

Some biofuels are better than others:
Thinking strategically about biofuels

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Parliamentary Commissioner
for the **Environment**
Te Kaitiaki Taiao a Te Whare Pāremata

Acknowledgements

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Volume and cost analysis of large-scale woody biomass supply; Southland and Central North Island, Scion, Rotorua.

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Biomass to liquids, CRL Energy Ltd, Lower Hutt.

These appendices are available on the website www.pce.parliament.nz

Commissioner's overview

Biofuels are our oldest fuels – simply by burning wood for warmth or using tallow candles for light, our forebears were using biofuels.

The first diesel engine was run on peanut oil. Henry Ford's early cars ran on ethanol produced from plants. Indeed, Henry Ford said, *"The fuel of the future is going to come ... from apples, weeds, sawdust – almost anything."* However, it was not long before petroleum fuels dominated and the use of biofuels for transport was forgotten, with seemingly unlimited cheap oil flooding in from the Middle East.

In the 1970s, the "limits to growth" movement and the oil price shocks revived interest in biofuels. Biofuels were seen as the renewable solution for transport energy in contrast to non-renewable fossil oil. In the same decade, the formidable economic power of a united Middle East and the oil price shocks led to energy security becoming a major focus for governments around the world.

In 1978, the New Zealand Government created the Liquid Fuels Trust Board, charging it with finding ways to break our economic dependency on imported transport fuels. The Board funded investigations into different feedstocks, such as lignite, Maui gas, and biomass, and into different fuels, such as methanol and rapeseed oil. I recall working for the Board for a short period in 1986 on options for reducing transport fuel consumption.

Concerns about energy security are currently increasing again as demand for oil in China and India accelerates and premium oilfields are depleted. The state-owned enterprise Solid Energy has picked up where the Liquid Fuels Trust Board left off, investigating the potential for producing transport fuel from Southland lignite. This would add a significant amount of carbon dioxide to New Zealand's greenhouse gas emissions.

In contrast, a significant reduction in our carbon dioxide emissions could be made if we were able to produce a substantial amount of transport fuel from biomass. In my time as Commissioner, two bills focused on biofuels have been introduced to Parliament. The analysis of these two bills, prepared for my submissions to the Local Government and Environment Select Committee, has motivated the writing of this report.

The Biofuel Bill in 2008 sought to establish a sales obligation, whereby a certain percentage of all petrol and diesel sold would have to be biofuel. Unexpectedly for a Parliamentary Commissioner for the Environment, I recommended that this bill not proceed. My major concern was that fuel companies could meet the obligation with "bad" biofuels. Biodiesel made from palm oil planted on land made available by the felling of rainforests is a "bad" biofuel, because of the release of huge amounts of greenhouse gases and the great loss of biodiversity. Ethanol made from subsidised maize in the United States is also a "bad" biofuel, because the life cycle greenhouse gas emissions can be about the same as petrol.

The biofuel sales obligation became law after three sustainability principles aimed at excluding "bad" biofuels were incorporated, but it was repealed after a change in government.

The Sustainable Biofuel Bill in 2009 was a private members' bill that was intended to ensure that all biofuels used in New Zealand were consistent with the

sustainability principles in the repealed legislation. At the time of writing, this bill remains with the Local Government and Environment Select Committee.

While the Sustainable Biofuel Bill, like the sales obligation, is well intentioned, it is simply not practicable for a number of reasons. One reason is that it would be strange to require biofuels to meet special sustainability principles when other land uses in New Zealand are controlled under the Resource Management Act 1991. Another reason is that it would be difficult to monitor and enforce compliance of imported biofuels with the sustainability principles offshore.

The purpose of this report is to take a fresh look at biofuels – to think strategically about how they might lessen our dependence on fossil fuels and thus reduce our greenhouse gas emissions. This fresh look has led me to the following four conclusions.

First, the kinds of biomass currently being used as feedstock for biofuels in New Zealand cannot take us very far. Most biofuel currently produced in New Zealand is made from by-products – ethanol from whey and biodiesel from tallow. Some more whey and tallow could become available, but the potential for growth is not great. A small amount of canola is grown for processing to biodiesel, but the amount of agricultural land available for growth is limited because other land uses are more valuable, certainly in the foreseeable future. Although Henry Ford was right about being able to make fuel out of virtually any plant material, only wood could be grown in sufficient quantities to make biofuel mainstream. Algae could well play a valuable subsidiary role, especially if its use as a biofuel feedstock can provide the added benefit of improving water quality. Other feedstocks, such as switchgrass, could also be minor players.

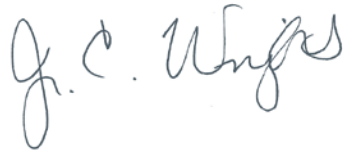
Second, the biofuels currently being produced in New Zealand can only be used to supplement conventional petrol and diesel. Ethanol can only be used in our cars in a blend of up to 10 percent with petrol, so its potential is limited for the foreseeable future. The same applies to the kind of biodiesel produced now, which cannot be retailed in more than a 5 percent blend with conventional diesel. So if biofuels are to be major players in our energy future, they should be drop-in fuels, so called because they do not need to be blended with petroleum fuels. Hydrogenated renewable diesels, not yet produced in New Zealand, are drop-in fuels. Drop-in biofuels could also be produced using the Fischer–Tropsch process, used to convert coal to liquid fuel in South Africa.

Third, it makes sense to focus on biofuel substitutes for diesel rather than substitutes for petrol. We run our trucks, tractors, and fishing boats on diesel, and, if we are concerned about energy security, diesel is more important than petrol. Most of our cars run on petrol, but, in contrast to the transport of freight and the cultivation of our land, there is much more flexibility in the demand for petrol. Electric cars appear to be coming into their own, and many trips can be made by public transport, cycling, and walking. The decrease in congestion on Auckland's motorways when the price of a litre of petrol rose above two dollars in 2007 is testament to this flexibility.

Fourth, it makes no environmental sense at all, and indeed is unethical, for us to import “bad” fuels made from feedstocks such as palm oil. The Government has set up a Biodiesel Grants Scheme, under which New Zealand biodiesel manufacturers can obtain subsidies on a per litre basis. Currently, no company is making biodiesel from imported palm oil in New Zealand, but there is nothing to stop this happening. It is ironic that our commitment to free trade could lead to taxpayers subsidising the felling of rainforest in countries like Indonesia and Malaysia.

In light of these conclusions, if biofuels are to play a significant role in our energy future, we should move toward developing drop-in biodiesel made from wood.

Some biofuels are good, some are bad, and some are probably downright ugly. The challenge that lies before us is to develop and commercialise biofuels in a practicable way that will significantly reduce our greenhouse gas emissions, improve our energy security, and genuinely make our country cleaner and greener.

A handwritten signature in black ink, appearing to read 'J. C. Wright'.

Dr Jan Wright
Parliamentary Commissioner for the Environment

1

Introduction

Energy is fundamental to our everyday lives. Capturing that energy in liquid form allows us to drive our cars, trucks, tractors, and fishing boats and run boilers and generators. Yet these liquid fuels are so integrated into our economy, and lifestyle, that it is easy to take them for granted.

That would be unwise. The future of fuels such as petrol and diesel is an area of active debate, with phrases such as “peak oil” entering our vocabulary. While governments around the world are grappling with the issue, business too is alert to the potential for change ahead. Lloyd's of London recently said:

“...we have entered a period of deep uncertainty in how we will source energy for power, heat and mobility, and how much we will have to pay for it. Is this any different from the normal volatility of the oil or gas markets? Yes, it is. Today, a number of pressures are combining: constraints on ‘easy to access’ oil; the environmental and political urgency of reducing carbon dioxide emissions; and a sharp rise in energy demand from the Asian economies, particularly China. All of this means that the current generation of business leaders – and their successors – are going to have to find a new energy paradigm.”

Biofuels will be part of this new energy paradigm.

So what exactly are biofuels? They are fuels that are made from biological material or “biomass”. This report focuses on liquid biofuels made from a range of sources – from sugarcane, corn, vegetable oils, animal fats, wood, or even algae.

Some biofuels are better than others. Making biofuel from used cooking oil is clearly sensible. On the other hand, clearing rainforest to grow biofuel feedstocks is not good for the environment – it releases huge amounts of carbon dioxide and destroys biodiversity.

However, many biofuels do have the potential to reduce our greenhouse gas emissions. Climate change is the greatest threat to our environment, and any steps that we can take to reduce emissions must be contemplated seriously.

Additionally, biofuels can improve our security of fuel supply. This matters environmentally because supply failure will send environmental concerns “out the window”.

And biofuels can support our “clean green” image. Not only is this an important part of how we see ourselves, it is the brand of many of our companies.

We are a country with low population density and an economy largely based on biological production. We are motivated to reduce emissions and protect our clean green image. If we cannot produce our own biofuels, who can?

1.1 Purpose of this report

This report has been produced pursuant to 16(1)(a–c) of the Environment Act 1986.

The Parliamentary Commissioner for the Environment is an independent Officer of Parliament. Her role allows a unique opportunity to provide Members of Parliament with independent advice in their consideration of matters that may impact on the quality of the environment.

As part of that work, the Commissioner made two submissions^{8,19} on legislation – on the Biofuel Bill in 2008 and the Sustainable Biofuel Bill in 2009. While supportive of the good intentions behind both pieces of legislation, the Commissioner raised concerns regarding unintended consequences of the sales obligation and the difficulties of implementing sustainability principles.

This work raised questions about the wider context of the role of biofuels in New Zealand. How might biofuels lessen our dependence on fossil fuels? Can they reduce our greenhouse gas emissions? What can New Zealand realistically achieve with biofuels, and what do we need to do if we want to make that happen?

1.2 Structure of the report

The remainder of this report is structured as follows:

Chapter 2 describes the rise of interest in biofuels that began in the 1970s in New Zealand.

Chapter 3 discusses methods used by the Government over the past four years to support the biofuel industry.

Chapter 4 begins to look at biofuels from a strategic perspective. What does New Zealand want from biofuels?

Chapter 5 considers the potential of New Zealand’s current biofuel industry.

Chapter 6 considers the potential of biofuels under development in New Zealand.

Chapter 7 contains the conclusions of the report and recommendations from the Commissioner.

Two technical reports were commissioned as part of this investigation. Crown research institute Scion considered future wood supply to centres in the Bay of Plenty and Southland. CRL Energy evaluated the production of biodiesel from wood by the Fischer–Tropsch process. These reports are available on the Commissioner’s website, www.pce.parliament.nz.

1.3 What this report does not cover

This report focuses on liquid biofuels because of their potential for replacing petrol and diesel. Still, it should not be forgotten that we already have a common biofuel – wood. Products such as wood pellets or wood charcoal are likely to be important solid fuels in the future. “Biogas” from sewage and landfills is also already part of our energy landscape.^{2,3} Even if a particular type of biomass cannot practically be turned into liquid fuel, it may well have other energy uses that should not be dismissed.

But the low-hanging fruit may be on the demand side rather than the supply side. Policy analysts also need to consider our ever-increasing consumption of transport energy. Since 1990, New Zealand’s petrol consumption has grown more than 20 percent, aviation fuel consumption has grown about 50 percent, and diesel consumption has gone up dramatically, by 117 percent. This report does not investigate options to better manage demand.

