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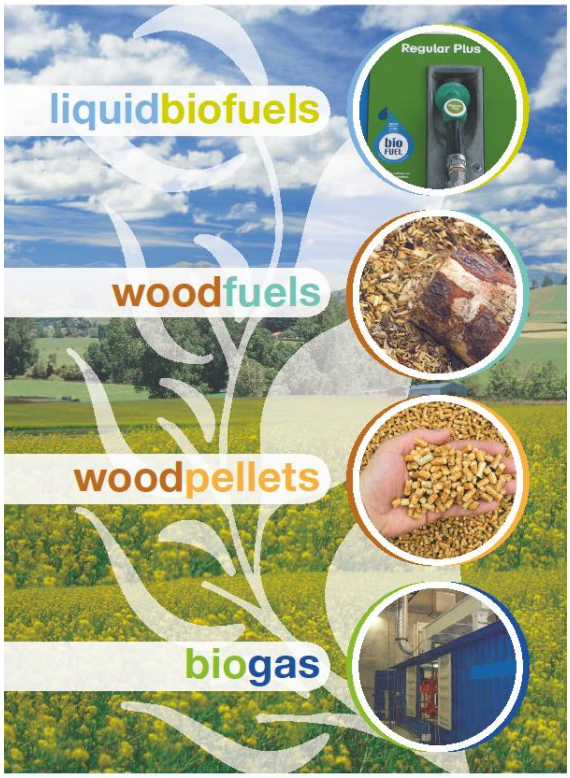


www.bioenergy.org.nz

# A Picture of Bioenergy Opportunities for New Zealand

**Leading to the development of a New Zealand Bioenergy Strategy**

**In partnership with**

**New Zealand Forest Owners Association (NZFOA)**

FOREST OWNERS ASSOCIATION

**August 2010**

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## Contents

# A Picture of Bioenergy Opportunities for New Zealand

## Leading to the development of a New Zealand Bioenergy Strategy

### 1. Executive Summary

A New Zealand Bioenergy Strategy[1] has been developed by the forest owner and bioenergy sectors so economic wealth can be obtained from bioenergy activities.

This paper provides extensive background information on biomass, bioenergy, and associated conversion processes and products as the basis for this strategy.

The New Zealand Bioenergy Strategy is designed to achieve:

> ***"Economic growth and employment built on New Zealand's capability and expertise in growing and processing wood-crops and converting organic by-products to energy, leading to new business opportunities which by 2040 supply more than 25% of the country's energy needs, including 30% of the country's transport fuels."***

The Strategy facilitates use of organic resources which would otherwise be wasted for energy production and gaining greater value from New Zealand's underutilised indigenous forestry resource, transitioning into the use of energy crops for energy production. The Strategy will lift growth in bioenergy use by 2040 substantially above its current 8.5% of consumer energy, with attendant economic, social and environmental benefits. In comparison a "business as usual" approach would achieve by 2040 only a figure of around 9.5% of New Zealand's total energy needs, including very little transport fuel.

The growth is driven by the demand for heat from wood fuel and biogas, and demand for transport fuels which may be in the form of biogas, biodiesel or bioethanol. These are generally proven technologies available for broader application however in energy terms the largest demand is for transport fuels. Analysis indicates that there will be only limited opportunity for use of bioenergy for production of electricity in the period to 2040.

Over the next 30 years the world is expected to face substantial increases in oil and gas prices and a reduction in availability of fossil fuels. World demand for biofuels is expected to rise. The Bioenergy Strategy covers the development of a nationally significant bioenergy business sector and also prepares New Zealand for the time when transport fuels need to come from non-hydrocarbon sources. The strategy also builds on the need for land and forest owners to improve their business resilience through diversification of products.

This paper and the Strategy build on the findings of the Bioenergy Options Project[2.] undertaken by Scion in 2009. This quantified the potential of biomass resources from the current forest harvest and other currently wasted residues, and the very considerable potential of extensive forest and energy-crop planting, to play a key role in this transition to a low carbon future and to meeting New Zealand's future energy needs. The Options Project indicated that the technical potential for production of transport fuels from wood could be around 70-100% by 2040. The Strategy targets a more modest economic potential of 30% based on expected fossil fuel price projections.

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[1] NZ Bioenergy Strategy, available from the Bioenergy Association of New Zealand, www.bioenergy.org.nz

[2] Bioenergy Options project (Scion, 2007, 2008, 2009a, 2009b, 2009c)

Application of the strategy will deliver the energy scenario that biomass offers, through a staged development providing significant benefits for landowners, forestry businesses and farmers; in addition to the national benefits of reduced dependence on imported fuels and significant carbon emission reductions.

In the short term, growth in the use of bioenergy will be based on existing resources, processes and markets and the increased utilisation of residues and wastes, progressively augmented by fuel crops, to supply wood-energy, for which there are significant opportunities, and to produce a range of bioenergy-based products including biogas and bio-oil. While products and processes are established and fuel-cropping develops in this early phase, the development of a comprehensive wood-fibre market is proposed, while research continues into the development of liquid-fuel manufacturing processes, including for biodiesel and bioethanol.

