow properties compared to mineral diesel is likely to set the pace of introduction in New Zealand. We anticipate wholesalers will take a cautious approach initially with trial blends, then moving to using biodiesel in low percentages in warmer climates where winter is less severe (i.e. Auckland and North of Auckland market). In order to provide a manufacturer with a year round demand we would see this market as setting the first stage for maximum biodiesel demand. Following that use could spread to the rest of the North Island for non winter use (eight months of year – Stage 2) and then into the South Island for non winter use (six months of year) – Stage 3. Once comfort is obtained with how the blend performs in use over the winter in northern regions and with the additives used in winter specification diesel, use would expand into normal winter diesel. This would be about 90-95% of the market (we expect some specific large customers who specify non biofuel diesel such as the navy and the winter grade of the south of the South Island to be kept free of biodiesel). The profile is shown in Figure 4.

Figure 4



Assumptions
Stage 1: Initially only use in -6 CFPP diesel or greater (Auckland only)
Stage 2: Expand to rest of North Island (non winter)
Stage 3: Expand to South Island (non winter)
Stage 4: Expand to include the winter -9 CFPP grade
Assumed 5% biodiesel in all diesel

Using these assumptions biodiesel demand is expected to grow from an initial volume of 36ml to 122ml over time. The speed of this introduction will depend on the success of the prior stages, if these go well wholesaler and consumer confidence will enable a smoother and quicker transition to the next level, however if there are problems or poor consumer reaction this could significantly slow down the move to the next level.

It would be realistic to assume that two winters are required at the Stage 1 level to demonstrate suitability in winter. Stage 2 and 3 are possible within two years if biofuel plant investment is made without year round offtake and if customer demand is there. While speculative, we would not expect stage 4 levels to be reached for two to three years after Stage 1 has been operating (some winter experience and then time for the investment required). If there is more international experience of tallow based biodiesel by the time New Zealand introduces it (quite possible) the process of building up to stage 4 volumes could be faster (one to two years in total), in all probability more limited by biodiesel supply than market demand.

Following Stage 4 the next step to increase biodiesel usage would be to increase the proportion of biodiesel in the blend. While this might be done for specific customers in the shorter term, we would not expect it to happen in the generic grade until Stage 4 is successfully rolled out and vehicle manufacturers are happy with higher levels of biodiesel. Different levels of biodiesel in blends for specific customers in the shorter term are only expected to have a minor impact on the total demand profile. We would then expect the rollout of a B10 grade for example to be similar to that for the B5 grade.

7.1.3 Combined Biofuel Demand over Time

The combined demand for ethanol and biodiesel using the above information is summarised in table 10. Table 10 also shows the proposed minimum and maximum biofuels targets as a reference to the distribution constraints.

Table 10

Demand (million litres)	2008	2010	2012	2015	2020
Max Ethanol	17	27	40	89	147
Max Biodiesel*	36	70	122	140	192
Max Biofuel	53	97	162	229	339
Min Target	12		60		
Max Target	60		240		

* Note 2015/2020 may be higher if suitable supply available

Note the table does not take into account the ability to supply these volumes or the time taken to put the infrastructure in place (which may be an issue for 2008 targets).

8.0 Quality and Monitoring

From the discussion in Section 5 there are two likely outcomes for the fuel specifications. In this section, we discuss the testing requirements for each of these. Other quality issues are also discussed.

8.1 On-grade Components

As discussed in Section 5.1 allowing on-grade petrol components to be blended but not requiring the final petrol blend to be on-grade for some properties, such as RVP, provides a more flexible and cost effective solution for ethanol petrol blends. To ensure fuel quality the regulations could be amended to provide a waiver up to some specified level for the properties that are likely to exceed the current specifications. This approach would be consistent with several other countries, including USA and some states of Australia.

However under this approach the current point of sale testing regime would need to be extended to also ensure the petrol components were on-grade prior to blending. This could take the path of drawing samples from storage tanks to prove compliance or use a reporting process where companies provide evidence of compliance via providing the supplier's certificate of quality. From a practical point of view it would seem that requiring reporting to prove compliance with the right to take samples on a random basis; this approach would limit the number of samples to be taken and tested but also ensure compliance over time.

8.2 On-grade Final Blend

The current point of sale compliance testing regime is sufficient under this option to ensure that the fuel complies with the current fuel regulations. No additional testing would be required.