2

The rise of interest in biofuels in New Zealand

Biofuels in New Zealand have a surprisingly long history. As long ago as 1918, options for producing fuel ethanol were considered.⁴ There are references to Southland beech being distilled into “wood alcohol” (bio-methanol) in the 1930s.⁵ But it was not until the 1970s that the use of biofuels for transport attracted serious consideration.

This chapter describes how the concept of renewable energy and the oil price shocks combined in the 1970s to put biofuels on the public agenda. That interest in biofuels has been revived by the need to avert dangerous climate change.

2.1 The concept of renewable energy

In the 1970s, much attention became focused on the concept of renewable energy. Many thinkers saw unacceptable risks in meeting the energy needs of a rapidly expanding population with the finite resources of fossil fuels. One key influence was the publication of *Limits to Growth*, reputedly the best-selling environmental book ever.⁶

The basic concept is that we should “live within our means” by moving to renewable energy supplies rather than relying on mineral deposits that have taken hundreds of millions of years to accumulate. Renewable energy sources include hydro power, wind, sunlight, geothermal heat, and biomass. Of these, only biomass can yield the liquid fuels needed for present-day transport.

The categorisation into renewable (good) and non-renewable (bad) sources of energy is somewhat misleading. Non-renewable resources do not “run out” as such, but become more expensive to obtain and process. There is a great deal of oil left in the world, but little left that is high quality and readily accessible. Biofuels are classed as renewable because plants store sunlight; but growing biofuel crops may rely on non-renewable fertilisers.

New Zealand’s electricity is mostly renewable. In 2009, 73 percent of electricity came from hydroelectric, geothermal, and wind resources.⁷ This is an important part of New Zealand’s “clean green” image, which is so critical to export industries like tourism and agriculture.

However, virtually all our transport fuels are fossil fuels. So biofuels, provided they genuinely have a low environmental footprint, offer a big opportunity to make our economy “cleaner and greener”. In this regard, biofuels are greatly preferable to liquid fuels that could be made from domestic fossil fuel resources like lignite.⁸

2.2 New Zealand responds to the oil price shocks

In 1973, the risk of dependence on oil was thrown into sharp relief when the world was hit with its first oil price shock.⁹ Virtually all New Zealand’s liquid fuels were imported. In 1970, the nation’s fuel bill was five percent of export earnings; in 1974 it was more than 20 percent.¹⁰

In 1978, the Liquid Fuels Trust Board (LFTB) was established to promote ways of reducing transport fuel imports.¹¹ Its work was conducted under some urgency. In 1979, a second oil price shock hit. Carless days were introduced, along with restrictions on the hours service stations could sell petrol. This time, New Zealand was shown to be vulnerable strategically, not just economically; at one point, there was less than a day’s supply of fuel in bulk storage around the country.

The LFTB investigated biofuels from canola seed oil, tallow oil, maize, lucerne, sugar beet, and wood. It funded pilot plant construction and conducted engine tests. Generally, production costs were considered to be significant obstacles. The LFTB saw potential for substantial volumes of methanol or ethanol from forest sources, but not from agricultural sources, because it would not be possible to grow enough feedstock economically.

A small whey ethanol plant was constructed at Reporoa in the Bay of Plenty in 1980, followed by two more plants at Edgecumbe and Tirau. In 1986, the excise tariff was removed from fuel ethanol. And SouthOil produced small quantities of biodiesel from canola seed at Awarua in Southland between 1982 and 1991.¹²

The LFTB facilitated the Government’s promotion of compressed natural gas (CNG) as a transport fuel. As this required engine conversion, the LFTB also recommended turning excess natural gas from the huge Maui field to methanol, and then

Figure 2.1 Volatility in transport fuel prices in New Zealand



Calculated from fuel price data published by the Ministry of Economic Development. All prices are converted to 2010 dollars and exclude GST.

into synthetic petrol using the Mobil process. This led to the construction of the Motunui synthetic petrol plant, the only one of its type ever built, capable of producing more than 700 million litres a year.

But then, worldwide, oil and gas production rose, and fuel prices fell back again and remained low for many years [Figure 2.1]. The LFTB was disestablished in 1987, biofuel projects were shelved, CNG disappeared from the market, and the Motunui plant ceased to operate. Only the three whey ethanol plants remained in business, serving industrial and beverage markets.

2.3 A new impetus for biofuels: climate change

The Earth's climate is changing, largely because of human activities that emit greenhouse gases into the atmosphere.¹³ In response, the Earth Summit in 1992 resulted in a treaty, the United Nations Framework Convention on Climate Change, which set out to stabilise greenhouse gas concentrations in the atmosphere at levels that would avert dangerous man-made climate change. Under the Kyoto Protocol of 1997, many industrialised countries undertook to reduce their greenhouse gas emissions. New Zealand committed to keep its net emissions to 1990 levels or less during 2008–2012.

In 2009, the New Zealand Government stated that it would commit to a target of 10 to 20 percent less than 1990 levels by 2020, if other countries did likewise.¹⁴ But New Zealand's total greenhouse gas emissions have already increased about 23 percent between 1990 and 2008.¹⁵ Currently, this increase is offset by carbon dioxide uptake by forests planted in the early 1990s. But those forests are approaching harvesting age. So New Zealand will soon have to substantially reduce its gross emissions, plant very large new areas of forest, or pay other countries to reduce emissions on our behalf.

Using liquid fuel generates carbon dioxide, the major greenhouse gas. Today, the carbon dioxide emitted from burning petrol and diesel makes up about one-quarter of New Zealand's greenhouse gas emissions.¹⁶ Therefore, reducing emissions associated with liquid fuels could be a significant step toward reaching our target.

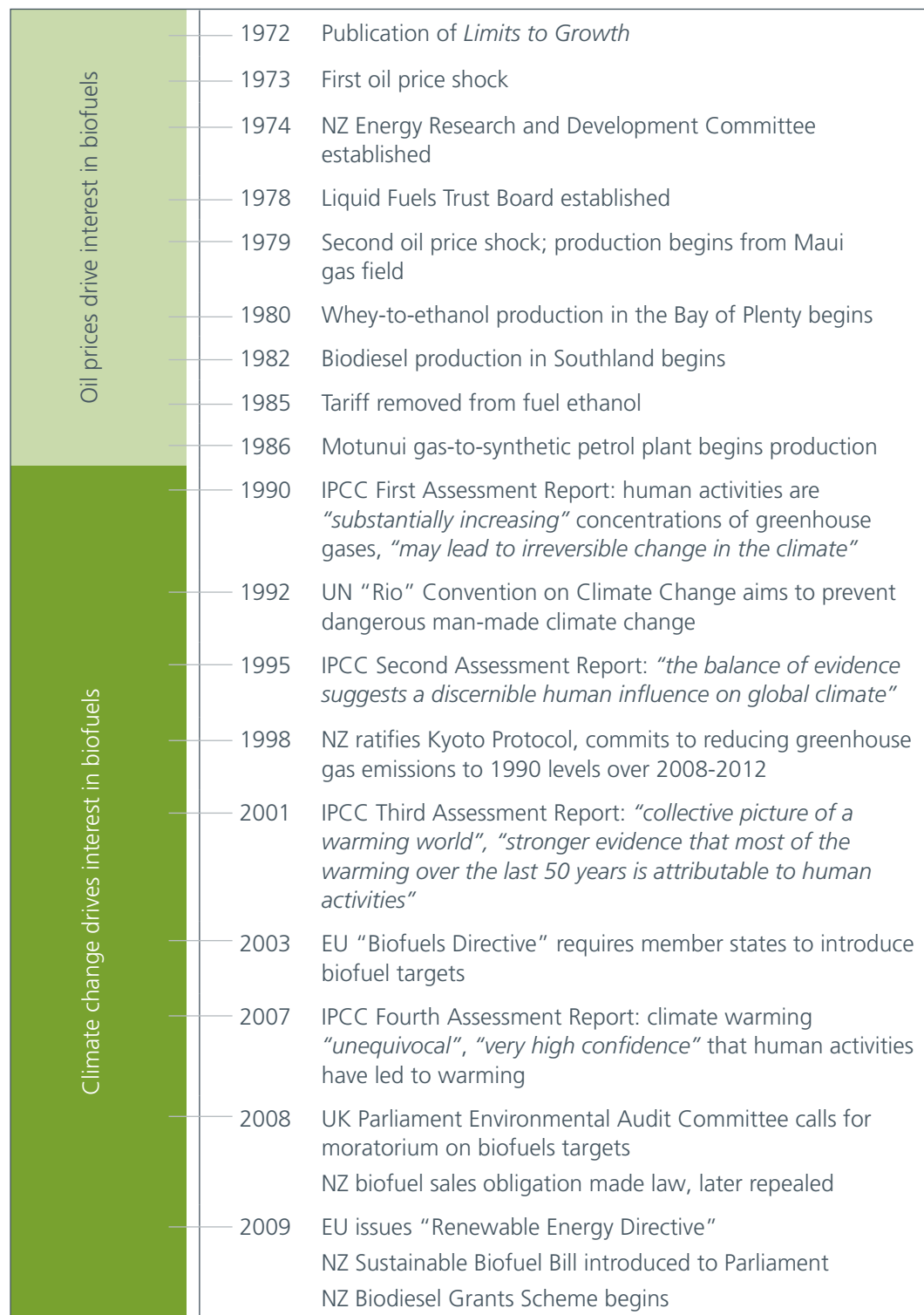
Biofuels might appear to be "carbon-neutral", because they are made from plants that absorb carbon dioxide as they grow, and this is equal to the carbon dioxide emitted when the fuel is burned.

However, greenhouse gases are emitted during the life cycle of all biofuels. For example:

- When palm and soy oils are produced on land previously covered in rainforest, felling and burning the forest releases vast amounts of carbon dioxide.
- Energy-intensive production steps, such as the distillation of ethanol, are sometimes powered by burning fossil fuels such as coal.
- Most energy crops grow better if well fertilised. But the process of making nitrogenous fertilisers, such as urea, also uses a lot of fossil fuels. And when these fertilisers are applied to soil, a proportion of the nitrogen content is released as nitrous oxide, a potent greenhouse gas.

Biofuels can, and should, be “low-carbon”. Such biofuels could help New Zealand reduce greenhouse gas emissions, and for this reason biofuels have recently attracted government support.

Figure 2.2 Timeline



Government encouragement of biofuels

This chapter discusses the four recent government initiatives aimed at encouraging biofuel production in New Zealand. They are:

- The Biofuel Bill, which briefly created a biofuel sales obligation in 2008
- The Sustainable Biofuel Bill, intended to ban certain biofuels because they do not meet sustainability criteria
- The Biodiesel Grants Scheme, a sales subsidy for qualifying biodiesels
- The Emissions Trading Scheme (ETS), which encourages biofuels indirectly by imposing costs on greenhouse gas emissions.

