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TRANSPORT ENGINEERING RESEARCH NEW ZEALAND LIMITED

Enabling Biofuels

Risks to vehicles and other engines

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Executive Summary

There is considerable international experience over quite a long period with the use of biofuel blends with relatively few recent reports of any negative impacts on vehicles and engines. A key issue for New Zealand is the relatively large proportion of the vehicle fleet that is made up of Japanese domestic market vehicles which have been imported as used vehicles. Japan does not currently use biofuel blends to any significant extent and thus compatibility is not guaranteed.

Two types of biofuel are considered. The first is ethanol blends with petrol to be used as a substitute for petrol. These blends are usually designated as Exx where xx represents the proportion of ethanol in the blend. Thus E5 represents a petrol blend containing 5% ethanol. The second type of biofuel is a blend of biodiesel blended with mineral diesel and used as a substitute for mineral diesel. These blends are similarly designated as Bxx where xx represent the percentage of biodiesel in the blend. Biodiesel can be manufactured from a number of different feedstocks ranging from vegetable oils to animal fats. The biodiesel proposed for use in New Zealand will be derived from tallow.

There are a number of potential problems associated with the use of ethanol in petrol. Ethanol is more reactive with some materials used in fuel systems primarily in older vehicles. This can potentially cause degradation of the components and fuel system leaks. Ethanol acts as a solvent and may mobilise scale and other deposits in fuel systems. This can lead to the clogging of fuel filters and lines and operability problems. Ethanol is water-soluble and may separate from the blend when excessive moisture is present. The ethanol molecule contains oxygen and this has the effect "enleaning" the fuel mixture which may lead to operability problems.

Three levels of ethanol blended petrol are considered - E3, E5 and E10. E3 has been permitted by law in Japan since 2003 and is therefore acceptable for Japanese domestic market vehicles. Although only relatively few tests have been undertaken with E3 they have been extensive and none have shown any adverse effects. Thus E3 is expected to be acceptable for all vehicles but from a practical point of view blending at this low a level is not very attractive to the fuel companies. E5 is permitted in Europe without labelling. The Australian biofuels task force has recommended that E5 should also not require labelling there. The first European regulation allowing for the use of E5 was introduced in 1985 and clearly the regulators there do not believe there is any significant risk associated with E5 even for the existing fleet at the time which was built without considering the use of ethanol blends. Apart from one extensive Japanese study which identified some minor potential problems, no reports of any adverse effects from the use of E5 have been found. E10 has been used extensively in the United States since the early 1980s. There are some reports of problems with the fuel systems of older cars (early 1970s models and older) but no issues currently. All automotive suppliers in the USA approve the use of E10 and most manufacturers of utility engines do as well. Australia has also recently approved the use of E10. The Federal Chamber of Automotive Industries (FCAI) has produced a list of vehicles that are and are not endorsed for E5 or E10 use by their manufacturers. Many of these vehicles are also sold in New Zealand so this is a useful list.

Biodiesel blends have fewer issues than ethanol/petrol blends. Biodiesel can potentially have fuel system materials incompatibility problems with older rubber-based seals and fuel lines. However, these problems are not observed with blends of 20% or less. The solvent effect of the biodiesel can mobilise deposits in fuel systems and cause filter clogging in the changeover period. Biodiesels are more susceptible to microbial growth than mineral diesel although this does also occur in mineral diesel. Finally the low temperature properties of biodiesel are different from mineral diesel and depend on the feedstock used to make it. Tallow-based biodiesel, in particular, has a much higher cloud point and cold filter plugging point than mineral diesel which may cause problems in low temperature environments.

Two levels of biodiesel blend were considered – B5 and B20. B5 is distributed in Europe without labelling. Standards exist for both diesel fuel and biodiesel and their blends and fuel quality is well regulated. B5 is widely used in some European countries and no reports of any problems associated with B5 use have been found. Higher blends, up to B100, are used for dedicated fleets particularly in Germany. B20 is widely used in the USA and has been used on dedicated fleets in Japan. Again the USA has a standard specifying the required properties of biodiesel and no reports of problems associated with its use have been found. Although most European biodiesel is derived from oilseed rape and most US biodiesel is derived from canola, there have also been trials with tallow-based biodiesel which have not reported any significant problems. The inferior low-temperature properties of tallow-based biodiesel are substantially improved through blending and can be controlled through fuel standards. New Zealand has a standard for biodiesel that will ensure its properties meet the requirements of existing engines.

Applying these findings to the New Zealand fleet we would expect all petrol-powered vehicles to be able to accommodate an E3 or an E5 blend without any risk of damage. It is likely that almost all vehicles could accommodate E10 without any risk of damage. However the use of E5 and E10 is not endorsed by the representatives of the automotive manufacturers for a significant number of makes and models. Of the 2.74 million registered light petrol vehicles, only just over one million are specifically endorsed for E10 use. Provided E10 is only used regularly by vehicles that have been endorsed as suitable there is virtually no risk to the New Zealand fleet. The Motor Industry Association (MIA) should be encouraged to prepare a list of vehicle makes and models showing their compatibility or incompatibility with E5 and E10 as has been done in Australia. Almost all new vehicles are E10 compatible so, in the longer term, the whole fleet will be able to use E10 with no risk.

Ethanol blends have been deemed unsuitable for aviation use by the Civil Aviation Authority (CAA) of New Zealand. The brief for this study also specified that they should not be considered for marine applications but a number of the outboard motor manufacturers endorse the use of E10 and it is encouraged in some American States. E10 is not suitable for use in older fibreglass fuel tanks. Many if not most of the motors used in other non-automotive applications (lawnmowers, chainsaws etc) are either sourced in the USA or at least sold there and are consequently E10 compatible. Those that are not sold in the US are sold in Europe and must be E5 compatible. The handbooks for these motors generally recommend draining the fuel system before storing the engine for any extended period but otherwise accept the use of E10.

Properly specified biodiesel blends do not appear to have caused any reported problems. B5, in particular, should be able to be distributed with no perceptible risk to any vehicle. B20 has higher potential risk but seems to have been used quite widely with no reported problems for properly specified fuel. It is probably better suited to fleet applications than general distribution. For non-automotive applications (marine engines, generators etc), the engines are made by the same manufacturers as the automotive engines and are equally compatible. The increased susceptibility to microbial attack may be an issue for engines with infrequent use such as standby generators and it is probably best not to use B20 blends for these although the evidence for problems is small.

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1. Biofuel blends and vehicle compatibility

1.1. International experience and current practice with biofuel blends

1.1.1. Brazil

Ethanol-petrol fuel blends have been used in a number of countries for up to 30 years now. The most notable example is Brazil (Berg 2004; La Rovere and Simões 2004). In the mid 1970s Brazil introduced a programme to encourage the use of ethanol derived from sugar cane and molasses. Fuel ethanol is used in two main forms, E22-25 and pure ethanol. Both fuel types require vehicle modifications although in recent years flexible fuel vehicles which can adapt to any level of ethanol blend have become available. By 1988 ethanol provided over 50% of the transportation fuels used in Brazil (Berg 2004). Between 1988 and 2002 this proportion dropped to about 30% as petroleum prices dropped and sugar prices strengthened. More recently oil prices have increased substantially and the proportion of ethanol used has increased again. The Brazilian situation is not particularly relevant to the proposed introduction of ethanol blends in New Zealand because the proportion of ethanol used in Brazilian blends is significantly higher than that proposed for New Zealand. However, Brazil's long history of successfully using relatively high ethanol blends does show what can be achieved.