8.3 Other Quality Considerations

Splash blending is not a reliable blending technique and would not be suitable for use in New Zealand. In-line blending is however proven technology, both overseas and also locally, although local experience is limited to additive injection systems at the fillstands.

Current fuel specifications require fuels to be fit for purpose. For diesel there are a couple of measures of this, firstly CFPP and secondly filter blocking technology. Regardless of the option taken for blending the effect of the biodiesel on the final blend will need to be managed by the supplier to ensure the final blend is fit for purpose.

The issue of how to manage off-grade products which contain biofuels requires some investigation. Small off-grade volumes are likely to be managed within the current 'slops' system that each of the current terminals have, although the effect of blending these slops including biodiesel and ethanol into regular petrol at small doses would need to be tested by the terminal operators to ensure there are no subsequent quality issues in the market place. Using common slops blending rates of less than 1% the resultant biofuels content is expected to be at trace levels only.

With the current infrastructure a significant off-grade fuel could be shipped out of a terminal via ship (although loading the ship can be slow). With biofuels there is not expected to be any impediment to also load these on to a ship if off-grade.

8.4 Sales Target

We have considered the issue of where a sales target would be applied and the obvious place to apply this is with the wholesaler companies as this will capture both imported and locally produced fuel sales. Some concerns were raised by some of the major oil companies that this could expose them to a target which they would not be unable to pass on to their distributors or independent retailers. However these arrangements are governed by contracts which expire and are renewed periodically, this provides the wholesaler with opportunities to pass on the biofuel sales target.

9.0 Summary of Recommendations

Analysis of the distribution system shows that the introduction of biofuels is feasible although there are decisions that can be made to facilitate its introduction. These include:

1. Allowing a waiver of RVP/E70 for ethanol blended gasoline to allow on specification ethanol to be blended with on specification petrol
2. Allowing the blending of biodiesel up to a 5% in diesel without requiring labelling
3. If there is concern about the limited scope for ethanol being introduced (volume growth) the ERMA decision on requiring double containment of petrol ethanol blends will need to be revisited.

Costs on a per litre basis of biofuels used are quite expensive especially in the case of ethanol. Generally biodiesel is much easier for distributing and can be integrated with current systems easily. We expect biodiesel to be rolled out on a national basis much earlier than ethanol which is likely to be marketed as a special grade in particular regions for a number of years until the distribution system is capable of handling greater volumes.

Appendix 1: Materials Compatibility of Biofuels and Specific Upgrades

General

B100[26]: B100 can degrade some hoses, gaskets, seals, elastomers, glues, and plastics, particularly nitrile rubber compounds, polypropylene and polyvinyl materials. Most tank materials will be acceptable including aluminium, steel, stainless steel and most fibreglass. Materials such as brass, bronze, copper, lead, tin, and zinc are not compatible as these may accelerate the oxidation process.

B20 or lower[26]: B20 experience in the USA over the last 10 years indicates good compatibility with existing elastomers, even those that are sensitive to higher blends, such as nitrile rubber. B20, like B100, is not compatible with metals such as copper, bronze, brass, or zinc.

Ethanol[27]: Equipment used with ethanol must be designed to withstand the solvent action of ethanol, this may require pump and meter upgrades to ensure the materials, particularly seals, glands, etc can withstand this.

E10 or lower blends, generally most current equipment such as pumps, filters and meters should be compatible with the fuel mixture. When first converted to gasoline/ ethanol blends the solvent action of the ethanol may loosen built up lacquer on the tank walls and sediment in the bottom of the tank, requiring regular filter changes initially.

Terminal Issues

Mild steel tanks as typically used in terminals should be compatible with both ethanol and gasoline/ethanol blends, however where lined with materials such as epoxy or polyester resins, compatibility checks would be required. Typical tanks used to store ethanol would have a fixed roof with an internal floater, similar to some current petrol tanks.
Minimising water in the tanks and associated equipment is already a core part of terminal operations but the presence of ethanol may require improved de-watering systems to be installed on some tanks and pipework.

Where foam fire protection systems are installed these are likely to be suitable for use with ethanol blended fuels. However the type of foam stocks is likely to require changing to a polymeric or alcohol type foam, rather than the more normal flouroprotein type[28].