3.1 The Biofuel Bill - a biofuel sales obligation

In 2007, the Biofuel Bill was introduced to Parliament. The Bill's principal aim was to create a biofuel sales obligation in New Zealand. In essence, every fuel supplier's sales would have to include at least 0.5 percent biofuels. If suppliers did not meet the obligation in any given year, they would have to pay a penalty of up to \$20 million to the Crown. The proportion of biofuel to be sold, and the size of the penalty, were to steadily increase.

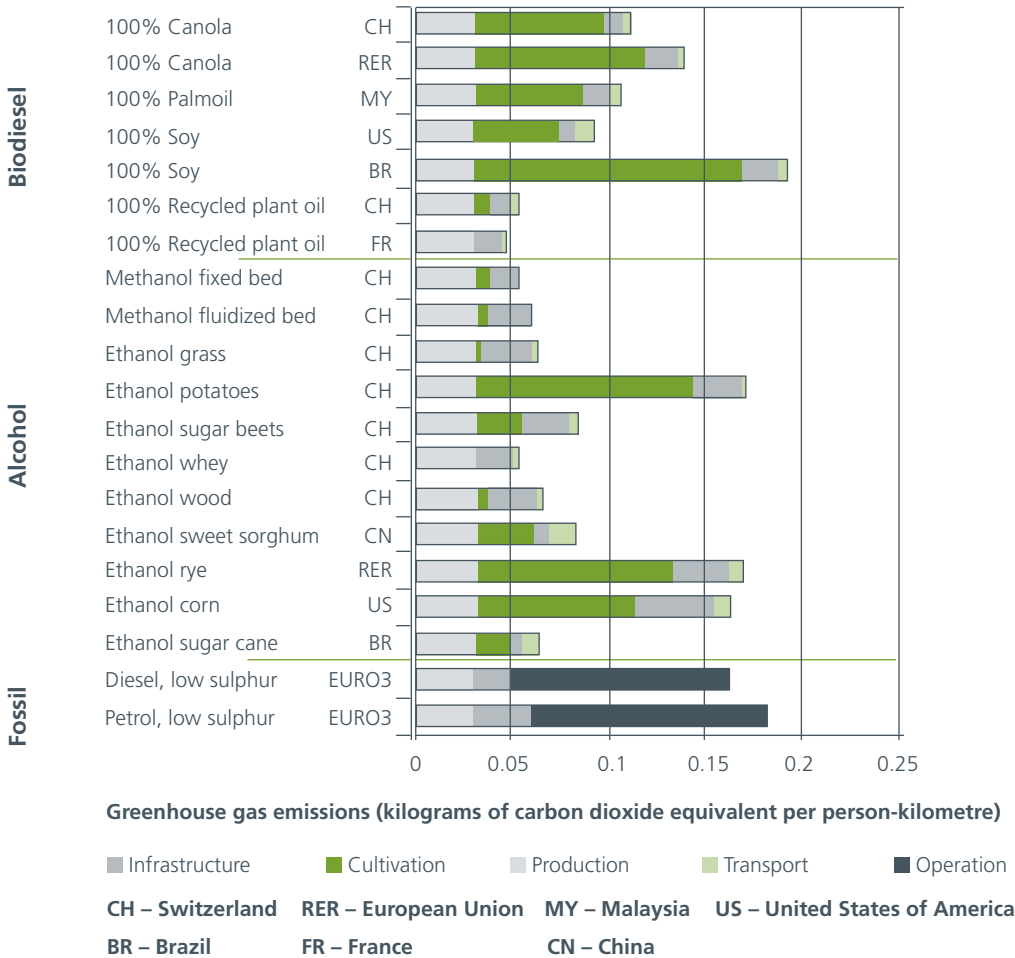
This Bill was inspired by similar legislation overseas, such as biofuel sales obligations in some European countries following the European Union's "Biofuels Directive" of 2003.¹⁷ Canada, several ASEAN nations, and the Australian state of New South Wales all have biofuel sales obligations.

After its First Reading in the House, the Biofuel Bill was referred to the Local Government and Environment Select Committee. In her submission to the Committee, the Parliamentary Commissioner for the Environment recommended that the Bill not proceed. Her main concern was that there was no way to stop "bad" biofuels being used to meet the sales obligation. Moreover, because "bad" biofuels come from developing countries, there was every likelihood that they would be cheaper than biofuels made in New Zealand.

Biofuels have widely varying environmental (and social) footprints. Some require producers to put in more fuel than consumers get out. Some increase net greenhouse gas emissions, not reduce them. Some compete with food crops for water, arable land, and fertilisers. In some countries, ecosystems are destroyed to make way for biofuel crops, or degraded by discharges from processing. The UK

Parliament’s Environmental Audit Committee concluded in 2008 that most biofuels available in Europe at that time had a detrimental effect on the environment overall. Figure 3 shows data from a Swiss study, comparing typical life cycle greenhouse gas emissions from biodiesel and ethanol from various sources, with life cycle greenhouse gas emissions from petrol and diesel. In this figure, emissions are shown in terms of greenhouse gases emitted per kilometre travelled in a standard vehicle. From the perspective of reducing greenhouse gas emissions, biofuels from some sources are considerably better than fossil fuels, but others are not.

Figure 3 Life cycle greenhouse gas emissions from a variety of biofuels



Adapted from Figure 2 of Zah *et al.* 2007²⁰
Examples of “bad” biofuels include:

Corn ethanol from the United States, which may deplete water resources in arid regions, discharge fertiliser and sediment into water bodies, threaten land currently in conservation programmes, and increase prices of food and animal feed. Corn ethanol can increase greenhouse gas emissions from fuel use, especially when indirect land use changes are considered.²¹**Biodiesels from Brazil or Indonesia** that have been made from soy or palm oil grown on cleared rainforest land. In Southeast Asia, expanding palm oil plantations are one of the leading causes of rainforest destruction and the consequent loss of biodiversity. Some of this land has peat soils, leading to particularly high greenhouse gas emissions when it is drained.

The Select Committee recommended that three “sustainability principles” be inserted into the Biofuel Bill to keep “bad” biofuels from being used to meet the sales obligation. The three principles were:

- That biofuels must emit at least 35 percent less greenhouse gas over their life cycles than fossil fuels
- That biofuels must not compete with food production or be produced using land of high value for food production
- That the production of biofuels must not reduce indigenous biodiversity or adversely affect land with high conservation values.

The Biofuel Bill was signed into law on September 2008, and the sales obligation began a month later. However, it was repealed by the incoming government in December the same year.²⁴

3.2 The Sustainable Biofuel Bill

In June 2009, the three sustainability principles were revived when a members’ bill, the Sustainable Biofuel Bill, was drawn from the ballot. If enacted, supplying or selling biofuels in New Zealand that did not meet the three sustainability principles would be an offence. Like the sales obligation, the intent of this Bill is good, but its implementation is fraught with difficulties.

The European Union’s “Renewable Energy Directive” allows biofuels to qualify for sales obligations only if several sustainability criteria are met. These criteria include a minimum greenhouse gas emissions reduction of 35 percent and restrictions on land where biofuels can be grown. Member states must report on whether their biofuel policies have had adverse social and environmental effects, both domestically and in the countries where biomass feedstocks are grown.²⁵

If the European Union can implement sustainability criteria, why then is it difficult for New Zealand to do so?

First, the Bill requires New Zealand to establish its own sustainability standards through regulation. However, biofuels can be produced anywhere in the world, from a bewildering variety of feedstocks, through many different processes. For any specific biofuel, performance against criteria may vary substantially between individual producers, and may vary substantially over time. Apparent performance can also vary substantially depending on the methodology used and the quality of data collection. How could New Zealand monitor compliance overseas effectively?

Second, as a small, open economy that relies heavily on trade, New Zealand is unusually careful to comply with World Trade Organization (WTO) rules. Technically, New Zealand cannot unilaterally impose environmental standards to block the import of goods from other countries.²⁶ Indonesia and Malaysia have already indicated that they may dispute the “Renewable Energy Directive” at the WTO, as they say its environmental provisions would make it hard to sell palm oil biofuel in Europe.²⁷

The way through this could be an international standard, such as the Montreal Protocol, which is designed to protect the ozone layer, or the Stockholm Convention, which deals with persistent organic pollutants.

Tentative steps are being taken. In 2009, the International Standards Organisation (ISO) began work on a standard ISO13065 *Sustainability criteria for biofuel*. The technical committee responsible is led by the national standards bodies of Brazil and Germany; New Zealand currently has observer status. However, it will probably be some time before this standard is completed, let alone widely adopted and enforced internationally.

There is also a significant problem with applying the sustainability standards to biofuels grown in New Zealand. Why should only one land use, that of growing biofuel feedstocks, have to meet these special sustainability criteria? Why would it be unacceptable to drain wetlands for planting energy crops, but acceptable to drain wetlands for expanding pasture?

3.3 The Biodiesel Grants Scheme

In July 2009, the Government established a Biodiesel Grants Scheme. The subsidy per litre was set to be equivalent to the excise exemption given to fuel ethanol.

The scheme provides a 42.5 cents per litre sales credit for FME biodiesels. FMEs are fatty acid methyl esters, made by reacting vegetable oils or animal fats with methanol. To qualify, FMEs have to be manufactured in New Zealand and sold in New Zealand as transport fuel. The feedstock does not have to be grown in New Zealand.

The scheme has been capped at \$9 million in 2009–2010, increasing to \$15 million in 2011–2012.²⁸ But uptake so far has been poor. Just \$200,000 of the \$8.2 million available was paid out between July 2009 and May 2010.

Until recently, biodiesel was to be blended with petroleum diesel up to a maximum of 20 percent (a “B20 blend”). But because of the low uptake of the subsidy, biodiesels blended in any proportion now qualify from 1 July this year. This change is intended to encourage biodiesel use in businesses such as ecotourism, which see the reduction of greenhouse gas emissions as particularly important.²⁹

3.4 Biofuels and the Emissions Trading Scheme

The intention of New Zealand’s ETS is to put a price on greenhouse gas emissions. The basic concept is that those who emit greenhouse gases should be required to pay for each tonne of carbon dioxide they emit, and those who remove greenhouse gases from the atmosphere should get paid for each tonne of carbon dioxide they remove.

The ETS should impose a larger cost on fuels that emit more carbon dioxide than on those that emit less. Because “good” biofuels have a much smaller carbon footprint than petroleum fuels, the ETS should reduce the price of biofuels relative to petroleum fuels. In theory, the introduction of the ETS should make government assistance to the biofuel industry unnecessary. But the reality is far from the theory.

Much of the biofuel traded internationally comes from developing countries such as Brazil and Indonesia. These countries do not have any system that puts a price on greenhouse gases, let alone one that tries to put a price on the carbon dioxide emitted when rainforest is felled.

Petrol and diesel are only partly exposed to the ETS. Fuel companies pay half the carbon price, passing it on to consumers. The taxpayer pays the other half, at least until the end of 2012. The transport sector entered the ETS on 1 July 2010, with the price of petrol and diesel at the pump expected to increase by three cents per litre.³⁰

The cost of biofuels produced in New Zealand will still increase slightly under the ETS because fertilisers, fuels, and electricity used to grow, haul, and process biofuels will all be partly exposed to the price of carbon.