1.1.2. United States of America

The USA also has a long history of using ethanol blended petrol (Berg 2004; Clean Fuels Development Coalition). In 1978 congress passed the Energy Tax Act which removed the fuel excise tax from blended fuels containing at least 10% ethanol. Subsequent Acts have increased the excise tax on petroleum but have maintained a reduction in tax for blended fuels. By 2005 some 30% of all petrol sold in the USA contained some ethanol and most of this blended fuel was E10 (Renewable Fuels Association 2005). The Clean Air Act Amendments of 1990, required gasoline sold during the winter months in areas of the country with high carbon monoxide pollution, and year-round in areas of the country with high ozone pollution, to contain cleaner-burning additives called fuel oxygenates. Fuel oxygenates include ethanol, an ethanol derivative known as ethyl tertiary butyl ether (ETBE), and methyl tertiary butyl ether (MTBE), a methanol derivative. Although MTBE was quite widely used initially it has been found to contaminate water supplies and its use has recently been banned in California. Increasingly ethanol has become the preferred oxygenate. The most widely used blend is E10, although, with increasing numbers of flexible fuel vehicles available on the market, E85 is now widely promoted particularly in the corn growing states that provide the feedstock for ethanol production. All American automotive engine manufacturers and most non-automotive engine manufacturers approve the use of E10 blends with their engines (Clean Fuels Development Coalition).

The use of biodiesel in the USA has been increasing steadily since 1999. In 2001 a standard for biodiesel, ASTM D6751, was issued. The most widely used blend in the USA is B20 with the main feedstock for the biodiesel being soybean oil. Some testing of biodiesels based on other feedstocks such as tallow has been undertaken (MARC-IV Consulting and Kansas State University). No evidence of any significant problems with biodiesel blends up to 20% has been found.

1.1.3. Europe

The European Council Directive 85/536/EEC in 1985 relating to oil savings through fuel substitutes provided for up to 5% ethanol in petrol. This provision was included in the 1993 standard, EN 228:1993, for petrol which provides for blends up to 5% ethanol or 15% ETBE without labelling. This standard has been updated twice since in 1999 (EN 228:1999) and 2004 (EN 228:2004). Although France and Spain are substantial consumers of fuel ethanol, this is primarily in the form of the derivative, ETBE, rather than raw ethanol. Sweden, on the other hand, uses E5 extensively.

In 2003 the European Parliament and Council issued a directive, 2003/30/EC, on the promotion of the use of biofuels or other renewable fuels for transport. This directive aims for EC member countries to achieve 2% by energy of fuel to be biofuel by 2005 and 5.75% by 2010. To achieve this target the use of biofuels will need to increase substantially. The 2005 UK report to the EC (Department for Transport 2005) on progress towards the aims of the directive details tax incentives introduced in early 2005 and notes a substantial growth in the use of ethanol blends (mainly E5) using imported Brazilian ethanol. Although the growth was substantial the overall level of E5 use is still small.

Similarly the European diesel fuel standard, EN 590:2000, which was issued in 2000 allows for up to 5% biodiesel blends to be sold without labelling. In addition there is also a biodiesel standard, EN14214:2003, issued in 2003 which specified the required properties of biodiesel and superseded national standards for biodiesel that existed at that time. The main feedstock used for biodiesel production in Europe is oilseed rape (also known as rapeseed or canola). Germany is the largest producer and user of biodiesel fuel in Europe and much of the fuel used is B100 in dedicated fleets such as buses (Körbitz 2001). In France most of the diesel fuel sold is B5 blend while Italy, Austria and Sweden also use substantial quantities of biodiesel. Again no evidence of any vehicle problems associated with the use of biofuel blends in Europe has been found.

1.1.4. Japan

Japan has permitted the use of E3 blends since 2003 (Nakazawa 2004) although relatively little blended fuel has been used. Testing programmes have been undertaken and the aim is to have most fuel in Japan as E3 by 2012. There is an intention to introduce E10 once E3 has been tested and accepted (Nakazawa 2004) . Prior to the 2003 regulation change there was no limit of the use of fuel alcohols and some high level blends (40-50%) of dubious quality were sold to automotive users with some adverse impacts.

Relatively small quantities of biodiesel are produced in Japan mainly derived from waste edible oil. Kyoto city uses about half of the biodiesel produced in the form of B20 to fuel

220 garbage trucks and 80 city buses (Nabetani et al. 2005). No reports of any problems with these vehicles have been found.

1.1.5. China

China is now the third largest producer of ethanol in the world and E10 blends have been used in five major cities on an experimental basis since 2001 (Berg 2004). Very little information has been found on the outcomes of these trials and thus no evidence of negative impacts. In any case it is difficult to relate the Chinese vehicle fleet to that of New Zealand.

1.1.6. Australia

As of 1 July 2003, the Australian Fuel quality standards have allowed ethanol blends of up to 10%. Since 1 March 2004, blends greater than 1% have been required to be labelled. In the initial stages a lack of quality control and poor blending practices led to some poor quality fuels with 20% or more ethanol content being sold. This resulted in some vehicle operability problems which had a significant negative impact on the reputation of ethanol fuel blends. Although the problems with fuel quality have now been addressed the poor public perception of ethanol blends is taking some time to overcome. The Australian government has commissioned a number of research projects to investigate the impacts of ethanol blends on both automotive and other engines (Orbital Engine Company 2002a; Orbital Engine Company 2002b). These projects have considered both E10 and E20 blends. The Federal Chambers of Automotive Industries (FCAI) have produced a list of vehicles that are compatible and incompatible with E10 blends. In many cases Australian and New Zealand vehicles are identical so this list has direct relevance to this study. In 2005 the Australian government commissioned a Biofuels Task Force to examine the latest scientific evidence on the impacts of ethanol and other biofuel use on human health, environmental outcomes and automotive operations. The report of this task force (Biofuels Taskforce 2005) provides a useful review of current trends and issues.

Although biodiesel use in Australia is still very low it has increased dramatically in recent years (400% between 2003-4 and 2004-5). Most biodiesel used is sold as blends of 20% or less. The task force expected that the mainstream blended fuel would become B5.

1.1.7. Thailand

Thailand has been experimenting with E10 blends and the government has implemented various incentives to promote its use. Some research (Tantithumpoosit 2004) has been undertaken to investigate fuel system materials compatibility with E10 with no significant adverse effects found. It is difficult to compare the Thai vehicle fleet with that of New Zealand but the most common makes sold in Thailand (the first five in order are Toyota, Isuzu, Honda, Mitsubishi and Nissan) are also among the most common in New Zealand. Thailand is also a supplier of vehicles to New Zealand and at least some of these models are the same specifications as for Thailand.

1.1.8. India

India has been using E5 blends in nine states and four territories since about 2003 (Berg 2004). The Indian vehicle fleet is dominated by domestically produced models. Some 70% of the fleet are motorcycles with only 19% cars. Indian-produced cars are typically local variants of international models produced by the major automotive manufacturers, such as Suzuki, Ford, Toyota and Mitsubishi. In the past, Indian-produced vehicles were often based on older models, for example, the Hindustan Ambassador, which is still produced, is based on a 1950s Morris Oxford although it has been modernised. In spite of this preponderance of old-technology vehicles no reports of any problems with E5 use in India have been found.

1.1.9. International fuel specifications

In 2002 a World-Wide Fuel Charter (European Automobile Manufacturers Association et al. 2002) was released jointly by the European Automobile Manufacturers Association (ACEA), the Alliance of Automobile Manufacturers, the Engine Manufacturers Association (EMA) and the Japanese Automotive Manufacturers Association (JAMA). The aim of the charter was to establish internationally harmonised specification for fuels. The charter allows up to 2.7% by weight of oxygen in petrol which corresponds to about 7.8% by volume of ethanol. E10 blends permitted by pre-existing regulations are also provided for. Blends of up to 5% biodiesel with mineral diesel are included. JAMA's own reports do not endorse ethanol blends higher than 3%. The apparent contradiction between these two positions has not been resolved.

1.2. Potential problems associated with ethanol blends

A number of potential problems have been associated with the use of fuel ethanol and ethanol blends (Orbital Engine Company 2002b). These are:

- Degradation of fuel system components
- Corrosion of fuel system components
- Phase separation
- Fuel system blockages
- Volatility changes affecting engine operability
- Enleanment affecting engine operability
- Paint damage from spillages

Degradation of fuel system components can potentially occur because of incompatibilities between the materials used for hoses, seals, O-rings, membranes and gaskets and ethanol. The typical mechanism is that the ethanol is absorbed into the material and breaks down the molecular bonds within it. This can lead to swelling of the material, softening or embrittlement and eventually failure of the component. With older motorcycles and marine applications there is a potential problem with fibreglass fuel tanks. In this case the ethanol may react with the resins in the matrix.