In the Foundation Building Phase (2010-2015) the technical and economic platform for the Development Phase (2015-2020) will be confirmed and a range of decisions around crops, processes and future fuel production made: based on expanded and commercially focussed research into fuel crop growing, processing technologies, and trial plantings. This will require the establishment of applied technology transfer programmes and the focusing of New Zealand research on being fast followers and adaptors of overseas research initiatives.

Biodiesel production technologies appear to be potentially commercially available in three to five years and economic within a similar period given projected oil price rises. However the scale of such plants requires very large volumes of biomass; this is obtainable in the medium term only from residues, existing low-value export logs and short rotation fuel-crops. Given decisions on volume planting of fuel crops and on biodiesel production in the three to five year timescale volume production of biodiesel as a drop-in fuel is seen as possible within a seven to ten year timescale.

The Bioenergy Options Project assesses the cost of ethanol production at $2.96/litre (petrol equivalent) or 9.23c/MJ, and the capital cost of production facilities at $200 million for a 90 million litre. Biodiesel, on the basis of a less detailed assessment, is costed in the Options report at $1.70/litre (diesel equivalent) or 5.8c/MJ, with the capital cost of production plant around two thirds of an ethanol plant.

High-level analysis indicates that given a current price of oil at US$80/barrel and a petrol price, ex all taxes and margins, of currently around 75c/litre (MED, 2009 average price) bioethanol may become economic at an oil price of US$315/barrel. For diesel however the current price is 79c/litre, ex taxes, which indicates that that biodiesel may be economic at an oil price of US$190/barrel. Clearly, further work is required on the economics, and the Options report suggests potential biofuel manufacturing price reductions of around 35%; requiring respective oil prices of US$205 and US$125/barrel.

In the longer-term the high growth bioenergy path suggested by the Strategy is based on both fuel crops and the planting of large areas of plantation forests and supporting the production in large-scale plants of liquid fuels which will displace hydrocarbon-based fuels in the New Zealand market. A strategic decision to commit to the large-scale planting of forestry crops will be required by around 2015, given their long growth cycle, if these are to supplement fuel crops in support of the high growth liquid biofuels programme envisaged. With this timing attention should now be focusing on the transition paths available to forest owners.

Additionally exports, of energy chip, pellets or potentially products produced by torrefaction, are expected to be economically viable given a projected world shortage of wood-fuel to meet European and Asian demand for green-energy products to meet climate change objectives.

If the strategy's high-growth target is not adopted current incremental bioenergy growth will continue, though this will forgo potential economic gains, and also substantial benefits in areas such as reduced dependence on imported fuels, improved security of energy supply, greenhouse gas emission reductions and other environmental benefits, regional employment growth and significant improvements in returns to landowners.

The bioenergy growth option offers New Zealand a very significant contribution to meeting the majority of its energy supply needs from sustainable and renewable resources while providing other significant benefits. It will however require very large investment in processing facilities and crops, and long investment horizons. It is

seen as the basis for the development of a sustainable and diverse bioenergy industry of significant scale, with potential for the export of intellectual property and products and processes developed.

## 2. Introduction

The "Bioenergy Options for New Zealand" project (the Options Project)3 was initiated to consider and quantify the potential of bioenergy (energy derived from organic matter) to contribute to New Zealand's energy future. Based on the Options Project a simplified picture of the opportunities for bioenergy over the next three decades is drawn below, and from that, and extensive consultation, the New Zealand Bioenergy Strategy has been developed[4].

The Strategy was developed as a joint initiative of the Bioenergy Association of New Zealand (BANZ) and the Forest Owners Association (NZFOA), with the support of the MED, NZTE, MORST, FORST and EECA. Technical support was provided by Scion and other BANZ members. This report includes feedback from all respondents received during the development of the Strategy, included to the degree possible.

The Options Project focussed on the utilization of forest residues and new forest plantings to produce biofuels. From that work it has been identified that there will be significant potential for biofuels from fuel crops but that significant additional research is required on wood-to-biofuel conversion technologies and transition paths.

During development of the strategy it has become obvious that Bioenergy is just one of the target products which will build a bio-based future for New Zealand. The production of high value bio-chemicals and other bio-materials provides other avenues for extracting value from our natural resources. Bioenergy is often a byproduct of the primary high value product derived from the biomass. Research and development in all bio fields requires on-going co-ordination between the products. Future construction of bio-refineries will provide multiple output streams of which bioenergy will be one of the most important.

While there is already some R & D being carried out in many fields, high level co-ordination at government level and within industry will help drive advancement and ensure that all parties have a shared focus.

## 3. Situation Analysis

### 3.1 New Zealand

New Zealand's consumer energy demand in 2007 was 576PJ, comprising:

- Heat 190 PJ (33%)
- Electricity 141 PJ (24%)
- All liquid fuels 245 PJ (42%)

Road transport fuels were 212 PJ (including; 3.4 billion litres of petrol, 2.9 billion litres of diesel and 1.4 billion litres of jet fuel).

Currently around 8.5% of consumer energy is produced from bioenergy.

The current official Government position on New Zealand's available natural gas reserves[5] suggest that supplies will be plentiful until at least 2022. This is based on information provided to the Ministry of Economic Development by major oil and gas field owners on so-called P10 reserves. When contingent reserves are added, local gas reserves could extend beyond 2030. Regardless there is a recognised finite limit to New Zealand's available gas reserves that will be required from greater use of domestic resources or imports.