The biofuels sold in New Zealand currently are blended with petroleum fuels. This dilutes the effect of the ETS even further. For instance, petrol blended with up to ten percent ethanol would have only a mere fraction of a cent per litre advantage over straight petrol.

The ETS is the right economic framework for building a price on carbon dioxide into our economy. Given the current overly generous allocation scheme, its effectiveness will be very limited.³¹ And it will not be effective at all in assisting the domestic biofuel industry to grow.

4

What does New Zealand want from biofuels?

Some recent government initiatives to support biofuels have implicitly rested on the assumption that one biofuel is as good as another, provided technical quality standards have been met. But there are different biofuels, different feedstocks from which they can be made, and different processes for making them. In considering the merits of biofuels, the devil really is in the detail.

In this chapter, biofuels are considered from a strategic perspective. What does New Zealand want from biofuels? Here it is argued that New Zealand wants biofuels that:

- Really do benefit the environment
- Can be produced in relatively large quantities
- Do not need to be blended with conventional fuels (“drop-in” fuels)
- Substitute for diesel rather than petrol
- Benefit the economy and, particularly, our clean green image.

4.1 Biofuels that benefit the environment

For biofuels to really help reduce greenhouse gas emissions, they have to be genuinely “low carbon”, with low greenhouse gas emissions throughout the life cycle of the fuel.

In New Zealand, that means:

- Finding land to grow biofuels on without felling forests or draining wetlands
- Growing biofuels without using large quantities of nitrogenous fertilisers
- Minimising diesel used in harvesting and haulage
- Using only small amounts (if any) of coal and natural gas in the production process.

New Zealand does not want feedstocks that are biosecurity hazards or that damage biodiversity or valuable conservation land.

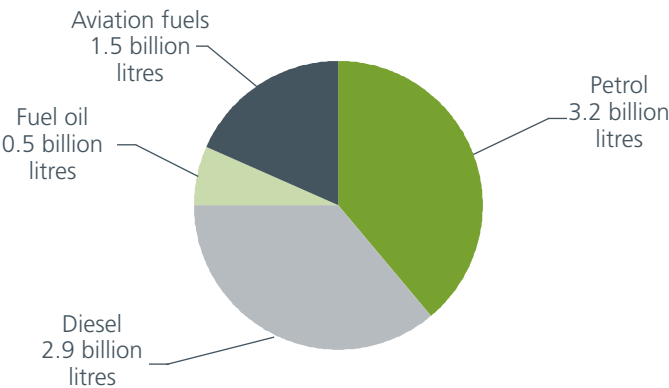
4.2 Biofuels that can be scaled up

Currently New Zealand uses about eight billion litres of liquid fuels a year [Figure 4.1].³² For biofuels to make any significant difference to New Zealand's greenhouse gas emissions, the volume sold will eventually have to substitute for a very large volume of fuel – hundreds of millions, preferably billions, of litres. This demand for scale has a number of implications.

It must be possible to get large quantities of feedstock. It makes excellent sense to turn used cooking oil into biodiesel, but there will never be significant quantities available.

An advantage of producing biofuels in very large quantities is that processing usually becomes cheaper because of economies of scale. However, *collecting* biomass may become more expensive as larger quantities are needed from bigger areas.

Figure 4.1 New Zealand's liquid fuel use in 2009



Calculated from fuel consumption data published by the Ministry of Economic Development.

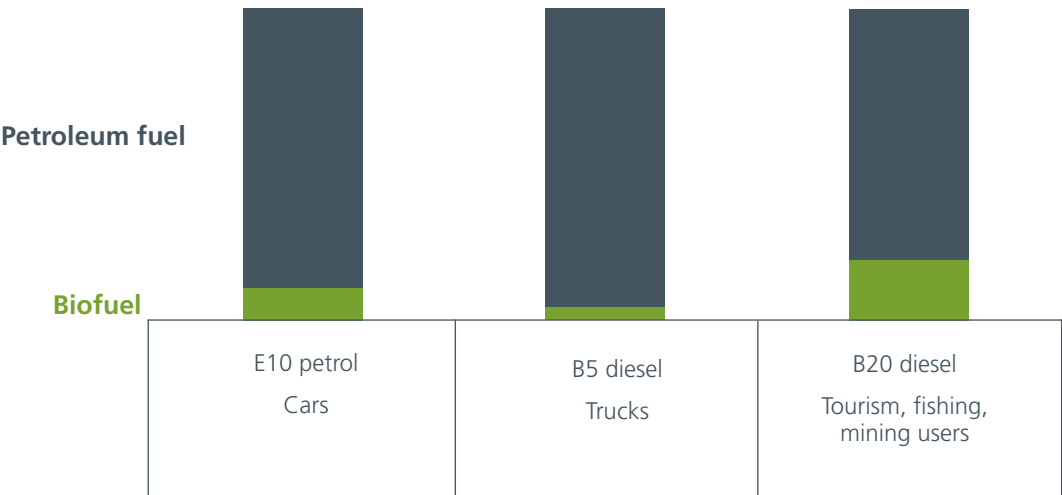
Box 4 Biofuel blends

A common shorthand is used for describing blends of biofuels and petroleum fuels. (See figure 4.2).

E10 is a fuel that is ten percent ethanol and 90 percent petrol.

B20 is a fuel that is 20 percent biodiesel and 80 percent petroleum diesel.

Figure 4.2 Biofuel blends and their uses



4.3 Biofuels that can be “dropped in”

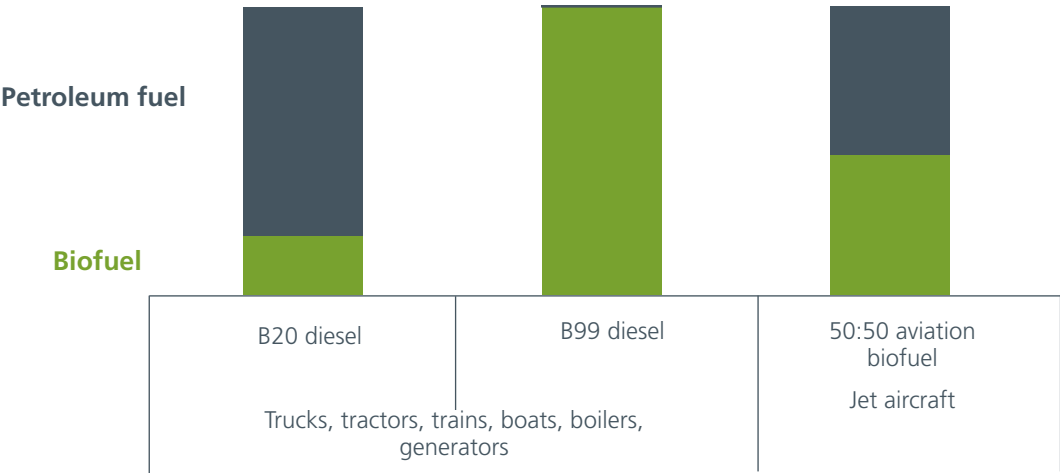
It is not enough to produce large quantities of biofuels; it must also be possible to sell large quantities.³³ Some biofuels are quite different from petroleum, and are not necessarily compatible with the existing distribution network or with vehicle engines.

Consumers require that a given blend works for every vehicle, every time.³⁴ Biofuels that only work in specially modified vehicles are of limited value. And if a biofuel can be used only in low-percentage blends, it can never substitute for a large percentage of demand. For such biofuels, there are practical limits, known as “blend walls”.

Figure 4.2 shows some typical biofuel blends and their uses, illustrating how much biofuel they actually contain. Clearly, E10 or B5 can never be much better for the environment than straight petroleum or diesel.

It is not practical to replace entire vehicle fleets or distribution networks. Ultimately, to be used on a large scale, biofuels must be “**drop-in**” – so similar to petroleum

Figure 4.3 Drop-in biofuels and their uses



fuels that they can readily be mixed together in any proportion, or not mixed at all. [Figure 4.3]

4.4 Biofuels that substitute for diesel

World demand for oil is growing, while production is slowing as good quality conventional oil resources are increasingly expensive to find and extract. Crude oil is still relatively cheap, but this cannot last much longer.^{35,36}

New Zealand still imports virtually all its liquid fuels.³⁷ Domestic crude oil production has expanded, but is not nearly enough to meet local fuel demand. Moreover, New Zealand crude oils are generally too light and waxy to make good aviation fuel or diesel.³⁸ So New Zealand’s liquid fuel bill will certainly increase again, and there may be security of supply difficulties. Replacing imported fuel with locally produced biofuels would reduce this risk.

Biodiesels would be particularly useful because our economy is critically reliant on diesel.^{39,40,41} Virtually all land freight is moved by diesel, whether carried by truck or train. Freight is essential for getting export produce to ports and, for that matter, for feeding our cities. Road freight volumes have been predicted to increase by more

than 70 percent over the next 20–30 years.⁴² Most public transport runs on diesel.

It is not just trucks, trains, and buses that rely on diesel. One-third of the diesel sold in 2007 was used for purposes other than carrying freight and public transport. Fishing boats, agricultural machinery, and forestry, construction, and mining equipment run on diesel. The Whirinaki power station, which provides reserve electrical generation, is diesel-fired. So are small back-up generators, off-grid generators in remote locations such as Stewart Island and the Chatham Islands, and some heating. Consequently, diesel use is difficult to reduce.

In contrast, petrol has only one major use – moving cars. The demand for petrol is more flexible – making fewer trips, making trips with more passengers, switching to more fuel-efficient vehicles, reducing speed, using public transport, cycling, and walking are options available to motorists.⁴⁴ Electric cars are showing promise and may also be alternatives in future.⁴⁵ A 30 percent petrol price spike in 2008 caused many car owners to change their behaviour significantly.⁴⁶

4.5 Biofuels that are good for the economy

Innovative biofuel technologies could be a good investment. Recent International Energy Agency estimates are that US\$10 *trillion* will need to be invested in low-carbon energy technologies, such as biofuels, by 2030 if the atmospheric carbon dioxide concentration is to be kept to 450 parts per million long term. Crude oil sales are currently worth about US\$3 trillion a year. A new commercial process that captured even one-tenth of 1 percent of these markets would be worth billions of dollars annually.

Innovation is at the core of our future prosperity.⁴⁷ And when it comes to environmental goods and services, New Zealand currently has a competitive edge.⁴⁸ The “Mills Group” of about 50 leading New Zealand businessmen, including green investor Sir Stephen Tindall and Air New Zealand CEO Rob Fyfe, believe New Zealand could create an export industry in environmental goods and services that would provide tens of thousands of jobs and be worth tens of billions of dollars by 2018.⁴⁹ Biofuel technologies could certainly be part of this vision.

Aviation biofuels would also be particularly helpful for the tourism industry. There is already widespread concern about the environmental impacts of international air travel, especially to such a distant destination as New Zealand.

New Zealand food exporters are also under increasing pressure to prove high environmental performance, especially by the “new regulators”, the huge European and American retail chains.⁵²

5

Biofuels in New Zealand today

Only two types of biofuel are currently being used in New Zealand. Ethanol is used in low-percentage blends with petrol, and FME biodiesels are blended with diesel. This chapter considers the potential of these two established technologies in New Zealand in relation to:

- Environmental performance, especially greenhouse gas emissions reductions
- Production limitations
- Vehicle fleet limitations.