Some soft metals such as aluminium copper (brass) and zinc are incompatible with ethanol and can suffer corrosion and pitting if exposed to it for extended periods. Furthermore ethanol dissolves in water and is more electrically conductive than petrol.

The presence of water can facilitate corrosion and the conductivity facilitates the possibility of galvanic corrosion.

As noted above water dissolves in ethanol to a much greater extent than it dissolves in petrol. Some water can be dissolved in ethanol-petrol blends and will pass through the fuel system with no effect. However, if the amount of water present is too great the blend will separate into an upper petrol layer and a lower water/ethanol layer. Generally fuel is drawn from the bottom of the tank so the water/ethanol layer will be drawn into the engine first and the engine will not run.

Ethanol has a solvent effect and will loosen gums and other deposits in fuel systems that have been operated on mineral petrol a long time. In extreme cases this can clog fuel filters and cause the engine to run poorly.

The volatility characteristics of an ethanol/petrol blend differ from those of the unblended petrol on its own. These differences in volatility can impact on engine operability. In particular the higher latent heat of vaporisation can lead to cold starting difficulties while higher vapour pressures can result in vapour lock problems when the engine is hot.

The ethanol molecule contains oxygen while the main components of petrol do not. The effect of this is that less oxygen from air is required to achieve complete combustion and so if the air/fuel mixture is not adjusted the mixture is leaner than it would be on pure petrol. This can lead to engine operability problems such as hesitancy at full throttle and/or higher exhaust temperatures (Orbital Engine Company 2002a).

The solvent effect of ethanol is more likely to cause damage to car paint work in the event of fuels spillages than conventional petrol (Orbital Engine Company 2003). However, the aromatics used in unleaded petrol to boost the octane level also have a corrosive effect of paint work. Modern paint systems are more resistant to this form of damage but in all cases petrol spillages should be washed off as soon as possible. Because ethanol is water-soluble it is easier to wash off.

1.3. How likely are these problems to occur

There are a number of factors which influence the likelihood of these problems occurring. The main ones are:

- Fuel system materials
- Engine technology
- Fuel quality standards
- Proportion of ethanol in blend
- Operating environment

1.3.1. Fuel System Materials

The susceptibility of fuel systems to degradation and corrosion is influenced strongly by the materials used in these systems. In Brazil where relatively high levels of ethanol blend have been in widespread use for many years now, appropriate fuel system materials have been fitted and these problems do not occur. When E10 was introduced in the USA in the late 1970s some problems were reported with the fuels systems on early 1970s vehicles. Changes in fuel system materials from the mid-1970s onwards have eliminated these problems. The elimination of tetra ethyl lead as an additive to petrol resulted in the use of various aromatics (benzene and toluene) as alternative octane boosters. These additives also have material incompatibility problems with some elastomers which are similar (Mesa Rubber Company) although not identical to the incompatibility with ethanol. Fuel systems that are designed to cope with unleaded fuel are less likely to have incompatibility problems with ethanol blends.

1.3.2. Engine Technology

Although the susceptibility of vehicles and engines to problems is often associated with year of manufacture (pre 1986 is an often quoted figure) they generally are associated with technology changes. Older vehicles typically use carburettors or mechanical fuel injection systems to deliver the fuel/air mixture to the engine. These systems are typically also open-loop which means that the fuel air mixture is pre-determined by the calibration of the fuel delivery system. More modern engines typically use electronic fuel injection systems and are closed-loop which means that the engine control unit (ECU) monitors the exhaust gases and adjusts the fuel/air mixture to optimise combustion. Carburettors typically contain materials that have compatibility problems with ethanol (aluminium and brass). Open-loop fuel systems will result in some enleanment but the engine can be recalibrated (i.e. tuned) for the higher oxygen levels. Closed loop systems can adapt to the additional oxygen in the ethanol and prevent enleanment.

1.3.3. Fuel standards

The potential problems associated with the different volatility characteristics of ethanol blends can be avoided through appropriate fuel standards. It is quite possible to achieve volatility characteristics that are within the acceptable range of all engines.

1.3.4. Blend proportions

The proportion of ethanol within the fuel blend has a major impact on whether any of the potential problems actually materialise. Generally speaking the lower the level of blend the less likely the problems are to occur. The one notable exception is that it takes less water to cause phase separation with low level blends than with higher level blends.

1.3.5. Operating Environment

The final factor is the operating environment. Some of the potential problems identified above are only likely to occur on the transition from using an unblended fuel to using an ethanol blend. The solvent action of the ethanol causing fuel filter blockages is only likely to occur on older engines that have been using petrol for a long time. Furthermore once the fuel system is clean and the filter has been replaced the problem should not recur and the cleaner fuel system should lead to improved performance. Similarly phase separation, if it occurs at all, is most likely to occur on the changeover to using blended fuels. Once any residual moisture has been cleared from the fuel system the ethanol blend will absorb any new moisture and allow it to pass through the engine so that the fuel system will be dryer than it is with petrol. The exception to this is where fuel is left to stand for extended periods. In this case the ethanol blends may absorb excessive amounts of moisture from the atmosphere and suffer phase separation. This scenario can occur with utility engines such as garden equipment which may be used infrequently. The user manuals for these engines almost invariably recommend draining the fuel system if the engine is not going to be used for some time.

1.3.6. Blends and Applications

Consider now specific fuel blends and specific applications. The brief for this study specified that ethanol blends would not be used in aviation and marine applications. The issue of aviation use is clear. Ethanol blends are specifically excluded by the FAA which sets the standards for aviation safety. Aircraft operate through significant changes in temperature and pressure and any operability issues resulting from ethanol could have serious consequences. The situation with respect to marine applications is less clear. The basis of this appears to be the risk of water ingress into the fuel system. However, this would also be a serious problem for a conventionally fuelled system. Many of the major outboard motor manufacturers accept the use of ethanol blends up to 10% with their engines and in a number of US states the marine use of ethanol blends is encouraged because fuel spills are less environmentally damaging with these fuels.

1.3.7. E3 Blends

3% ethanol blends are permitted in Europe, the United States, Australia and Japan who are the main sources of petrol engines in New Zealand. No evidence of any problems with E3 blends has been found and it is extremely unlikely that there are any significant long-term risks associated with using this fuel on either automotive or non-automotive applications. For older engines the transition to E3 may cause the fuel filter clogging effect noted previously but this is a minor temporary problem and the positive outcome is a cleaner fuel system.

1.3.8. E5 Blends

E5 blends are an accepted fuel in Europe, Australia and the United States but not in Japan. In Europe E5 does not need to be labelled and there is a proposal to remove the labelling requirement in Australia. The fact that there is no labelling requirement in Europe suggests that European legislators do not believe there are any risks associated with the use of E5 even for older engines. No evidence has been found of any problems with the use of E5 blends but, to date, the fuel has only achieved a relatively low market penetration. It is quite extensively used in Sweden but only in limited quantities in other European countries. The Australian Biofuels task force have also suggested that the labelling requirement could possibly be removed for E5 blends but that some further testing should be undertaken first. This position would appear to be based on the European stance.

India has also trialled E5 extensively with no reported problems. Although Indian vehicles are not comparable with the New Zealand fleet, they generally reflect old automotive technology. (Bursa 1999) notes that when India introduced its emission standards in 1999, Murati, who is India's largest car manufacturer, still had carburettors on all models. All current models do have fuel injection but overall the fleet has relatively old technology.

JAMA have produced a test report that indicates potential problems with fuel system degradation and corrosion for blends higher than E3. EECA commissioned Fuel Technology Ltd to undertake a brief review of this report. Fuel Technology's review found some significant inconsistencies in the results presented in the report and suggested that there may have been some problems with their experimental procedures. However, as noted by Fuel Technology, the English version of the report is a summary translation from the original Japanese and some of the original intent may not have been fully conveyed.