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3 "Bioenergy Options for New Zealand" (Scion, 2007 - 2009) , which included contributions from NZ Forest Owners Association, MAF, MED, EECA, and MORST. For details see the original reports on www.bioenergy.org.nz or www.scionresearch.com or www.bkc.co.nz

4 'NZ Bioenergy Strategy', available from the Bioenergy Association of New Zealand www.bioenergy.org.nz

5 New Zealand Petroleum Reserves Review, Ministry of economic development, August 2010. Options paper released for public discussion www.med.govt.nz/upload/70853/NZ_Petroleum_Reserves.pdf

Table 1 shows the breakdown of the current potentially available quantities of biomass and wastes which could be used to produce an additional 45.9 PJ (8.5%) of consumer energy; this unused resource is mainly from the forest processing industries. Under a business as usual scenario this could grow to 9.2% by 2030.

**Table 1: Potential additional consumer energy from currently available but unused biomass resources**

| Type / source | 2005 PJ p.a. | 2030 PJ p.a. |
|---|---|---|
| Forest Residues | 14.6 | 34.4 |
| Wood Process Residues | 7.0 | 9.1 |
| Municipal wood waste | 3.5 | 2.2 |
| Horticultural wood residues | 0.3 | 0.3 |
| Straw | 7.3 | 7.3 |
| Stover | 3.0 | 3.0 |
| Fruit and Vegetable Culls | 1.2 | 1.2 |
| Municipal Biosolids | 0.6 | 0.7 |
| Municipal solid waste , landfill gas | 1.9 | 2.3 |
| Farm Dairy | 1.2 | 1.2 |
| Farm Piggery | 0.1 | 0.1 |
| Farm Poultry | 0.0 | 0.0 |
| Dairy Industry | 0.4 | 0.4 |
| Meat Industry (effluent only) | 0.5 | 0.5 |
| Waste oil | 0.2 | 0.2 |
| Tallow | 3.6 | 3.6 |
| **Total** | **45.9** | **66.5** |
| Available Biomass as % of consumer energy | 8.5 | 9.2 |
| Available Biomass as % of primary energy | 6.6 | 7.3 |

Source: Scion

Currently utilised bioenergy is derived almost entirely from processing residues (in large part sawdust, bark and shavings from wood processing and black liquor in the pulp industry) with few purpose grown energy crops.

Forest residues, forest and wood processing residues and straw are the largest potential contributors. Biogas is produced from municipal and food-processing organic wastes in niche opportunities.

Bioenergy is presently primarily used to produce heat with a minor amount used for electricity generation.

There is a fledgling liquid biofuels sector evolving based on feedstock from tallow, used cooking oil, whey and purpose-grown canola crops.

Implementation of the Strategy so that not 9.2% but 25% of energy is produced from bioenergy will require significant new plantings and adoption of new growing and harvesting methods in addition to use of the unused resources identified in Table 1.

### 3.2 International energy trends

Forecasts (refer Figure 7) for international oil prices are for steep increases in prices in real terms with a mid point in the range showing a doubling of the current cost by 2035, from the current $70 - 80/barrel to $200/barrel. This is based on rapidly increasing global demand and decreasing supply. Forecasts for other fuels such as coal and gas are less aggressive but an expected cost of carbon arising from climate change reduction initiatives will drive increases in the price of all fossil fuels. This provides a key driver for the uptake of biomass fuels by improving their relative price competitiveness. Future gas supply and prices will be determined by the size and location of any new gas discoveries, unless LNG imports eventuate.

Internationally governments are making large investments in ensuring that bioenergy opportunities will be maximised in their countries. Substantial focus is on developing and proving new conversion technologies and to ensuring that planting are carried out to ensure supply of suitable feedstocks when required. Numerous studies have been carried out and many countries have already developed bioenergy strategies at government or industry levels.

Some of the many examples of such support are:

- U.S. Department of Energy award of up to $6.3 million towards fundamental research leading to the improved use of plant feedstocks for biofuel production in July 2009.
- US commitment of $600 million for biofuel research between 2008 and 2015.
- The US President has set up the Biofuels Interagency Working Group, which is headed by the chiefs of the Environmental Protection Agency, the Department of Energy and the Department of Agriculture and Bioenergy
- The US EPA has proposed targets by 2022 of:
    - 16 billion gallons of cellulosic biofuels;
    - 15 billion gallons annually of conventional biofuels;
    - 4 billion gallons of advanced biofuels; and
    - 1 billion gallons of biomass-based diesel.

- In Australia, the State of Victoria will prioritise research to explore the potential use of wood for biofuel production.
- The Australian Centre for Renewable Energy (ACRE) is part of the Australian Government's $4.5 billion Clean Energy Initiative and draws together more than $560 million of renewable energy investment to help commercialise renewable energy. ACRE's programs include:
    - $300 million Renewable Energy Demonstration Program
    - $15 million Second Generation Biofuels Research and Development Program
    - $150 million for new initiatives, including funding from the formerly proposed Clean Energy Program.