5.1 Ethanol

About two million litres a year of fuel ethanol is currently sold in New Zealand by Gull⁵³ and Mobil – about 0.06 percent of petrol sales. This comes from two sources:

- Whey ethanol made by Anchor Ethanol, a by-product of New Zealand's dairy industry
- Sugarcane ethanol imported from Brazil.

Environmental performance

Whey ethanol offers life cycle greenhouse gas emissions about 25 percent less than those of petrol. As whey is a by-product of food production rather than a crop, its use supports food production and avoids waste.

Currently, Brazilian sugarcane ethanol has life cycle greenhouse gas emissions about 75 percent less than those of petrol, and does not appear to be a threat to the Amazon rainforest.^{57,58} It also does not appear to be having adverse effects on food production. However, water and air quality are being downgraded by sugar processing in some areas, and rapidly expanding sugarcane plantations pose a direct threat to Atlantic forest and cerrado (savannah) ecosystems. The Brazilian sugarcane industry has also been severely criticised for its performance on social issues, including labour conditions and land rights abuses.⁵⁹

Production limitations

Ethanol, the “ordinary” alcohol found in wine and beer, is made by fermenting and distilling feedstocks that contain sugar and starch. In New Zealand, the principal feedstock for ethanol manufacture is whey, a by-product of the dairy industry.

The potential production of whey ethanol is small and fluctuates seasonally. Currently, only about 20 million litres a year of whey ethanol can be produced.⁶⁰ This could probably be doubled with little adverse environmental impact, but would still not meet even one percent of New Zealand's petrol demand. No other readily fermentable low-value materials are currently available in quantity in New Zealand, let alone year-round.

More ethanol could be imported. But that increases the risk of adverse environmental impacts in other countries and does little to improve security of supply.

New Zealand could also convert agricultural land to growing fermentable crops such as beets or maize. Growing fuel crops on less valuable hill and high-country land is not an option because yields would be poor, and on steep land the crops could not be harvested. In principle, crops on good land could yield billions of litres of ethanol a year. However, this land use change would demand more fertiliser, water, pesticides, and diesel, and it would displace current food production.

Vehicle fleet limitations

The current light vehicle fleet can use ethanol only in low-percentage blends. The petrol blends sold by retail can contain 10 percent ethanol at most (E10), and most manufacturers will not warrant vehicles to use higher blends.

This is because ethanol and petrol are rather different. In ordinary petrol engines, high-ethanol blends can cause swelling and failure of some rubber seals and lines. Ethanol's combustion properties are different too. And, unlike petrol, ethanol mixes readily with water. To avoid fuel separation problems, distributors must transport ethanol separately and blend it as late in the petrol supply chain as possible.

Despite these concerns, Gull and Mobil have now made hundreds of thousands of sales of low-percentage ethanol blends, virtually without incident.^{64,65}

Still, because ethanol can be used only in low-percentage blends, it can make only a very small difference to greenhouse gas emissions from light vehicles. Low-percentage blends also impose a "blend wall" on ethanol – it is not possible to use more than about 300 million litres a year at current petrol consumption.⁶⁶ Clearly ethanol can only play a minor role in fuelling our cars for the foreseeable future.

5.2 Biodiesel

About one million litres a year of FME biodiesel is currently sold in New Zealand.⁶⁷ All of this biodiesel is produced in New Zealand by several companies using established technologies and local feedstocks:

- Inedible tallow from meat processors
- Locally grown canola oil
- Used cooking oil.

The methanol used to produce these fuels is made in New Zealand from natural gas.

Environmental performance

FME biodiesel made from inedible tallow has about half the life cycle greenhouse gas emissions of petroleum fuel. It is a by-product so does not threaten food production or conservation.⁶⁸

FME biodiesel from canola generally offers even better emissions reductions than tallow, provided the canola is grown as a break crop. It helps condition soil, cleans up carry-over diseases of the primary cereal crops, and, after oil extraction, the residual meal can be sold as animal feed.⁶⁹

However, the environmental impact of canola depends on how it is farmed. Cross-pollination by canola could degrade valuable seed crops of related brassica species, such as broccoli.⁷⁰



Canola in bloom. Courtesy of Finn Traalle Jacobsen

Production limitations

New Zealand produces enough inedible tallow a year for approximately 100 million litres of FME biodiesel – three percent of current diesel demand.⁷¹ However, much of this tallow is currently exported, mostly to China.

Using canola grown as a break crop in grain farming, New Zealand might produce another 20 million litres of FME biodiesel.⁷² Only small quantities of used cooking oil are available.

Methanol, the other component of FME biodiesels, is not currently a limiting factor.⁷³

Processing capacity is currently very limited. However, there are several plans for commercial-scale biodiesel production in New Zealand. Biodiesel NZ has the option to expand into a new facility producing up to 70 million litres a year.⁷⁴ Ecodiesel's 40 million-litre-per-year facility in Auckland is under construction and is expected to be completed this year.⁷⁵

Still, in today's mature fuel market, building biofuel processing plants presents significant commercial challenges. These include:

- Obtaining capital while the international crude oil price is volatile and the domestic regulatory environment is uncertain
- Securing supply chains and a ready customer base
- Meeting demanding technical specifications while keeping biofuels economically competitive.

The commercial prospects of FME biodiesels have been improved by the introduction of potential government support through the Biodiesel Grants Scheme. But because the scheme is only guaranteed through to June 2012, it is unlikely to incentivise investment in large new processing plants.

Vehicle fleet limitations

Heavy vehicle manufacturers usually support the use of FME biodiesel only in low-percentage blends. The *Engine Fuel Specifications Regulations 2008* limits the FME content of diesel blends sold by retail to no more than B5.

Some manufacturers may require even higher technical specifications than the New Zealand regulations.⁷⁸ These stringent requirements demand tight quality control and can be technically impossible to meet for some FMEs, particularly those based on used cooking oil. However, FME biodiesels may have some advantages over petroleum diesel – for instance, a very low sulphur content and better lubricating properties.

Although the B5 restriction creates a blend wall for retail sales, the limitation does not necessarily apply to commercial users. Some businesses see advantages in higher percentage blends and purchase biodiesel blends directly from the producers [see Box 5].

Large commercial customers may have fewer engine warranty problems than private vehicle owners. They are more likely to do their own engine maintenance, and they may have access to more tolerant engines warranted for higher blends.⁸⁰ However, many of these potential biodiesel customers will have been discouraged because, until recently, the Biodiesel Grants Scheme only supported biodiesel blends of up to B20.

Box 5 Environmentally “savvy” consumers

Otago Polytechnic’s Centre for Sustainable Practice recently opened a commercial refuelling station in Queenstown, supplied by Allied Petroleum and selling a B20 blend of Biodiesel New Zealand’s canola FME.

Thirty local businesses have signed up for a 12-month pilot, including tourism operators such as Nomad Safaris, Kiwi Discovery and Queenstown Rafting, Dart River Jet Safaris, Shotover Jet, Ziptrek Ecotours, and Appellation Wine Tours.⁸¹

Some off-road uses, such as boilers, may not need high-specification fuels. It is likely that lower specification fuels could be made more easily and sold more cheaply, a win–win proposition for some biofuel producers and prospective consumers. But the Biodiesel Grants Scheme offers no support for lower specification fuels.

5.3 Today’s biofuels will not take us far

Today’s biofuels are considerably better for the environment than petroleum fuels [Figures 5.1-5.3], but their potential is limited.

Figure 5.1 shows typical reductions in greenhouse gas emissions over the life cycle of ethanol from whey and sugarcane, and biodiesels from tallow and canola. These reductions are in comparison to petrol and diesel, which therefore appear as zero on the figure.

Figure 5.2 shows the ratio of energy in each fuel to the energy used in growing the feedstock (or extracting the crude oil) and processing them into fuels – a high value means a good return on energy invested.

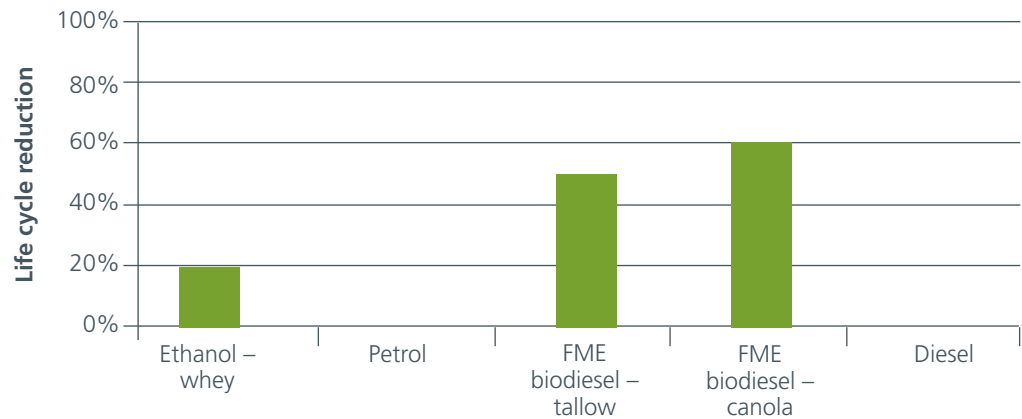
Figure 5.3 shows potential domestic production of each fuel. The potential for ethanol from whey is so low that it appears as zero. The same applies to biodiesel from canola grown as a break crop.

There simply are not enough fermentable materials or vegetable oils available in New Zealand to make significant quantities of traditional biofuels. Moderate quantities of FME biodiesel could be made from tallow if more processing capacity can be constructed.

More ethanol or FME biodiesel could be made by turning good agricultural land over to energy crops such as beets, maize, or canola. However, the requirements of the current vehicle fleet would still limit the amounts of ethanol and FME biodiesel that could be used.

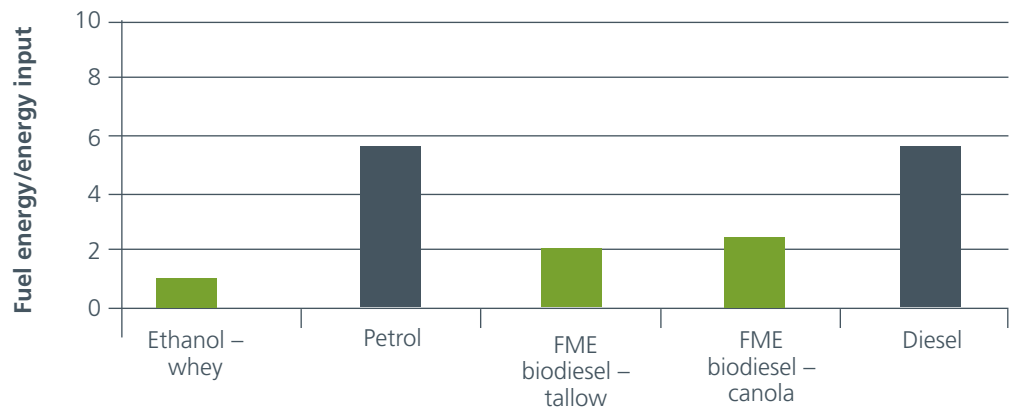
If biofuels are to reach any substantial proportion of the New Zealand fuel market, more plentiful feedstocks for making more compatible “drop-in” fuels are needed.