Overall it would appear that the risks associated with the use of E5 blends are not significantly higher than those associated with E3. However, a number of the Japanese vehicle manufacturers are not prepared to endorse the use of E5 and so there may be a reluctance of the part of operators of these vehicles to use the fuel.

1.3.9. E10 Blends

E10 blends are permitted in both the USA and Australia. In the USA there were some problems with older vehicles (pre early 1970s) when the fuel was first introduced but these have long since been resolved. All US automobile suppliers now endorse the use of E10 fuel on their vehicles and most producers of other utility engines[1] also endorse the use of E10. In Australia, the FCAI produced a list of vehicles that are capable or not capable of operating on E10 which includes a significant number of not-capable vehicles. Although the general thrust of most reports is that only older vehicles (usually pre 1986) are likely to have compatibility problems the FCAI contains a significant number of newer vehicles. Associated with the FCAI list is a range of reasons why vehicles might be incompatible. The main reason for the newer vehicles appears to be that the level of oxygen in E10 is outside the range of the ECUs ability to adjust the fuel mixture. Based on the US experience it would appear that there may be some problems with fuel system materials compatibility on older vehicles but that these are relatively minor. However, there are a significant number of vehicles whose manufacturers do not endorse the use of E10 and this is likely to deter many owners from using the fuel. If the only users of E10 blends are those whose engine manufacturers endorse its use then there should be virtually no risk.

1.3.10. Blends above 10%

Blends higher than E10 have been used extensively in Brazil for many years now but these required vehicle modifications. Tests in Australia with E20 blends on unmodified vehicles have identified some problems with materials compatibility and engine operability. It is clear that higher proportion blends do have risks for unmodified engines although these can be overcome with sufficient commitment to this type of fuel. It is worth noting that the World-Wide Fuel Charter specifies a 10% ethanol limit and so

[1] http://www.e10unleaded.com/smallengines.htm#approval, a web-site developed by the Nebraska Corn Board, Nebraska Ethanol Board and Nebraska Corn Growers Association provides a list of US-based utility engine suppliers that are E10 compatible. Many of these are also sold in New Zealand.

moving to higher blends would take New Zealand outside the current mainstream engine market.

1.4. Potential problems associated with biodiesel blends

Many of the potential problems associated with the use of biodiesel are similar to those of ethanol. The main ones are:

- Degradation of fuel system components
- Corrosion of fuel system components
- Fuel system blockages
- Microbial growth in old or weathered fuel
- Low temperature properties affecting engine operability and fuel useability

The first three issues above are similar to those identified for ethanol fuels earlier while the last two issues are specific to diesel fuels.

Microbial growth does also occur in mineral diesel but biodiesels are more susceptible to it. The problem typically occurs where fuels are stored for extended periods and thus is more common in storage tanks than in vehicle fuel tanks. It can be an issue for stationary engines which only get intermittent use such as standby generators.

All diesel fuels will solidify as the temperature reduces. This is generally characterised by various temperature measures, the main two being the cloud point when the first crystals appear in the fuel and the Cold Filter Plugging Point (CFPP) where sufficient crystals have formed to plug a test filter. Generally these points occur at higher temperatures for biodiesels than for mineral diesel and thus there may be issues using biodiesels in colder environments. Different biodiesels have different cloud points and CFPPs with those made from tallow and animal fats generally being higher that those made from vegetable oils.

1.5. How likely are these problems to occur

Again a number of factors affect whether or not these potential problems are likely to occur in practice. The main factors are:

- Fuel system materials
- Fuel quality standards
- Feedstock for biodiesel
- Proportion of biodiesel in blend
- Operating environment

1.5.1. Materials Compatibility

Materials compatibility issues obviously depend on the materials used in the engine's fuel system. Modern engines compatible with low sulphur fuels are compatible with biodiesels (National Biodiesel Board). Older engines using rubber or older elastomer seals or fuel lines may have problems with biodiesel. Blends of 20% or less have not shown these problems. In this context low sulphur relates to the US requirement introduced in 1993 which was a maximum level of 0.05%. This is the same level as the Euro II specification which was introduced in 1996.

1.5.2. Fuel Standards

Biodiesel standards exist in both the USA and Europe which provide specifications for engine manufacturers to work to. It is expected that there should be no operability issues with fuels that meet the specifications. The New Zealand standard for biodiesel, *Automotive Biodiesel – Specification for manufacture and blending (NZS 7500:2005),* was issued in June 2005. This standard is aligned to the European and American requirements but is not identical. It specifies a maximum level for retail blends of B5 and ensures that the blended fuel has the same properties as mineral diesel. Currently it is a voluntary standard.

1.5.3. Feedstock

The low temperature properties of biodiesels depend very much on the feedstock used to produce them, with biodiesels based on tallow having significantly higher melting points than those based on vegetable oils such as rapeseed or soybean. However, the effect of diluting the biodiesel in a blend reduces the impact of these effects substantially. For example, the cloud point of pure tallow-based biodiesel has been reported as 14°C while the cloud point of a 2% blend of the same fuel is -20°C compared with -23°C for mineral diesel (Cold Flow Consortium 2005). The cold properties of the biodiesels are an important issue for the fuel blending process but, for B5 blends, once blended should not cause any problems in New Zealand temperatures. A trial undertaken in Kansas city in 1997-98 compared the performance of four city buses using a B20 blend based on tallow biodiesel with four buses using mineral diesel (MARC-IV Consulting and Kansas State University). The trial ran for 10 months and included the North American winter. No problems associated with the use of biodiesel were reported in this trial.

There have been two New Zealand trials involving tallow-based biodiesel blends. In the 1980s the Liquid Fuels Trust Board sponsored a trial using B10 blends (Worley Consultants 1985) which found no major issues. The report refers to the possibility of problems at low temperatures which owing to the weather and other factors were not fully tested. They conclude that at the B10 blend level there should be little effect but note that there was no assurance of fuel specification at the time. A diesel fuel specification has been introduced since then. The other potential problem raised in the report was that of biological attack. Their view was that a B10 tallow-based blend would not introduce any problems that did not already exist. A more recent trial involving five Stagecoach buses, five Waste Management trucks, a BP line haul tanker and two light vehicles all operating on a B20 blend of tallow-based biodiesel (Blackett 2005) also found no major issues other than some fuel filter blockages after the changeover from mineral diesel. These were attributed to the solvent effect of the biodiesel mobilising existing rust and scale in the fuel tank.

1.5.4. Blend Proportions

B5 blends are permitted to be used in Europe without labelling and are in common use in some countries. No evidence has been found of any problems associated with this fuel. While there are differences in the feedstock used to produce the biodiesel with European biodiesel based primarily on oilseed rape and the proposed New Zealand feedstock being expected to be tallow there is no reason to expect this difference to cause any problems. The Kansas city bus trial referred to above demonstrated that blends involved tallow-based biodiesels can operate successfully in cold climates. All the major diesel engine manufacturers endorse B5 provided fuel standards are met.

There is some evidence B20 increases risk of fuel system degradation for older engines (Engine Manufacturers Association 2003). All modern engines use materials that are expected to be compatible with biodiesels. There is also some risk of fuel filter clogging on the transition from operating on mineral diesel to using biodiesel blends particularly for older engines that have been operating on mineral diesel for a long time.

2. Quantification of risk to fleet

2.1. Numbers of engines at risk of problems with ethanol blends

2.1.1. Engine Suppliers' Views

In general the engine and vehicle manufacturers take a conservative approach to endorsing the use of ethanol blends with petrol particularly with older engines. This is very understandable. Older engines were designed without consideration of the use of ethanol blends. Consequently, in order to endorse the use of these fuels the manufacturers would at the very minimum need to review their original design to determine whether there are any critical issues and possibly would need to undertake testing. Endorsing the use of these blended fuels could also leave them liable should any problems arise. On the other hand there is little or no further revenue for the manufacturer from these engines so there is no incentive for them to take this risk.