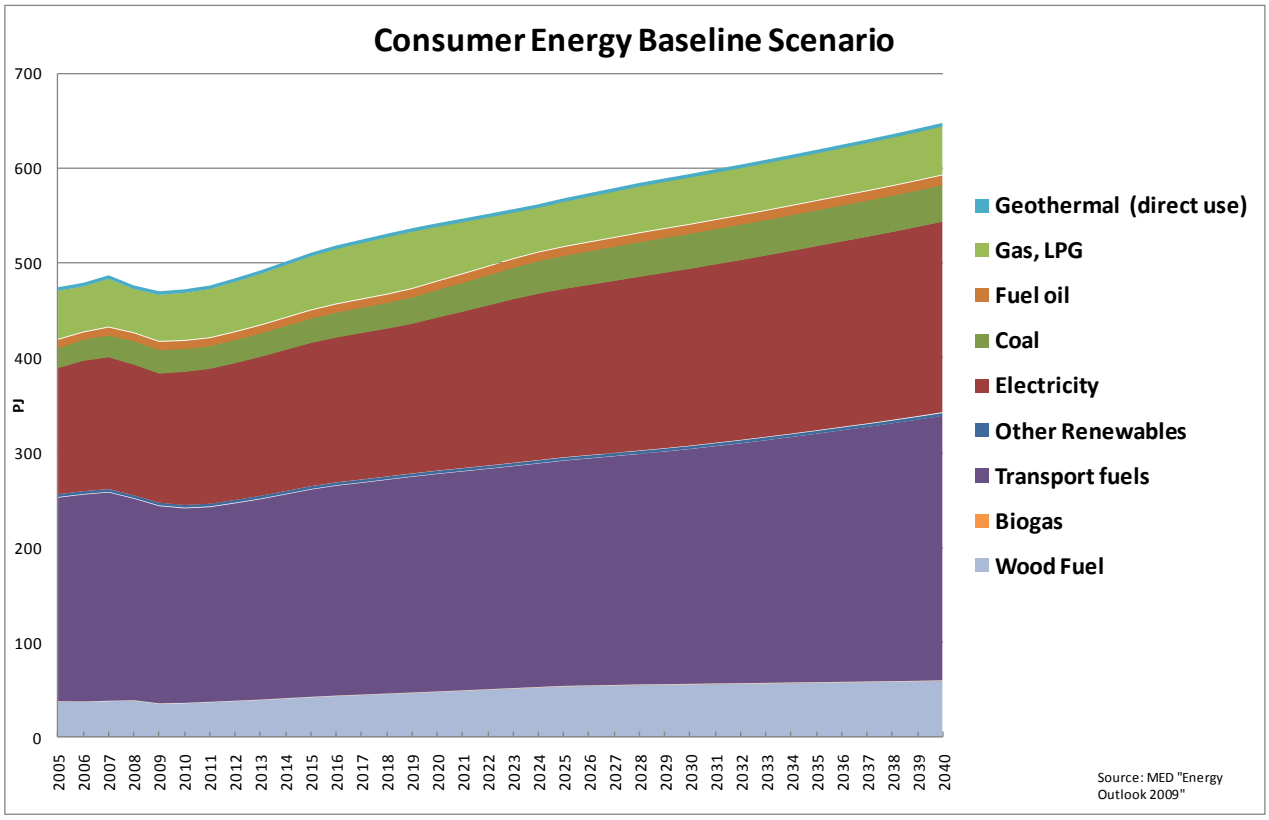
- The 2009 UK budget included a GBP 10 million funding package for the commissioning of new composting and anaerobic digestion facilities
- In England the government currently provides support worth GBP 47 million just for the development of energy crops, with grants covering 50% of the establishment costs. It has also committed GBP 1.5 million towards research on the feasibility of short rotation forestry and established a Biomass Sustainability Working Group.
- The European Union requires that the proportion of motor fuels made up of biofuel should be increased to 5.75 per cent by 2010 and 10 per cent by 2020.
- The European Commission is developing its Strategic Energy Technology Plan[6] (SET-Plan) to address bioenergy's technical and economic barriers to the further development and accelerated commercial deployment of bioenergy technologies for widespread sustainable exploitation of biomass resources. The SET-Plan also aims to ensure at least 14% bioenergy in the EU energy mix by 2020, and at the same time to guarantee greenhouse gas (GHG) emission savings of 60% for bio-fuels and bio-liquids under the sustainability criteria of the new RES Directive

[6] . ***European Commission SET-Plan***

## 4. The opportunities

Figure 1 shows the baseline "business as usual" Consumer Energy Reference Scenario from the Ministry of Economic Development's (MED) Energy Outlook 2009/10 publication[7]. This scenario shows projected energy use and indicates the significant opportunity for substitution by bioenergy and its derivatives of gas, coal and transport fuel use. This bioenergy could come from a wide range of biomass feedstocks including forest residues, energy forests and crops, municipal and food processing organic waste, and algae. Depending on the fuels made, substitution will require acceptance of ethanol and biodiesel and changes to vehicle fleets and fuel distribution.

**Figure 1: Consumer energy by source**




The consumer energy demand interpretation in the Bioenergy Options project shows that the production of heat and transport fuels to substitute fossil fuels will become progressively more economic through the next three decades. This will be for heat during the early period, followed by transport fuels from around 2025.

Large scale electricity production from biomass does not become economic within this 30 year period, though in some cases distributed generation based on local on-site demand and biomass supply may be viable.