Figure 5.1 Today’s biofuels – greenhouse gas emissions reductions



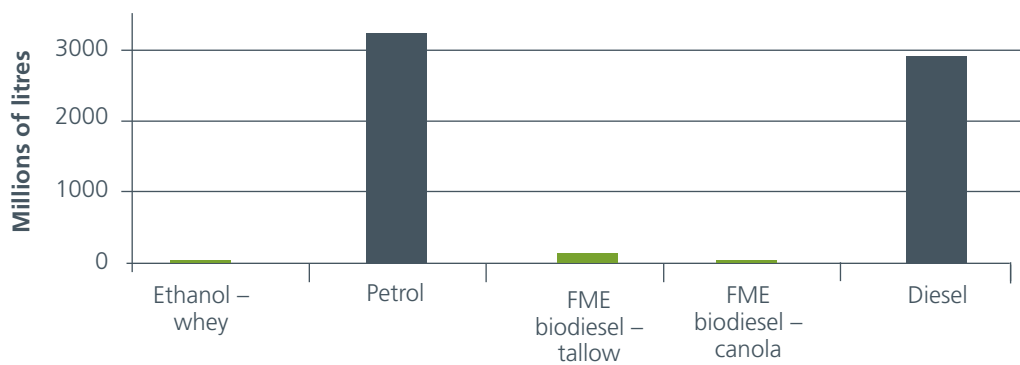
These values are comparisons to typical petroleum fuels used in New Zealand.

Figure 5.2 Today’s biofuels – energy requirements



These ratios compare the energy contained in fuel, to the external energy consumed in growing the feedstock (or extracting the crude oil), converting it into fuel and shipping it to New Zealand.

Figure 5.3 Today’s biofuels – potential production and demand



These are domestic production estimates compared to 2008 fuel consumption. It is assumed that canola is grown only as a break crop.

All values shown in these figures are estimates for typical products and depend on assumptions made in the underlying life cycle analyses.

6

Biofuels in New Zealand tomorrow

Today's biofuels in New Zealand use established technology to process low-value agricultural products. But supplies of these feedstocks are limited, and the biofuel products are poorly compatible with the vehicle fleet.

The first four sections of this chapter surveys biofuels under development namely:

- Ethanol from wood and waste gases
- Drop-in biodiesels and aviation fuels from fats and oils
- "Green crude" from algae
- Synthetic fuels from wood.

Greenhouse gas emissions reductions, energy requirements and potential production of each of these fuels are presented in Figures 6.1, 6.2, and 6.3.

In the fifth section, the problem of reaching commercial scale is discussed. In the final section of this chapter, the question of whether biofuels produced from feedstocks grown in New Zealand can play a big role in our energy future is addressed.

6.1 Ethanol from wood

Crown research institute Scion and others are pursuing "cellulosic" ethanol, made by digesting and fermenting woody materials. Cellulosic ethanol has attracted billions of dollars in investment in the United States and Canada, and commercial-scale facilities are already being constructed.⁸⁶ By adapting American enzyme technology to New Zealand feedstocks and putting some effort into collecting wood, cellulosic ethanol is technically feasible here. A 90 million-litre plant in the central North Island has been proposed, although it would not presently be economic.⁸⁷

New Zealand's 1.8 million hectares of plantation forest could be a huge source of biomass for feedstock. These forests do not require intensive fertilisation, irrigation, or cropland.

There are also large areas of marginal hill country into which forestry could be expanded, so long as road access is feasible. New forests would have other benefits for the country, such as storing carbon dioxide, reducing erosion, and improving water quality.⁸⁸

Cellulosic ethanol technologies also work on hardy, productive grasses such as miscanthus⁸⁹ and switchgrass.⁹⁰ These could be grown as fuel crops, potentially producing more fuel than traditional fuel crops, with much less need for fertiliser, water, or pesticides. Willow pioneer Biojoule showed that coppiced willows could also fill this role,⁹¹ and developed technology for separating the various components of willow wood.

However, in New Zealand all these cellulosic feedstocks have competing uses, such as heating,⁹² co-generation of electricity at wood-processing facilities, and manufacture of wood pellets.⁹³

LanzaTech are developing a bacterial process to produce ethanol from carbon monoxide-rich gases. Whether this is technically a biofuel or not depends on the source of the gases. LanzaTech's pilot plant uses flue gas from the Glenbrook steel mill, but the technology could be applied to gasified biomass.⁹⁴

Although much larger quantities of ethanol could be produced in New Zealand, the E10 blend wall is still a restriction. And ethanol supplements petrol, which has less strategic importance than diesel.



Courtesy of Ministry of Agriculture and Forestry

6.2 Drop-in biodiesels and aviation biofuels

If vegetable oils such as canola and animal fats such as tallow are reacted with hydrogen, biofuels that do not need to be blended with conventional fuels can be produced. These drop-in fuels are called hydrogenated renewable diesels (HRDs) and hydrotreated renewable jet fuels (HRJs).⁹⁵

HRDs have been produced by Finland's Neste Oil since 2007⁹⁶ and, more recently, by Brazil's Petrobras.⁹⁷ Neste Oil has two 200 million litre per year HRD biodiesel plants in Finland, and expects to open a 900 million litre per year palm oil HRD biodiesel plant in Singapore at the end of 2010. HRJs have been made from

vegetable oils. Air New Zealand conducted one of the first commercial aviation biofuel test flights at the end of 2008, powering one engine of a 747 on a 50:50 mix of ordinary jet fuel and an HRJ biofuel for two hours. The fuel used in this trial was made from jatropha oil, which does not appear to be a suitable feedstock for New Zealand.⁹⁸

Because they are made from oils and fats, these drop-in fuels are subject to the same feedstock constraints as FME biodiesels.⁹⁹ And, if they were to be made in large quantities in New Zealand, the cheapest feedstock might well be imported palm oil.

Nonetheless, drop-in HRD biodiesels would be better biofuels to make from tallow than the FME biodiesels currently made in New Zealand, although presumably they would be less economic. The Biodiesel Grants Scheme applies only to FME biodiesels, so it does not support HRD biodiesel or “green crude” (discussed below).

6.3 “Green crude” from algae

Algae have become promising candidates as fuel crops. Indeed, the petroleum on which we rely today began as vast quantities of dead algae, buried deep in marine sediments.

These microscopic plants contain oils and, with skill and practice, can be grown very fast year-round in equatorial or temperate countries. Also, algae grow in dirty water, not in good agricultural soil.

However, there are major problems with algae as fuel crops. It has so far been difficult to efficiently collect algae and extract their oil. Although certain laboratory strains can have very high oil content, these strains do not survive in open ponds.

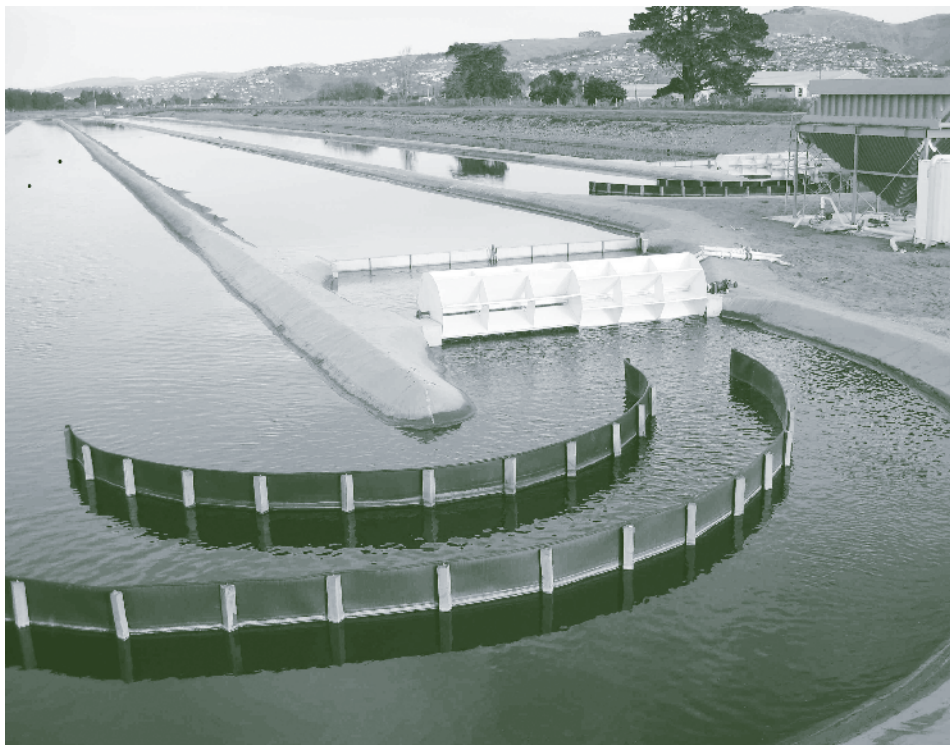
Two New Zealand groups are working on these problems. They harvest algae without drying or extracting the oil, and process them whole at high temperature and pressure, doing in minutes what geology does in millions of years. The resulting green crude can be refined into drop-in biodiesel and other fuels, and can even contain a bitumen-like fraction.

Solray and NIWA are making biodiesel from algae grown in Christchurch’s waste water. Ponds at the Bromley waste treatment plant grow large quantities of wild algae. To maximise yields, algae need to be fed large quantities of fertilisers and concentrated carbon dioxide. The algae in the Bromley ponds are fertilised by the phosphorus and nitrogen in the sewage. Carbon dioxide from burning the biogas from the plant’s sludge digesters is pumped into the water.¹⁰⁰

Aquaflow Bionomic are also using algae to clean up discharges from oxidation ponds in Marlborough and the Bay of Plenty. Their biocrude has been transformed into aviation biofuel by a US partner.¹⁰¹

Making biofuel from algae holds the promise of helping to improve water quality by removing excess nitrogen and phosphorus, essentially growing useful algae instead of pest algae. Algae ponds may offer cleaner water than conventional sewage treatment, at lower cost. The solid residue from green crude production contains all the nitrogen and phosphorus taken up by the algae, so would make an excellent fertiliser. Complex chemicals in the waste water, such as pesticides or hormones, should be destroyed in the process.¹⁰²

A key disadvantage is that, to be highly productive, algae ponds must be shallow, which means that they must cover large flat areas. It has been estimated that three hectares of algae ponds per thousand cows would be enough to clean up dairy shed effluent. However, the effluent from piggeries, dairy sheds, freezing works, and so on could be used to produce biogas for heat and power at the same time.