2.1.2. Biofuel Advocates' Views

The advocates of biofuel blends who include biofuel producers and environmentalists see no difficulties at all with blends of 10% or less. The independent tests that have been undertaken have found relatively few problems with blends up to 10%. However, these tests have necessarily only involved small numbers of vehicles and other engines so there will always be some uncertainty about whether there are any adverse effects. If only 0.1% of the vehicle fleet was adversely affected this would still be more than 2700 vehicles which is a large enough number to generate considerable negative publicity. After the introduction of unleaded fuel into New Zealand there was a series of incidents involving fuel system and performance issues, some of which resulted in vehicle fires, which were blamed on the new fuel (Taylor et al. 1997). Over 2500 claims were investigated by the Ministry of Commerce for possible compensation payments. The proportion of the vehicle fleet involved was very small but the numbers of claims and adverse publicity was not insignificant.

2.1.3. Petrol Vehicles

Land Transport New Zealand has provided data on vehicle registrations by age and make for light petrol vehicles, light diesel vehicles and heavy diesel vehicles. One of the most striking characteristics of these data is the large number of vehicle makes. For light petrol vehicles there are 430 makes identified. A number of these are clearly duplications (for example, Land Rover and Landrover are identified as separate makes) but there are nevertheless a large number of different makes of vehicle registered in New Zealand.

The age distribution of light petrol vehicles is shown in Figure 1. It is notable that nearly 14% of vehicles are 1986 or older models. There is a substantial increase in vehicle numbers when vehicles are about nine years old. This reflects the influx of second hand Japanese imports, which are typically about that age. If we assume that nearly all of the vehicles newer than 2001 are New Zealand-new then we can fit a linear trend line to estimate the annual growth in new vehicle numbers. Similarly if we assume that there are very few vehicles older than1996 being imported today, we can fit a trend line to the data for 1987-1996 to estimate the average annual growth in numbers of all vehicles. Note that the annual growth in vehicle numbers does not just reflect increased sales. Each year some vehicles are eliminated from the fleet through mechanical failure, accident damage or inability to meet roadworthiness standards. Extrapolating both these trend lines to 1996 we find that we would expect about 27.5% of the pre-1997 fleet to be New Zealand-new and 72.5% to be used imports. If we extrapolate back to 1986 vehicles the linear models estimate that 35% of 1986 vehicles are New Zealand-new and 65% are used imports. However, the annual change in New Zealand-new numbers is based on newer cars (2001-05) which are less likely to be removed from the fleet for mechanical or roadworthiness reasons. Thus it is likely that the 35% figure is an over-estimate. Of the 2.74 million registered vehicles, 0.38 million are pre-1986 and hence 2.36 million are 1987 or newer. Using the linear models described above we can estimate that approximately 1.11 million of these 1987 and newer vehicles are New Zealand-new and hence 1.25 million are used imports. That is, 53% are used imports and 47% are New Zealand-new.

The four largest manufacturers in the registration database are Toyota, Nissan, Mitsubishi and Honda, which between them account for over 50% of vehicle registrations. Representatives of the local distributors of each of these makes were approached to obtain their companies position on the use of ethanol blends. Remarkably their positions are quite different. Honda New Zealand's (Seymour 2006) position is that all Honda cars in New Zealand since the mid 1980s are E10 compatible. This includes used Japanese imports. Toyota's position (Rounthwaite 2006) is that all their New Zealand new cars since the mid-1980s are E10 compatible but that used imports are only E5 compatible and will need a fuel system replacement after 100,000km. The estimated cost of this replacement is $600-$800 but, on older vehicles, 100,000km may represent all of the remaining life of the vehicle. The reason for this difference is that export models had their fuel systems modified in the mid 1980s to cope with variable fuel quality in some export markets. This change was not made to domestic market vehicles. Toyota believes that, when this change was made, Honda, being a smaller volume producer, changed the fuel systems on both domestic and export market vehicles which explains the difference in position on E10 compatibility. Mitsubishi's position (Robinson 2006) is that they have no experience with ethanol blends and cannot endorse its use. As of January 2006, New Zealand new vehicles must meet Euro 3 performance requirements. Mitsubishi vehicles meeting these emissions requirements are also E10 compatible and thus since December 2005 all Mitsubishi vehicles are E10 compatible. Nissan's position (Perez 2006) is similar to Mitsubishi's with all post 2004 vehicles being E10 compatible and no endorsement of ethanol blends on older vehicles.

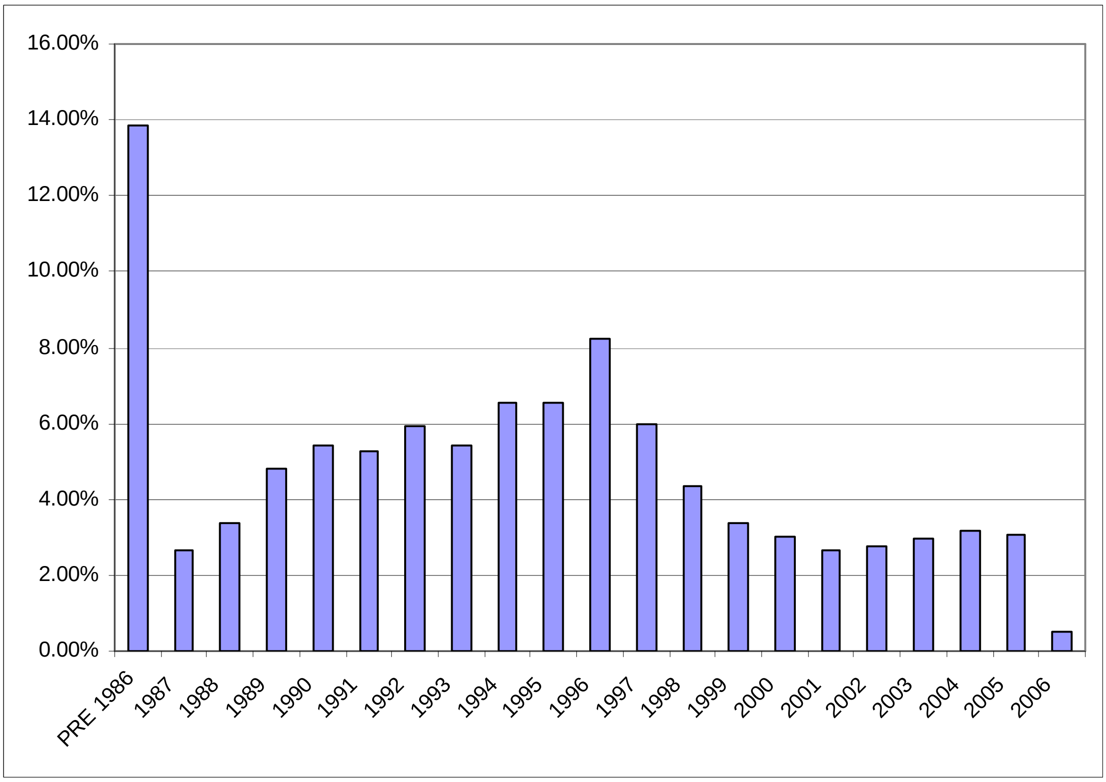

Figure 1. Distribution of light petrol-powered vehicles by age.

The light vehicle numbers shown in Figure 1 also include motorcycles. Although these vehicles are sold in the USA where they are all E10 compatible, the position of most local distributors is that New Zealand market models are different and are not compatible with E10. The notable exception is Honda whose motorcycles are also endorsed as E10 compatible.

Blends with more than 10% ethanol generally require that modifications be made to the fuel system for the engine to be able to function satisfactorily. Internationally flexible fuel vehicles are available that can handle any ethanol blend from zero to 85%. However these have not been brought into New Zealand in any numbers.