The MED has produced a Changing Gears Scenario[8] for the Energy Outlook and this evaluates how New Zealand could reduce its reliance on imported oil. The Scenario identifies that " By 2040 in the High Uptake case biomass makes up almost 25% of the country's primary energy supply. Much of this biomass is used for the production of advanced biofuels".

[7] Ministry of Economic Development, Energy Outlook 2009/2010 http://www.med.govt.nz/templates/MultipageDocumentTOC____41969.aspx
[8] Energy Outlook Changing Gears Scenario http://www.med.govt.nz/templates/MultipageDocumentTOC____41969.aspx

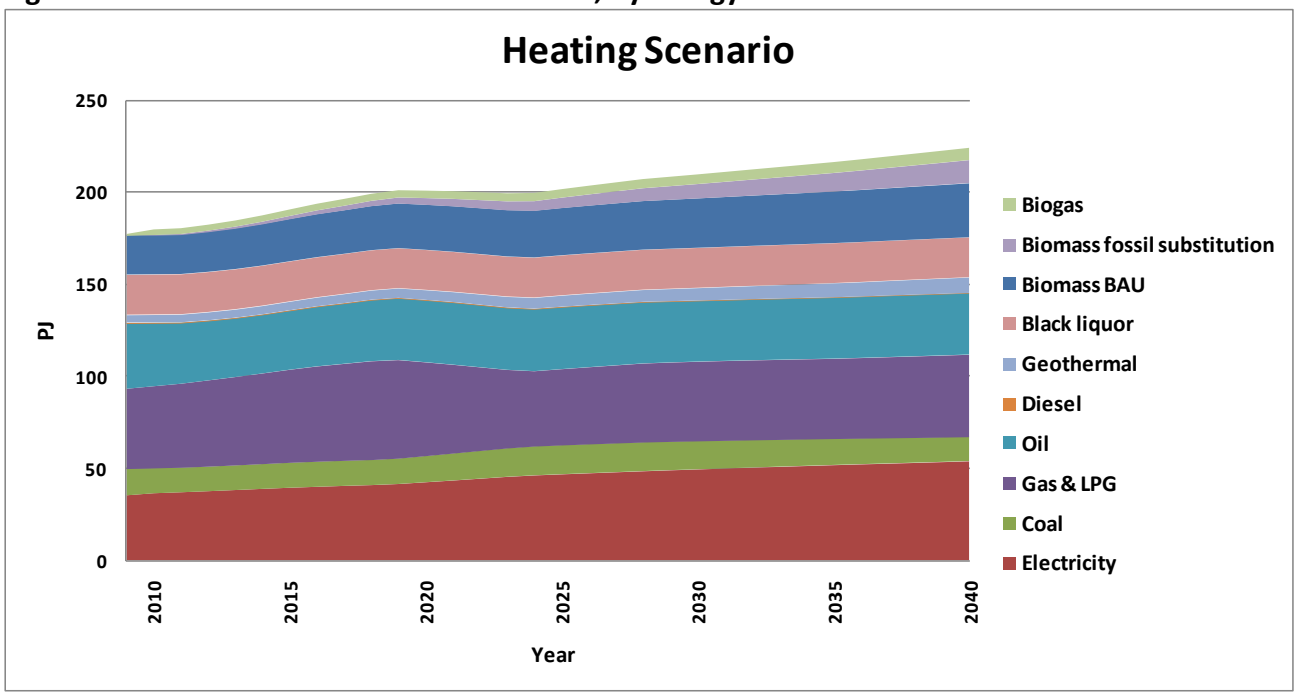
### 4.1 Heat energy

Figure 2 shows a scenario for national heat use to 2040. The total heat use is based on the energy forecasts in the Energy Outlook 2009 with the mix of contributions based on an interpretation by East Harbour Energy of the outcomes of the Bioenergy Options project. This shows biomass use potentially increasing from the current 8.5PJ to 35PJ pa, with the biomass fuels used being wood, fuel crops or biogas. The assumptions behind this are outlined in Appendix 1.

The early stages of the strategy should focus on the immediate opportunities to expand the existing use of wood as a source of heat. This will be by identifying existing users of fossil fuels and adding biomass to their fuels. Developing industries with heat needs should be shown the advantages of producing heat from biomass. This will require that long-term supplies can be guaranteed with an ensured price path. There are "low hanging fruit' to be picked which will help build the existing base and acceptance of bioenergy as the viable route to be followed.

Growth in the production of heat from biomass, beyond that shown in Figure 2, is constrained because of the continued relatively low cost of fossil fuels for heating, the capital requirements associated with changes in fuel, and the limited industrial demand for heat at significant scale; though some opportunities such as Fonterra plants, Huntly Power station and cement factories exist for progressively increasing substitution, if bio-fuel is available and economic. Increased future oil and gas prices plus carbon charges will make hydrocarbon fuels more expensive, encouraging fuel substitution.

**Figure 2: Heat use scenario – future heat use, by energy source**




Source: Total heat use from MED Energy Outlook Reference Scenario
Mix based on an interpretation by East Harbour Energy

The scenario shown in Figure 2 is based on the MED Energy Outlook Reference Scenario. If gas supply from fields of natural gas do not eventuate as in the MED scenario then the production of biogas from gasification of wood could quickly develop such that an estimated additional 100PJ of biogas could be made available for reticulation.