Courtesy of NIWA. High rate algae pond, Christchurch

6.4 Synthetic fuels from wood - the way ahead?

Technologies to transform cellulosic (woody) feedstocks into drop-in liquid fuels will soon be available in New Zealand. Information in the public domain on these technologies is limited. The technologies include:¹⁰³

- The Fischer–Tropsch process, which will soon be used in commercial-scale biofuel projects in Germany,¹⁰⁴ the United Kingdom,¹⁰⁵ and potentially Sweden.¹⁰⁶ Solid Energy¹⁰⁷ and L&M Mining¹⁰⁸ are considering using the Fischer–Tropsch process to make synthetic fuels from lignite in New Zealand. This would increase carbon dioxide emissions rather than reducing them.
- Supercritical water processing and hydrogenation, similar to the process used to turn algae into green crude. A consortium of firms, including Ignite Energy and Methanex, has recently proposed introducing this technology to New Zealand. But, like the Fischer–Tropsch process, if this technology is used to process lignite, the resulting fuel would not be *biofuel*.¹⁰⁹

Because significant quantities of biodiesel could be made from wood in New Zealand using the Fischer–Tropsch process, two peer-reviewed studies were commissioned. These appear as Appendix A and Appendix B on the website www.pce.parliament.nz:

- An analysis of potential wood supply to specific sites, by Scion. Study sites were Kawerau in the central North Island, close to New Zealand’s largest plantation forests, and Maitua in Southland, close to one of New Zealand’s largest lignite resources.

- A feasibility study for a wood-to-biodiesel plant using the Fischer–Tropsch process, by CRL Energy.

The Scion analysis indicates that for a price of up to \$85 per cubic metre, about 6,000 dry tonnes of low-quality wood a day could be delivered to Kawerau.¹¹⁰ For Mātaura, however, wood resources will be very scant for the foreseeable future. There are other wood resources elsewhere around the country and still greater yields could be obtained with new plantations and energy crops.

The CRL Energy analysis suggests that a Fischer–Tropsch plant processing 6,000 dry tonnes per day could produce about 1 million litres a day of unrefined synthetic biofuel. The majority of this would be high-quality diesel, enough for 10 percent of New Zealand’s 2008 diesel consumption.

Taking the Scion and CRL Energy studies together, it appears that a useful quantity of high-quality diesel could be produced from low-quality wood, at a cost of about \$1.85 per litre [Figure 6.4].

The process also makes co-products such as unrefined aviation biofuel along with the biodiesel. Taking the revenue from their sale into account would effectively reduce the *production* cost of the biodiesel below \$1.85 per litre.

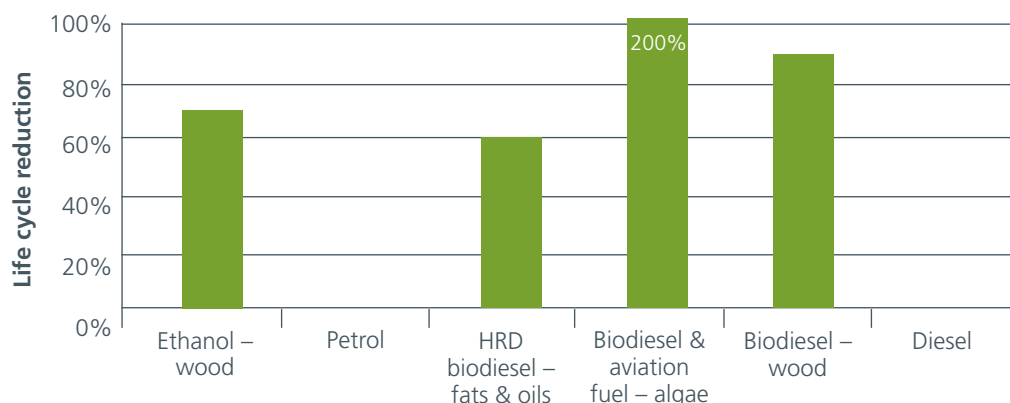
Figure 6.4 Production cost of a litre of drop-in biodiesel from wood

	Contribution to cost (NZ dollars)
Growing wood	\$0.44
Logging	\$0.54
Hauling wood	\$0.50
Chipping	\$0.07
Feedstock total	\$1.55
Capital repayment	\$0.11
Maintenance	\$0.08
Labour	\$0.03
Gas cleaning	\$0.01
Electricity	\$0.07
Processing total	\$0.30
Production cost	\$1.85

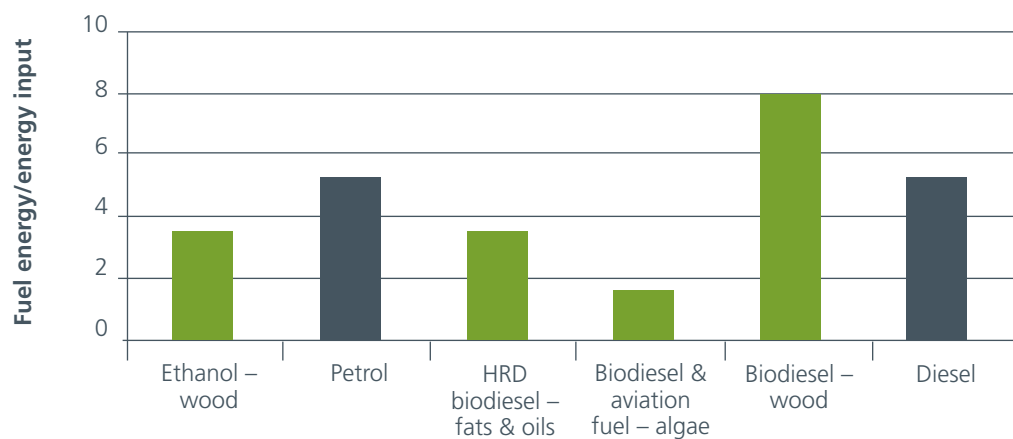
These costs are based on assumptions and calculations in Appendices A and B.

The model envisages a plant using the Fischer-Tropsch process converting 6,000 dry tonnes of low quality wood per day into approximately 800,000 litres per day of high-quality diesel. The costs of growing, logging and hauling wood will vary substantially depending on plantation management, logging method and distance from the site. The plant’s capital cost is estimated at \$900 million, with an annual interest rate of ten percent.

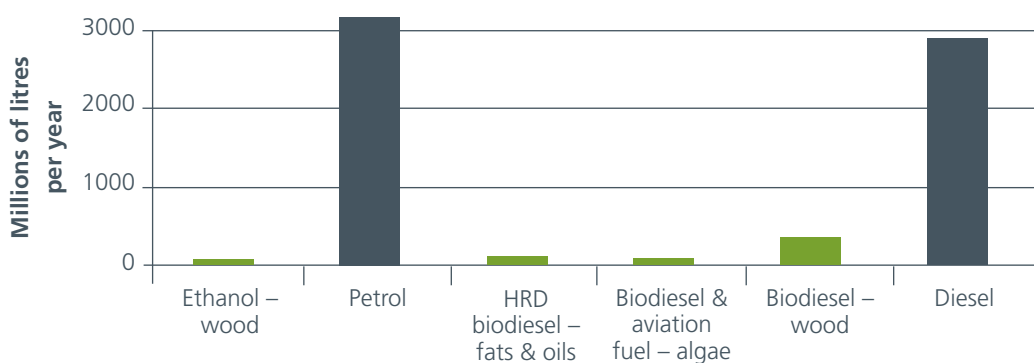
As a production cost, this estimate does not include manufacturer and retailer profit, transport to point of retail sale, or sales taxes, so the pump price would be higher.

Figure 6.1 Developing biofuels – greenhouse gas emissions reductions

These values are comparisons to typical petroleum fuels used in New Zealand. For biodiesel from wood, trucks and equipment are assumed to run on biodiesel.

Figure 6.2 Developing biofuels – energy requirements

These ratios compare the energy contained in the fuel, to the external energy consumed in growing the feedstock (or extracting the crude oil), converting it into fuel and shipping it to New Zealand.

Figure 6.3 Developing biofuels – potential production and demand

These are domestic production estimates compared to 2008 fuel consumption. Wood values are proposed sizes for a single plant in the Central North Island. Algae value assumes $\frac{1}{3}$ of large wastewater sources treated by algae ponds.

All values shown in these figures are estimates for typical products and depend on assumptions made in the underlying life cycle analyses.

6.5 Getting over the commercialisation hurdle

Reaching commercial scale is a major issue for existing biofuel technologies. It is *critical* for advanced biofuels projects, which face even greater commercial risks because their technology is new. This amounts to a catch-22 situation: in order to persuade commercial investors to fund construction of a large-scale production facility, developers need to have a working large-scale production facility. Access to public capital is probably vital if advanced biofuels are to become commercially viable. Recognising this need, the United States Government has put several hundred million dollars into constructing advanced biofuel production facilities.

If the Government were to support advanced biofuels over the commercialisation hurdle, it could ensure that the intellectual property remains in New Zealand. It is hard to imagine that this will be the outcome if commercialisation is driven by foreign investment. Already, a Singapore company, Pure Power Global, has acquired Biojoule and a stake in Aquaflo Bionomic.¹¹² LanzaTech's majority shareholder is a California company, and they have recently signed a commercialisation agreement with China's largest steel and iron company and the Chinese Academy of Science.¹¹³

The Government has already invested substantial sums in biofuels research. The Foundation for Research Science and Technology has supported all of the innovative biofuels mentioned here, and it currently supports nine biofuel research projects with grants totalling about \$41 million.¹¹⁴ The Ministry of Agriculture and Forestry and the Energy Efficiency and Conservation Authority have also put money into supporting biofuels and their feedstocks.

But, at present, access to capital is a serious constraint for bioscience organisations in New Zealand.¹¹⁵ Public, and indeed private, investment in research, development, and commercialisation is well below the OECD norm.¹¹⁶

Currently, the principal source of public funding for commercialisation is New Zealand Trade and Enterprise. It is supporting three biofuel projects toward commercialisation, with grants totalling just \$340,000 for the year ending June 2010.¹¹⁷

6.6 Can biofuels play a big role in our energy future?

Imagine that whey ethanol, tallow, and canola biodiesels, algae green crude, and even one cellulosic ethanol plant all reach commercial-scale production. New Zealand would then be producing more than 100 million litres of ethanol and 200 million litres of biodiesel and aviation biofuel a year [Figures 5.2, 6.2]. This is still only a few percent of New Zealand's fuel demand, currently running at more than 8 billion litres a year. Fundamentally, there are just not enough biomass residues, by-products, and wastes in New Zealand.

Meeting a significant part of New Zealand's current liquid fuels demand will take much more ambitious solutions, capable of producing millions of litres of drop-in liquid fuel per *day*. To produce biofuels in this quantity would require millions of tonnes of feedstock per year.

Only New Zealand's plantation forests are currently big enough to produce biomass on anything like this scale. Growing hardy, productive grasses is a possibility, but that would take up cropland and have adverse effects on food production. Traditional fuel crops such as canola or maize would present even more problems, as they require fertiliser and irrigation.

Making plantation forest into diesel requires new synthetic fuel technologies. The current front runner is Fischer–Tropsch processing of low-quality wood from existing managed plantation forests. It would need a huge wood collection area, which means high haulage costs. The processing plant would need to be located near New Zealand’s largest forests, in the central North Island.¹¹⁸ And the Fischer–Tropsch process does not get a lot of fuel out of the wood. To be economic in the near future, a wood-to-diesel technology would need to work at a smaller scale and a higher efficiency.