E10 is accepted by all US automotive suppliers for all current products. Almost all vehicles sold in the US since the early 1980s are able to operate satisfactorily on E10. The Australian FCAI has produced a list of vehicles that are compatible and incompatible with E10 use. More recently this list has been expanded to include whether or not vehicles are E5 compatible (FCAI 2006). It identifies a significant number of vehicle models that the manufacturers do not consider suitable for E5 or E10 use with only a very small number that are E5 compatible and not E10 compatible. The European and Australian vehicle models on the FCAI list are generally the same as those sold in New Zealand. The Japanese vehicle models on the list are not necessarily the same as those in New Zealand even for vehicles originally sold here new. New Zealand also has a large number of vehicles that have been imported second-hand from Japan which Australia does not have. Japanese domestic market vehicles may have different specifications from export market vehicles. However, even for vehicle models where it would appear that the Australian and New Zealand supplier position regarding ethanol blend compatibility should be the same this is not necessarily the case. For example, Mitsubishi Australia is reported as saying that all post 1986 fuel-injected models are E10 compatible while Mitsubishi's New Zealand distributor does not endorse E10 use on any pre-2005 vehicles. At least some of the same models were sold in both countries between 1986 and 2005. A study undertaken in the Netherlands (van den Broek et al. 2003, p268) also includes a list of vehicle models and their compatibility with ethanol-petrol blends. Although for most vehicle models this list is consistent with the FCAI list there are some differences for specific cases.

Based on these data, Table 1, listing the number of vehicles suitable for E5 and E10 use, was generated. A number of assumptions were made in preparing this table:

- the data were all supplied by the vehicle distributors who, as noted previously, are likely to take a conservative approach.
- all pre-1986 vehicles are assumed to be potentially at risk
- for the four largest makes, the local distributors' views were used
- for all the remaining makes the FCAI list was used
- Toyota made a distinction between NZ-new vehicles and used-imports. The proportion of vehicles in the two categories was estimated using the model described above.
- Some other makes (most notably Ford) distinguished between models. The 2005 registration data were used to estimate the proportions in the two categories.
- the "others" category contains less than 10% of the fleet but includes more than 400 makes. Most of these are not identified as compatible and hence are classed as a possible risk, i.e. possible risk is the default value.
- there is a widely-held view by the manufacturers that pre-1986 vehicles are not suited to ethanol-blends. Thus these have been made a separate category.

Not being endorsed for E5 or E10 use by the manufacturer does not mean that these vehicles would necessarily have problems using ethanol-blended fuel. The (International Energy Agency 2004) reports that "it is widely accepted…. that nearly all recent-model conventional gasoline vehicles produced for international sale are fully compatible with 10% ethanol blends (E10)". Furthermore they state that: "The cost of making vehicles fully compatible with E10 is estimated to be a few dollars per vehicle." (Arcoumanis 2000) in a report to the European Commission goes further and says that: "Blends of gasoline with ethanol up to 22% (E22G) can be used in spark ignition engines without any material or other operating problems". The European policy of allowing E5 to be sold without labelling and the subsequent lack of any reported problems since as well as the extensive American experience with E10 suggests that there would be very few problems with either level of blend. However, the owners of vehicles whose manufacturers do not endorse the use of ethanol blends are likely to be reluctant to take the risk.

Table 1. Vehicle Compatibility with Ethanol-Petrol Blends.

	Number of vehicles (000)						
		E5 Compatibility			E10 Compatibility		
Vehicle Make	**Total**	**No risk**	**Possible risk**	**Pre 1986**	**No risk**	**Possible risk**	**Pre 1986**
TOYOTA	529.4	478.1	0.0	51.3	224.7	253.4	51.3
NISSAN	348.2	10.6	321.7	15.9	10.6	321.7	15.9
MITSUBISHI	306.6	0.6	277.1	28.8	0.6	277.1	28.8
HONDA	277.9	243.1	0.0	34.8	243.1	0.0	34.8
FORD	273.7	148.4	69.8	55.4	130.9	87.3	55.4
MAZDA	202.5	25.7	154.1	22.7	25.7	154.1	22.7
HOLDEN	163.7	134.6	3.5	25.6	134.6	3.5	25.6
SUBARU	122.3	110.5	7.8	4.0	110.5	7.8	4.0
SUZUKI	67.2	5.8	52.0	9.4	5.8	52.0	9.4
BMW	55.5	50.5	0.0	5.0	50.5	0.0	5.0
HYUNDAI	33.1	6.2	26.5	0.4	6.2	26.5	0.4
DAIHATSU	25.3	2.2	21.1	2.0	2.2	21.1	2.0
MERCEDES-BENZ	24.9	20.2	0.0	4.7	20.2	0.0	4.7
VOLKSWAGEN	24.6	18.4	0.0	6.1	18.4	0.0	6.1
PEUGEOT	15.4	8.3	6.2	0.9	8.3	6.2	0.9
Others	265.4	53.6	100.5	111.3	51.5	102.6	111.3
Total	**2735.5**	**1316.9**	**1040.2**	**378.4**	**1044.0**	**1313.1**	**378.4**

In this context the risk of any problems can be virtually eliminated. Provided unblended fuels continue to be readily available and vehicle owners have good information on the compatibility status or otherwise of their vehicle, few potentially at risk vehicles will use blended fuel. All new vehicles will be E10 compatible and thus over the longer term the entire fleet will be able to use blended fuel.

2.1.4. Non Automotive Engines

The situation with non-automotive applications is a little different. The brief specified that aviation and marine applications were not expected to be able to use ethanol fuel blends. As noted earlier the situation with aviation is unequivocal but E10 blends are used in marine applications in the USA without any known difficulties. Many of the major outboard motor suppliers endorse the use of E10 (Mercury is a notable exception) and a number of states encourage it for environmental reasons.

Lawnmowers are a major non-automotive fuel application. The market in New Zealand is dominated by one major manufacturer (65%) and even then their competitors for the most part use the same engines. Three engine manufacturers, Briggs and Stratton, Tecumseh and Honda dominate the market with smaller numbers of Australian Victa two stroke motors. All are rated E10 compatible. The average age of a lawnmower is estimated to be 10 years but significant numbers of older mowers (up to 30 years plus) are still in use (Mackay 2006). These older engines are of a vintage where materials compatibility is likely to be an issue.

Most chainsaws sold in New Zealand are also sold in the USA where most suppliers approve the use of ethanol blends up to E10. Echo, Homelite, McCullough, Poulan, Ryobi and Stihl all approve the use of ethanol blends up to 10% although in some cases with additional recommendations such as draining the fuel before storage. Some other brands make no mention of ethanol (Shindaiwa and Husqvarna, for example). Husqvarna being European should be at least E5 compatible.

Other utility engines are mostly two stroke and tend to have a shorter average life. These are a mix of name brands nearly all of which are sold in the USA and are E10 compatible and some generic brands sourced from China and Asia. These generics are also sold in Europe and so should be E5 compatible but the situation with respect to E10 is unknown.

2.1.5. E10 Blends

Overall it would appear that there are some minor risks associated with the use of E10 in all applications. There is some risk for older engines of fuel system clogging on the transition but this has some longer term benefits of a cleaner fuel system. There is also some risk of degradation of fuel system components in the longer term for older vehicles. Typical costs of parts from Toyota are $60 for a fuel filter, $85 for a fuel pump gasket set and $150 for a complete fuel line.

The oxygen content of the ethanol may cause some minor operability issues but these can be addressed through engine tuning. Because it has been assumed that aviation and marine users will need to use ethanol-free fuels, these fuels should continue to be readily available. It is therefore expected that the users of engines that have been identified as being potentially at risk from the use of E10 will not use it or if so only in an emergency. In this case the risks are negligible.

2.1.6. E5 Blends

E5 blends are permitted and sold in Europe without labelling. No evidence has been found of any reported problems. Used Japanese cars are imported into the United Kingdom and Ireland in significant numbers. However, at this stage only relatively small quantities of E5 are being sold in the United Kingdom and almost none in Ireland. Thus the likely exposure of Japanese domestic market vehicles to E5 blends in Europe has probably been small. On the other hand, older European vehicles which were also designed without any consideration of E5 operation have had considerable exposure to this fuel particularly in Sweden. It is expected that there would be very little risk of problems arising from the use of E5 blends. However, two of the major Japanese vehicle distributors do not endorse its use on older vehicles in New Zealand and so some vehicle users may still be reluctant to take the chance.