For biodiesel filters may have to be upgraded to cope with the crystallised saturated fatty acid methyl esters that may occur with lower temperatures.

Transport Issues

While equipment suitable for transportation of petrol is generally acceptable for handling ethanol, there are a few extra precautions to take, such as ensuring the truck compartment(s) are clean and dry before loading, avoiding contamination from water, not loading into compartments that have held leaded fuels such as AVGAS, ensuring the prior

[26] Energy Efficiency and Renewal Energy, 2004 Biodiesel Handling and Use Guidelines
[27] Renewable Fuels Association, Fuel Ethanol, Industry Guideline, Specifications and Procedures
[28] Renewable Fuels Association, Fuel Ethanol, Industry Guideline, Specifications and Procedures

load was ethanol or unleaded petrol. Normal safety precautions for handling flammable liquids are also required.

Hoses and seals must also be suitable for use with ethanol.

Biodiesel[29] handling requirements are similar to diesel handling requirements. Unless the prior cargo was diesel, truck compartments should be washed out and left clean and dry (using standard cleaning procedures) prior to loading biodiesel. Hoses and seals must also be suitable for use with biodiesel.

Special consideration should also be made for transporting biodiesel to ensure the biodiesel or biodiesel blend remains ~ 5 °C above it’s cloud point.

Service Stations

Materials compatibility is discussed below for both biodiesel and ethanol petrol blends.

B20 or less[30]: There are no reported problems with service station tanks. Dispensing equipment does not need to be modified for blends of 20% biodiesel or lower blend levels, although elastomers (for seals, etc) should be checked for compatibility. The USA literature also suggests that some exposed parts of the dispensing systems may need protection from freezing in cold climates.

E10 or less[31]: Both steel tanks and fibreglass tanks (manufactured after 1981) designed for petrol storage seem to be compatible with ethanol petrol blends containing up to ten volume percent ethanol. This view was also expressed by Maskells who are the predominant fibreglass tank manufacture in New Zealand. Higher blends (above 10% ethanol) may require a tank constructed of a special chemical resin.

Most materials used in service station dispensing systems are likely to be compatible with ethanol petrol blends. Based on experience in the USA[31] pumps, meters, hoses and nozzles have been using for ethanol petrol blends with no accelerated wear or leakage problems.

Filters are likely to be compatible with ethanol petrol blends. However due to the solvent action of the ethanol built up lacquer on the tank walls and sediment in the bottom of the tank may loosen and initially clog the filters requiring a filter change shortly after conversion. Once the system is clean, filter life seems to be similar normal.

[29] Energy Efficiency and Renewal Energy, 2004 Biodiesel Handling and Use Guidelines
[30] Energy Efficiency and Renewal Energy, 2004 Biodiesel Handling and Use Guidelines
[31] Renewable Fuels Association, Fuel Ethanol, Industry Guideline, Specifications and Procedures

Glossary

Basestock: A tem used in this report to define Petrol that has tighter specification limits than standard petrol or diesel to allow biofuels to be blended without exceeding the petroleum fuel specifications.

Blendstock: A special petroleum product that is delivered to a refinery for blending with the refinery produced components to make on-grade products. This is particularly common with petrol.

CFPP: Cold Filter Plugging Point is an indictor of the temperature at which the precipitation of wax crystals in distillate fuel may lead to blocking or plugging of equipment filters and fuel lines.

Cloudpoint: Cloudpoint defines the temperature at which a clear diesel fuel becomes hazy or cloudy due to the formation of wax crystals.

FBT: Filter Blocking Tendency, this is a test that measures the filterability of diesel to ensure the diesel is fit for its intended purpose.

E70: E70 is a measure of how much petrol has evaporated at 70^{o}c. The petroleum specifications set lower and upper limits to ensure good starting and engine performance when warm.

RVP: Reid Vapour Pressure. This is a measure of the pressure exerted by the vapours delivered form a liquid at a given temperature and pressure.

Giveaway: An oil industry definition that describes where petroleum products have excessive properties versus the required specification. An example: petrol may be required to have a 91 Research Octane Number (RON) but the current cargo may have a 91.5 RON, this cargo has 0.5 RON giveaway.

IMO: International Marine Organisation.

MARPOL: International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).

MR Ship: A MR vessel is used for carrying bulk petroleum products and has a cargo capacity typically in the range of 30,000 tonnes to 40,000 tonnes.