While it is too early to pick winners, there are encouraging signs that better processes will be found. Swedish engineers have predicted that they can make Fischer–Tropsch aviation biofuel from wood that is cheaper than buying petroleum jet fuel. The Ignite Energy process promises to be modular, so it should be able to work at smaller scales. Ignite’s process offers opportunities to liquidise wood near the point of harvest, making it easier to haul large quantities of wood.



Courtesy of Ministry of Agriculture and Forestry

Conclusions and recommendations

New Zealand is well placed to grow biomass and produce biofuels. We have abundant natural resources within our farming and forestry sectors and an innovative science and engineering community. Our point of difference in a competitive world is our clean green image; fostering biofuels would support this.

Biofuels made from whey and tallow have been sold in New Zealand for some time. Gull and Mobil have sold low-percentage ethanol blends virtually without a hitch. Small trials of biodiesel blends by Mobil, Biodiesel NZ, and others have also been successful.

Still, today's biofuels have limited prospects. There simply are not enough fats, oils, and fermentable materials in New Zealand to make large volumes of biofuels. And our current vehicles can only use today's biofuels in low-percentage blends. Today's biofuels should still be encouraged – their producers have taken biofuels beyond the laboratory, and much has been and is being learned.

Importing “bad” biofuels grown at the expense of rainforests and food production in the developing world is no solution.

Biofuels do have the potential to make a real difference – to substantially reduce greenhouse gas emissions, to improve fuel security, and to make our economy cleaner and greener. This report has focused on how we might do this and concludes the following.

- We should produce biofuels that benefit the environment. Unless biofuels reduce greenhouse gas emissions, there is little point in producing them.
- We should plan to invest in biofuels that can be produced in large quantities. The only source of biomass large enough in New Zealand is wood, although grasses and algae could also play significant roles.
- We should focus on biodiesel rather than ethanol for two reasons. First, substituting for diesel is more important than substituting for petrol because of the role diesel plays in our economy. Second, biodiesels can be produced as drop-in fuels, so blending is not necessary.

7.1 The Sustainable Biofuel Bill

The Sustainable Biofuel Bill 2009 seeks to ensure that biofuels supplied or sold in New Zealand comply with three sustainability principles. If enacted, the Bill would require suppliers to prove that their biofuels reduced greenhouse gas emissions and did not adversely affect food production or conservation values.

I support the Bill's intent of ensuring that the biofuels we use in New Zealand are "good" biofuels. But it is not workable. It would impose its environmental standards only on biofuel production and not on other land uses or other fuels. And I do not see any credible, cost-effective means of monitoring compliance offshore.

I recommend that:

- 1. The Local Government and Environment Select Committee recommends to Parliament that the Sustainable Biofuel Bill 2009 does not proceed.**

7.2 Importing "bad" biofuels

There is no question that much of the biofuel grown in developing countries is environmentally and socially damaging. It is why many European environmentalists are opposing biofuel obligations despite the incorporation of sustainability criteria.

It is difficult to see how New Zealand could prevent the import of biofuels, whether they are "good" or "bad", under current trade policy. New Zealand is unusually diligent about complying with WTO rules because it is a small open economy that relies heavily on trade.

The International Standards Organisation has begun work on a standard, *Sustainability criteria for biofuel*, but it will be some time before it is completed, let alone widely adopted and enforced internationally.

Biodiesels qualifying for the Biodiesel Grants Scheme only have to be manufactured in New Zealand; the feedstocks they are made from can come from anywhere. Reportedly, no manufacturers currently obtaining support from the Scheme are using imported biomass as feedstock. However, there is nothing to prevent New Zealand taxpayers subsidising the production of biodiesel from imported feedstocks such as palm oil, and thus subsidising the felling of tropical rainforests. This is a classic example of what policy analysts call a perverse outcome.

There are no indications that "bad" biodiesels are being subsidised under the Biodiesel Grants Scheme. But, should this happen, it appears that the only way of preventing it, given current trade policy, would be to discontinue the scheme.

I recommend that:

- 2. The Minister for the Environment:**
 - **directs officials to monitor the biomass feedstocks used by companies receiving support under the Biodiesel Grants Scheme, and**
 - **recommends to Cabinet that the Scheme is discontinued if taxpayers are subsidising environmental and social damage in developing countries.**

7.3 Encouraging biofuels

The Biodiesel Grants Scheme is not as effective as it could be. Only a very small proportion of the available financial support is being taken up. Modifying the scheme in a number of ways could help.

One such modification has recently occurred. “Clean green” branding opportunities are valuable to the tourism and agriculture sectors. But no amount of low-percentage biofuel blends will substantially reduce a user’s carbon footprint. The Biodiesel Grants Scheme was limited to biodiesel blends not exceeding B20. Commendably, the Minister of Energy and Resources has recently removed the arbitrary B20 barrier, allowing qualifying biodiesels to be sold in any blend up to B100.

The Scheme requires qualifying fuels to meet the *Engine Fuel Specifications Regulations*. These regulations have been developed for petroleum-based diesel and do not cover problems with some biodiesels, such as long term stability of the fuel. If biodiesels to be used for transport were to meet higher standards, there might be more demand.

On the other hand, some diesel users do not need high-specification fuel, especially for stationary engines such as boilers and generators. They might well switch to biodiesel given the opportunity. Biodiesels that cannot readily meet transport specifications may be good fuels for these purposes. The scheme could subsidise these lower specification biodiesels.

The Biodiesel Grants Scheme covers only FME biodiesels. This discourages future production of more desirable drop-in biodiesels, such as HRD biodiesels or algae biodiesel.

The Biodiesel Grants Scheme is guaranteed through to only June 2012. This is not a long enough horizon to encourage investment in production facilities.

I recommend that:

3. The Minister of Energy and Resources modifies the Biodiesel Grants Scheme in the following ways:

- Requiring biodiesels to be used for transport to meet higher specifications**
- Providing partial subsidy for low-specification biodiesel for uses such as boilers and generators**
- Allowing biodiesels other than fatty acid methyl esters to qualify for support**
- Guaranteeing the Scheme beyond June 2012**

The Biodiesel Grants Scheme alone is not capable of helping innovative biofuel technologies get from development to a sound commercial footing. It should be remembered that the New Zealand petroleum industry received very substantial government support during its development.

7.4 Large scale biofuel production

In recent months, several companies have proposed to produce synthetic fuels in New Zealand on a very large scale:

- Solid Energy has plans for producing Fischer-Tropsch diesel from lignite at Maitua in Southland
- L&M Mining unveiled similar plans for the Hawkdun lignite deposit in Otago
- Ignite Energy, Methanex and others have presented a scheme for making synthetic fuels at Motunui in Taranaki using novel proprietary technology.

These projects would undoubtedly increase domestic fuel production. But if the feedstock is lignite, they will not reduce our greenhouse gas emissions or enhance our 'clean green' image. In fact, they will increase our greenhouse gas emissions, unless many trees are planted to sequester carbon dioxide or the capture and storage of carbon dioxide underground becomes feasible and economic.

These synthetic fuel plants could produce biodiesel using wood as feedstock. This would mean having access to large plantation forests. Wood supply near Maitua will not be adequate for this purpose in the foreseeable future. But it would be possible to transport processed biomass to Motunui by sea and perhaps rail.

It is clear that it will be challenging for these technologies to be economic using wood. But this may well change. If New Zealand is to produce really substantial amounts of biofuels for transport, drop-in biodiesel from wood should be the main target.

Solid Energy is a state-owned enterprise and when it invests in infrastructure it pays a lower dividend, thus reducing Government revenue. The responsible Ministers should take a strong interest in any major long-term investment by Solid Energy, especially one with the potential to increase national greenhouse gas emissions. More generally, the New Zealand petroleum industry has traditionally received a great deal of government support during its development.

I recommend that:

- 4. The Minister of Finance and the Minister of State-Owned Enterprises should not support large-scale synthetic fuel production facilities without considering whether they are designed and located to be able to run on wood.**

Endnotes

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103. Another option is fast pyrolysis and upgrading. See, for example:
 Jones et al. 2009. *Production of gasoline and diesel from biomass via fast pyrolysis, hydrotreating and hydrocracking: a design case*, Pacific Northwest National Laboratory report PNNL-18284 for U.S. Department of Energy, Richland, Washington.
 Renewable Oil Corporation 2010. www.renoil.com.au
 A case might also be made for producing dimethylether (DME) from wood. DME handles like natural gas, but combusts like diesel, so it can be used efficiently in modified diesel engines, but it is not a drop-in fuel. See, for example:
 Haldor Topsoe 2009. www.topsoe.com, www.chemrec.se
104. Kiener 2008. *Start-up of the first commercial BTL production facility: CHORENs BETA-plant Freiberg*, presentation to 16th European Biomass Conference & Exhibition, Valencia, Choren Industries GmbH, Freiberg, 3 June.
105. BA 2010. *BA fuels green revolution*, press release, British Airways, London, 15 February.
106. Ekbohm et al. 2009. *Pilot study of Bio-jet A-1 fuel production for Stockholm-Arlanda Airport*, Värmeforsk Service AB, Stockholm.
107. Solid Energy 2010. www.coalnz.com
108. L&M Mining 2008. www.lmgrou.net.nz
109. Maxwell 2010. *Conversion of cellulosic biomass to transportation fuels*, presentation to Bioenergy Association of New Zealand Liquid Biofuel Interest Group Workshop, Ignite Energy Resources NZ, Auckland, 22 April.
110. Converted from study figures, that around 5 million cubic metres of low quality wood could be delivered to Kawerau every year, at a cost of up to \$85 per m³.
111. US DOE 2009b. *Department of Energy to invest \$366M in energy innovation hubs*, press release, Department of Energy, Washington, District of Columbia, 22 December.
 US DOE 2010. *Secretary Chu announces nearly \$80 million investment for advanced biofuels research and fueling infrastructure*, press release, Department of Energy, Washington, District of Columbia, 13 January.
112. Pure Power 2010. www.purepowerasia.com/portfolio.html
113. LanzaTech 2010b. *LanzaTech signs first commercial partnership deal at Shanghai Expo*, press release, 22 June.
114. FRST 2009. Email to office of Parliamentary Commissioner for the Environment from Corporate Governance Manager, Foundation for Research Science and Technology, Wellington, 30 November.
115. Statistics New Zealand 2010. *Bioscience Survey: 2009*, Statistics New Zealand, Wellington.
116. Statistics New Zealand 2008. *Research and development survey: 2008*, Statistics New Zealand, Wellington.
 Gluckman 2009. Speech to Massey University by Chief Science Advisor, Office of the Prime Minister's Science Advisory Committee, Wellington, 17 July.
117. NZTE 2009. Letter to office of Parliamentary Commissioner for the Environment from Group General Manager – Strategy and Capability, New Zealand Trade and Enterprise, 18 December.
118. As another approach, much more low-quality wood could be produced within a given collection radius of a wood-to-diesel plant from purpose-grown energy forests. But, as there would be no high-value timber logs, the price for this wood would have to be quite high in order to maintain returns to the grower. And this would sacrifice the flexibility of the current multiple-product forest model, which helps minimise grower risk. See Hall, Jack et al. 2009 and, for example:
 Horgan 2009. *Economic analysis: forest biomass energy densification options*, Ministry of Agriculture and Forestry, Wellington, September.