2.1.7. E3 Blends

E3 blends are accepted by all the major automotive supply countries including Japan. There has been relatively little experience of this blend in practice but all the testing work shows no observable risk. Thus it would seem that the risks from E3 blends are negligible.

2.2. Numbers of engines at risk of problems with biodiesel blends

2.2.1. Diesel Vehicles

The distributions of light and heavy diesel-powered vehicles by age registered in New Zealand are shown in Figure 2 and Figure 3 respectively. The patterns of the age distribution are similar to those for light petrol-powered vehicles but there are some notable differences. The proportion of pre-1986 light diesel vehicles is just under 9% compared to 14% for petrol vehicles. This probably reflects the increase in popularity of diesel vehicles in recent years. The same bulge in vehicle numbers around 1997 vehicle age reflecting the inflow of used imports is apparent. For heavy vehicles the fleet is significantly older with 25% of vehicles 1986 or older. There is an influx of used imports around 1997 vehicles but it is not as large as the bulge in light vehicle numbers and may be spread over a wider age range.

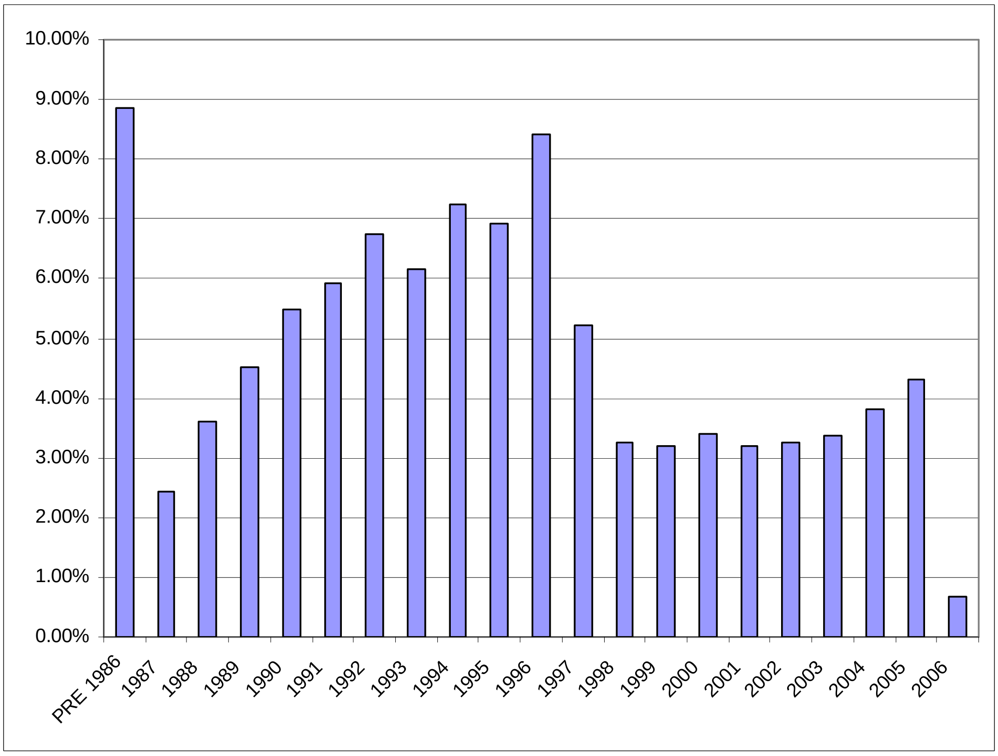

Figure 2. Distribution of light diesel-powered vehicles by age.

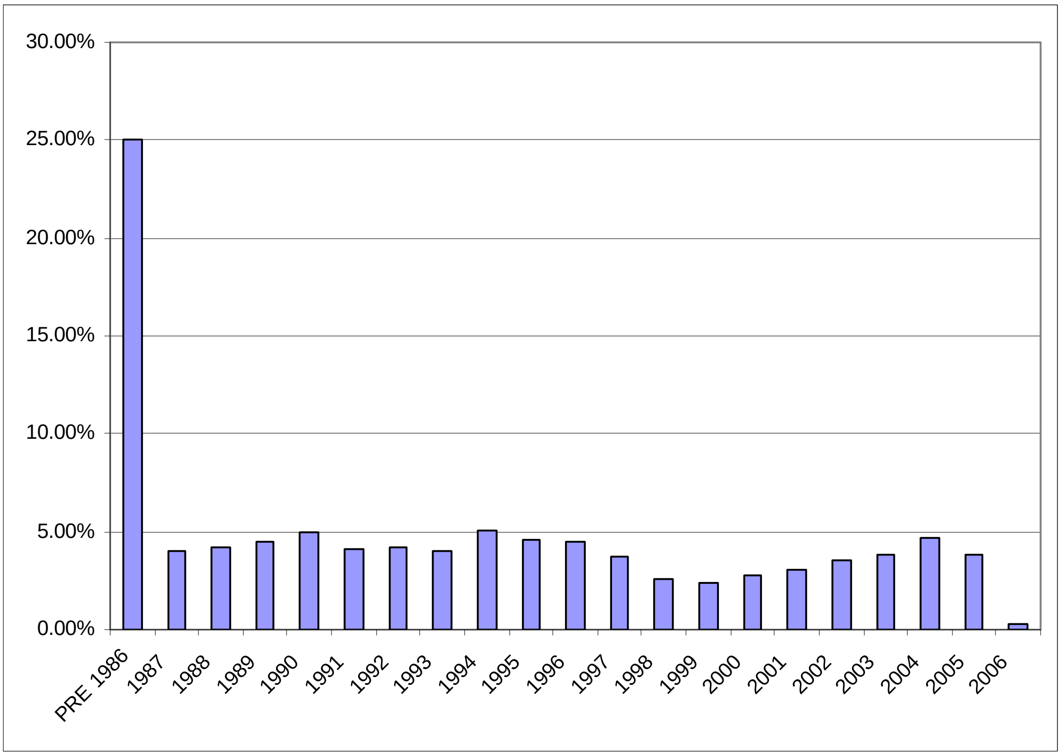

Figure 3. Distribution of heavy diesel-powered vehicles by age.

In terms of overall numbers there are (as at February, 2006) 477,000 light diesel vehicles registered and 142,000 heavy diesel vehicles (cf 2.74 million light petrol vehicles). The vehicles listed include all registered vehicles and thus there are a significant number of tractors and other machinery. For example, the eighth highest light vehicle make is John Deere who make primarily tractors and farm equipment.

2.2.2. Biodiesel Blends

B20 biodiesel blends have been quite widely used in the United States with very few reported problems. Although most of the biodiesel used in these blends has been based on soybean oil some successful tests have been undertaken with tallow-based biodiesel. There are issues of fuel system materials compatibility for older engines. All of the major diesel engine manufacturers endorse the use of biodiesel blends up to B5 provided the biodiesel meets appropriate fuel standards. Furthermore B5 blends may be sold in Europe without labelling and are widely used in some countries. No reported problems with B5 blends have been found.

The Japanese car makers in New Zealand are for the most part taking the same position as they do for ethanol petrol blends; that is they have no experience of their use and cannot endorse them.

Based on the European experience and the stated position of the major diesel engine manufacturers it is expected that B5 blends could be used by all vehicles with negligible risk provided both the biodiesel and the mineral diesel meet appropriate fuel standards.

Higher blends may cause problems for vehicles older than the mid 1990s which for light vehicles represents about half the fleet (243,000 vehicles) and for heavy vehicles about 65% (92,000 vehicles).

2.2.3. Non Automotive Engines

For non-automotive applications the diesel engines are made by the major diesel engine manufacturers who have all endorsed the use of B5 blends. The main risk for some of these engines is the potentially shorter shelf life of the biodiesel fuel particularly for applications where the engine is used infrequently. Again this is less of an issue for B5 than B20.