### 4.2 Transport energy

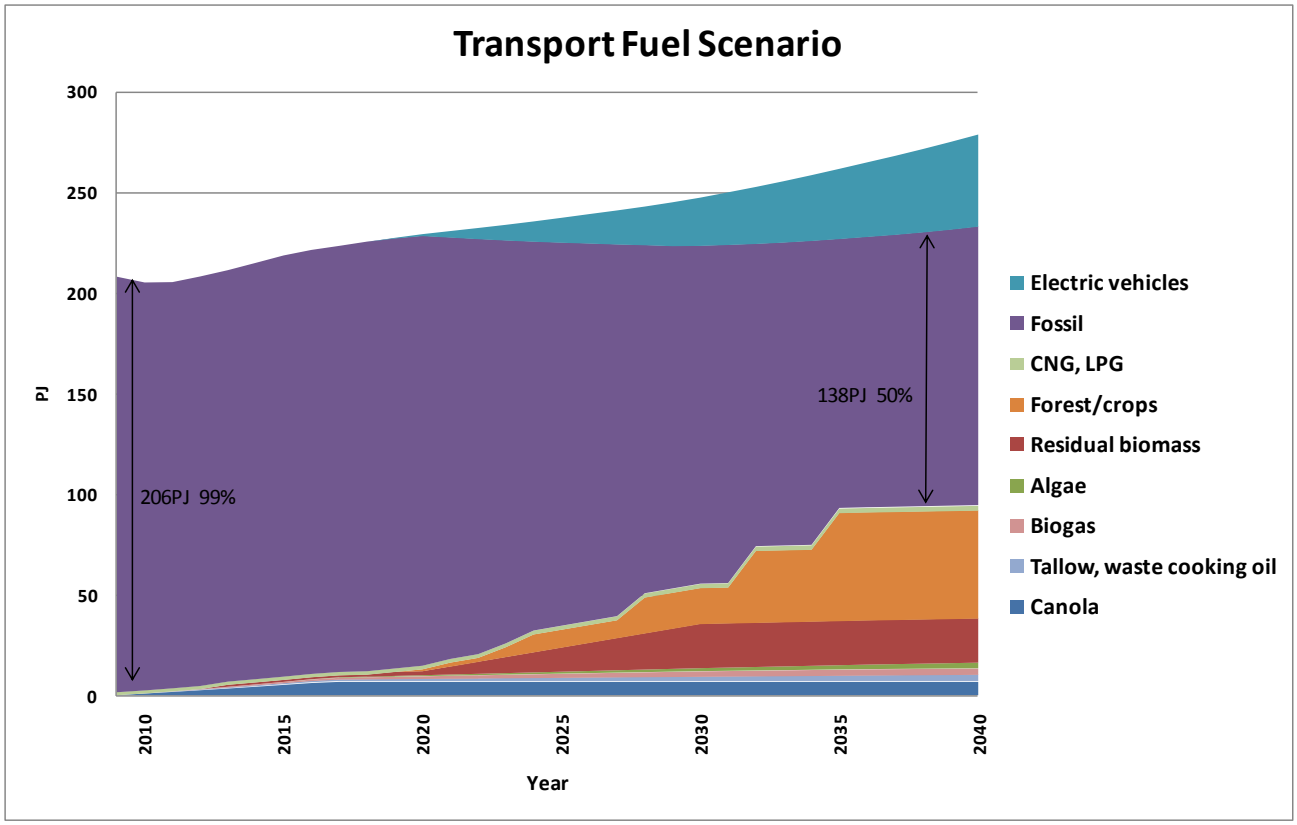
Figure 3 shows a scenario, prepared by East Harbour Energy, showing transport fuel use to 2040. As for heat the total fuel use is based on the energy forecasts in the Energy Outlook 2009 Reference Scenario, while the bio-

energy components are based on an East Harbour interpretation of the results of the Bioenergy Options project, and the electric vehicle component from the Electricity Commission and Meridian/Contact reports of 2009. The assumptions are outlined in Appendix 1, including that lignocelluloses to fuel is likely to be commercialised overseas in a 3 to 5-year time frame (biodiesel - bioethanol seems likely to be on a longer timeframe) and able to be progressively introduced in New Zealand starting in 7-10 years, depending on economic drivers, and the availability of adequate biomass volumes; in the short-term the biomass is likely to come from harvest and process residues, fuel crops and low-value export logs. In the longer term the biomass could come from production of biofuels from energy crops grown on marginal land.

Achievement of the targeted quantities of transport fuel by 2040 will depend on the success of the sector development during the Bioenergy Strategy Foundation Building Phase (2010-2015) and R&D into the feedstocks and conversion technologies in the Bioenergy Strategy Development Phase (2015 -2020). The R&D will specifically require construction of demonstration projects. Funding for demonstration plant and trial crops in the Bioenergy Strategy Development Phase (2015 -2020) could be from a contestable loans fund or similar. Such a fund could be a targeted fund and would signal to landowners and investors that there is support, and a viable future for bioenergy.

The fund would be used to encourage and support research into the development of bioenergy opportunities in New Zealand and for increased international exposure to the rapid advances in technology and identification of the most suitable feedstocks to ensure that the country is well placed to adapt this knowledge for the development of a world class bioenergy sector.

**Figure 3: Scenario - potential transport fuel supply, by feedstock**




Source:Total heat use from MED options study
Bioenergy contributions based on an interpretation by East Harbour Energy

The Bioenergy Options project shows a theoretical potential for use of lignocelluloses for production of around 70-100% of transport fuels by 2040 which is significantly greater than the 30% figure of 72PJ shown in Figure 3,

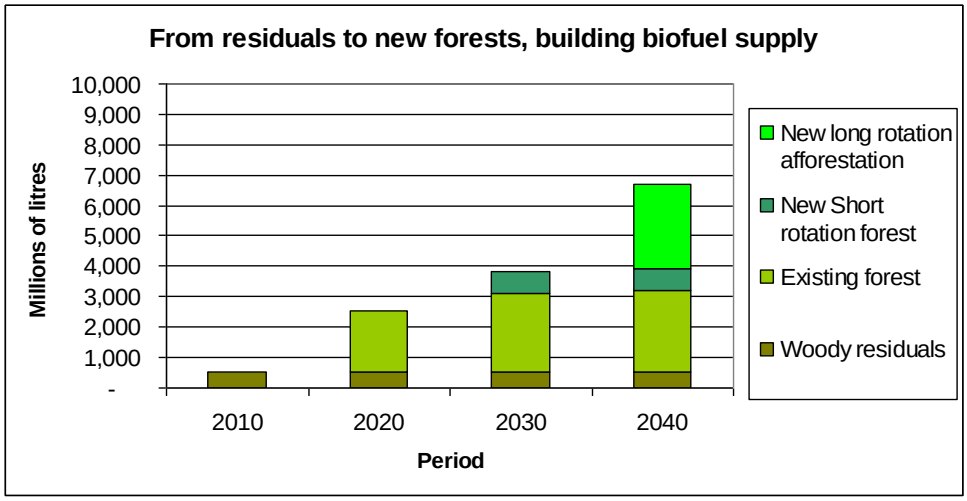
but the target potential has been reduced in the Bioenergy Strategy to account for economics, the international fuel price data from Figure 7, and a range of practical and geographical considerations.

## 5. Bioenergy Options analysis

### 5.1 The potential resource

The Pathways Analysis, the second part of the Bioenergy Options project, assessed currently available woody residues as having the potential for 46 PJ pa of additional consumer energy from existing available resources with this having the potential to rise significantly by 2030 (refer Figure 4). In addition 3.37 million ha is seen as available for planting in purpose-grown forests and fuel crops which could potentially produce up to 600 PJ pa of primary energy, though impacts on other land-uses would be significant. Hill country land is available at lower cost for long rotation forests while short rotation energy forests or fuel-crops are likely to be grown on less-steep marginal or currently pastoral land.