3. Options to minimise risk

Where a fuel is not endorsed by the engine manufacturer many users may be reluctant to use it. Although this would reduce the potential market-penetration of ethanol blends in the short-term it can virtually eliminate the risk of any problems associated with the use of ethanol-petrol blends. To achieve this requires:

- good public information on the need for users to check with vehicle suppliers on the compatibility of their vehicle with E5 or E10 blends
- vehicle suppliers to provide service stations and garages with information on the E5/E10 compatibility of their vehicles
- continued widespread availability of unblended petrol in parallel with ethanol blends.

This approach is very conservative as many vehicles that could use ethanol blends will be discouraged from doing so but it does eliminate risk. The Motor Industry Association (MIA) should be encouraged to prepare a list of vehicle makes and models showing their compatibility or incompatibility with E5 and E10 as has been done by the FCAI in Australia. All new vehicles sold in New Zealand are very likely to be E10 compatible and so in the longer term the entire fleet will be able to use E10 without risk.

Some applications (aviation and marine) require unblended fuel and thus there is a need for a continued supply of this fuel. Furthermore this implies that all ethanol blends should be labelled. Although taking the European approach of not requiring labelling for blend of 5% or less is unlikely to cause any harm to road vehicles and utility engines (based on their experience) it would allow ethanol blends to be used inadvertently for aviation purposes which has safety implications.

Labelling practice for bioethanol blends is not consistent internationally. In the USA, there are no Federal requirements and labelling is left to the individual states. A number of the states have now removed the labelling requirement for blends up to 10% on the basis that all vehicles can use this fuel. E85 blends do have to be labelled. Europe does not require labelling for blend up to E5. Australia requires labelling for all blends containing more than 1% ethanol although the recent biofuels task force recommended that the labelling requirement could be removed for blends less than 5%. The lack of a labelling requirement in some US states does cause problems for aviation users because some aircraft are approved to use automotive petrol but not approved to use ethanol blends. Therefore it is recommended that all petrol containing more than 1% ethanol should be labelled. The label should identify the upper level of ethanol content, e.g. "this fuel contains up to 10% ethanol" or some similar wording. The decision on whether to offer E5 or E10 blends can be left to the commercial judgement of the fuel suppliers.

B5 biodiesel blends have been used quite extensively in Europe and there is no evidence of any problems associated with them. In the USA B20 is the most popular blend (National Renewable Energy Laboratory 2001). As with the ethanol-petrol blends biodiesel blends of 5% or less do not require labelling in Europe while in the USA labelling requirements are left to the individual states. Although it is not mandatory in all states it appears that labelling is often used as a marketing tool to promote the pro-environment aspect of the fuel. B5 could be allowed in New Zealand without labelling provided appropriate fuel standards are applied. Compliance with the current standard for biodiesel in New Zealand is voluntary. Mandatory compliance would eliminate risks associated with poor fuel quality. For higher level blends labelling is recommended given that its use is not endorsed by all vehicle suppliers.

Key messages for the public relating to the use of biofuels are:

- the levels of biofuel blends being offered in New Zealand have been used extensively in other countries with no significant problems
- the biofuel component of the blend is a renewable resource which is derived from low-value waste products. Biofuels are environmentally friendly compared to fossil fuels.
- biofuels are clean-burning and generally less polluting than fossil fuels. They are also more biodegradeable and cause less damage if spilt.

Key messages for the motor trade are:

- biofuel blends have been used extensively internationally with very few problems
- the cleansing effect of biofuels may lead to clogging of the fuel filters during the initial changeover. These should be checked at servicing.
- fuel systems should be monitored during servicing to watch for any signs of materials degradation

4. Summary

The purpose of this section of the report is to consider the risks to vehicles and other engines of introducing biofuel blends into the New Zealand market. Specific blends to be considered are ethanol blends with petrol and tallow-based biodiesel blends with diesel.

Ethanol blends above 10% generally require vehicle/engine modifications to operate without problems. This has been done successfully in Brazil but was not considered viable for New Zealand.

!0% ethanol blends have been used widely in the United States for over 25 years and have recently been permitted in Australia. Apart from some initial problems with older (1970s) vehicles there appear to be no issues with the use of E10 for automotive applications in the USA. Most non-automotive utility engine suppliers in the USA also endorse the use of E10.

In Australia the FCAI have prepared a list of compatible and incompatible vehicles. The New Zealand motor vehicle distributors have been canvassed for their views on the compatibility of New Zealand vehicles with E10. Although the vast majority of new vehicles in New Zealand are compatible with E10, 62% of the existing fleet are not endorsed by the manufacturer as suitable for use with E10 blends. This does not necessarily represent a real risk of damage to the engine because it is in the manufacturers' interests to be conservative in their assessment. However, in the author's opinion fuel users are likely to be unwilling to take the risk and will follow the manufacturers' advice. Even if all the fuel users whose vehicles are not endorsed as suitable for E10 continue to use unblended fuel, about 40% of the current fleet will be able to use E10 and there will be little risk of any complications. Nearly all new vehicles are E10 compatible and so the proportion of vehicles that can use E10 with no risk will grow over time.

Most utility engines (lawnmowers, chainsaws etc) are the same as the models available in the USA and should be able to use E10 without risk. Very old engines do have a risk of fuel system materials incompatibility problems as occurred in the USA when E10 was first introduced. Engines that are not used in the USA are generally sold in Europe. These will be E5 compatible but there is some uncertainty about their compatibility with E10.

5% ethanol blends are permitted in Europe without labelling. This clearly implies that the European regulators consider that there is no risk to their existing fleet from the use of E5 blends. Australia is also considering removing the labelling requirement for blends of 5% or less. The obvious question then is: how does the New Zealand vehicle fleet differ from that in Europe? A large proportion of the New Zealand vehicle fleet is made up of Japanese manufactured vehicles and a significant proportion of these are domestic models that have entered New Zealand as used imports. New Zealand-new vehicles are not necessarily the same specification as Japanese vehicles sold in Europe. Domestic model Japanese vehicles are imported into the UK and Ireland as used imports but only limited amounts of E5 fuel are sold in the UK and very little in Ireland. However, older European vehicles were designed without consideration of E5 fuel and have used it without problems for several years now. There is no reason to believe that Japanese vehicles would have greater problems. The risks associated with E5 use are believed to be minimal but a number of vehicle suppliers do not endorse its use for all models.

E3 blends are a permitted fuel in Japan, the USA, Europe and Australia. Thus there is no reason to expect any vehicles to have problems with E3 blends.

B20 biodiesel blends have been used extensively and successfully in the USA for a number of years. B5 blends are permitted in Europe without labelling and are extensively used in some countries, most notably France. The main difference between the overseas biodiesels and that proposed for New Zealand is that US biodiesel is mostly based on soybean, European biodiesel is based on oilseed rape while a significant source for the proposed New Zealand biodiesel is expected to be tallow. The main difference between tallow-based biodiesel and vegetable oil-based biodiesels is that the tallow-based product has a significantly higher melting point and thus is likely to be more susceptible to cold weather problems. At the B5 blend level this effect is very small and will pose no problems. A trial in Kansas used tallow-based biodiesel in a B20 blend through the winter without any issues.

B5 blends are endorsed by all the major diesel engine manufacturers provided that appropriate fuel standards are met. New Zealand has recently developed a biodiesel standard which is compatible with the US and European standards and provides for 5% biodiesel blends to be sold at the retail level. It ensures that biodiesel blends meet the same specifications as mineral diesel. With this fuel there should be a negligible risk of any adverse impacts for automotive use.

Non automotive diesel engines are made by the same manufacturers as automotive engines and will have no operational difficulties with B5 blends. However, there is some evidence that the shelf life of biodiesel blends is lower than that of mineral diesel and that the fuel is more vulnerable to microbial growth. Thus for infrequent use applications such as standby generators some extra care may be needed to ensure that fuel quality is maintained.

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