**Figure 4: Potential growth in liquid fuel supply from biomass, by source**

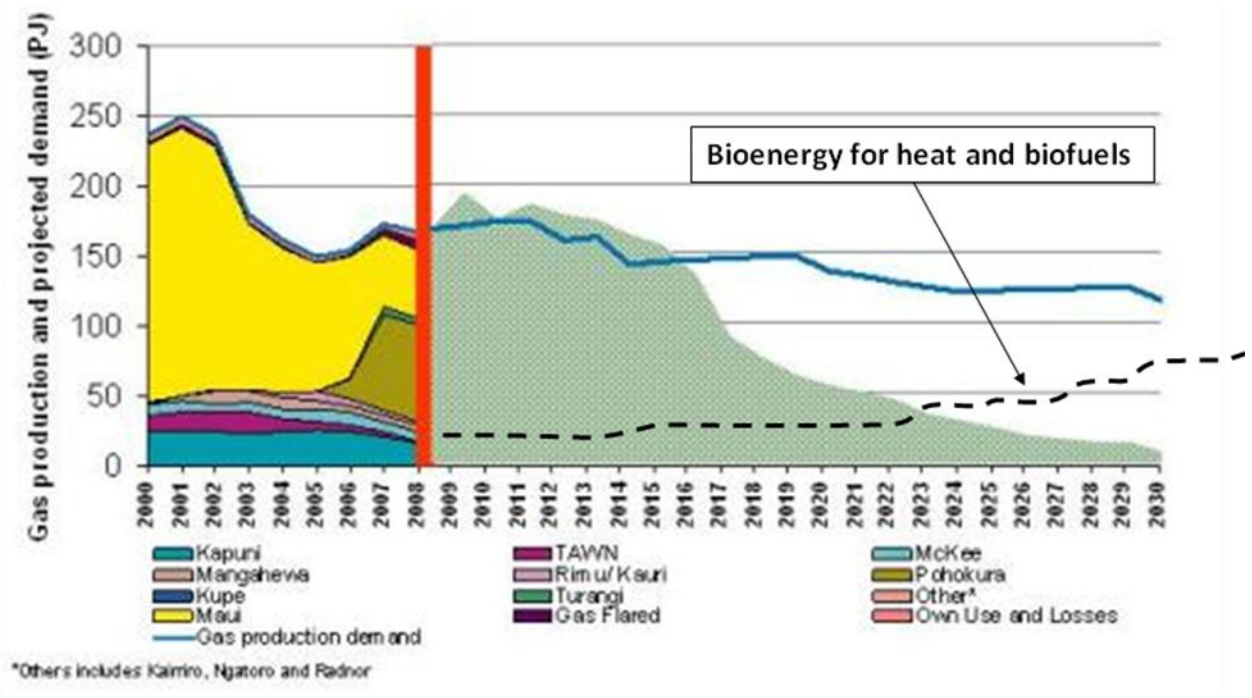



Source: Bioenergy Options for New Zealand – Transition Analysis

Whether such land is used for energy forests and fuel crops or more traditional agricultural applications will depend on a range of factors including the relative financial returns. Short rotation forests and fuel-crops offer a range of benefits for land owners, including earlier and potentially higher returns that are not available from long-rotation forests.

To put the size of the available bioenergy resources into perspective Figure 5 shows the scenario for possible production of transport fuel from bioenergy resources overlaid on the Ministry of Economic Development's summary of known gas fields. One can see that in energy terms the quantity of transport fuel that could be produced from bioenergy is greater than many of the existing gas fields.

**Figure 5: Overlay of transport biofuels with NZ's historical and projected gas production**




## 5.2 Environmental benefits

The Options study life cycle analysis of the use of woody-biomass feedstocks for energy production shows that they generally give an excellent return in the range 4.5 (ethanol production) to 10.9 (direct combustion) on the basis of energy produced in relation to energy inputs. This indicates that there are substantial greenhouse gas (GHG) reduction drivers for woody-biomass use, as well as for the utilisation of municipal waste, industrial effluent and agricultural waste. These include carbon sequestration in the case of crops, the reduction of methane emissions from the biodegradation of waste materials, and reductions in other emissions from fossil fuel combustion, such as sulphur. The use of wastes also reduces solid waste volumes with major impacts on waste disposal.

The production of 72PJ of biofuel in the Bioenergy Strategy will reduce New Zealand's carbon dioxide emission by around 4.5 million tonnes, this being around 30% of transport-generated emissions. Environmental drivers aimed at reducing disposal of residuals as waste eg farm effluent, will encourage the production of biogas for embedded use, i.e. farm vehicles.

Environmental and other drivers are summarised in Appendix 2.

## 5.3 Other benefits

These include improved security of energy supply, increased revenues for landowners, diversification of farming outputs and revenue streams, nitrate management, job creation, increased resilience of rural communities with new jobs, and shorter harvesting rotations.

## 6. Realising the potential

The underlying growth of the bioenergy business sector through the next three decades will be driven by economics and by recognition of the range of other benefits available. These will drive demand for heat from forest and wood processing crops and residues and the production of transport fuels from lignocelluloses, tallow, waste cooking oil and canola, assisted by technological developments. Biogas from utilisation of organic wastes is likely to also have a small but important part to play. Alternatively products may be exported.

Key drivers in the growth of the sector are:

- The planting of extensive areas of energy forests and fuel crops
- The economic returns available from developing new processes and markets for bioenergy. (There is significant work to be completed on the economics and some work in this area is presently being carried out.)
- The need to improve the security of future energy supply and for New Zealand; to reduce national dependence on imported fossil fuels; given forecasts of reducing global oil reserves and increasing prices
- The projected increases in world demand for biofuels and bioenergy
- International, and New Zealand, commitments to reduce greenhouse gas emissions.
- The Emissions Trading Scheme which will result in additional forest (and energy crop under this strategy) plantings and biomass availability
- Wood processers recognising the value of wood fibre residues for a wide range of uses other than combustion, or export and receiving appropriate returns from these uses
- Wood processors selling high quality wood fibre for high value uses such as wood pellets or ethanol production, and purchasing-in lower value wood fibre for combustion
- Increased use of biomass for direct heat by non wood processors
- The need to develop better management strategies for municipal, industrial and agricultural waste including reduced waste going to landfills
- Biogas generated from municipal and food processing residues used for heat and as a vehicle fuel
- A transport biofuels wholesale and retail market created through establishment of production expertise, fuel standards, infrastructure, and quality assurance schemes
- The potential to enhance New Zealand's clean and green image and mitigate potential market-perception and other impacts on our reputation and industries including tourism.
- Industry developing a cohesive common message
- Industry creating a community of interest for lignocelluloses conversion to energy

To realise the potential from bioenergy New Zealand must be an early adopter based on existing feed stocks and market opportunities, regardless of whether through wood fuel, biogas or transport biofuel, to get the opportunity to develop markets and best practices so that when the more substantial market growth occurs from purpose grown energy forests/crops we are ready to take full advantage of this economic growth opportunity.

The development of this large business sector, requiring long-term business horizons, will require support from policies that:

- Offer consistency over long time periods
- Recognise the wide-ranging benefits available
- Encourage the retention and expansion of a sustainable wood processing sector
- Encourage or facilitate the planting of forests and fuel crops (reversing the decline in this area)

- Recognise the environmental benefits of biofuels
- Recognise the future fuel price and supply threats to New Zealand
- Assist in overcoming the uncertainty and risk imposed by the high levels of investment and long time horizons associated with the sector.

## 7. Residues alone are not enough

As energy prices (especially for oil and gas) rise in the future, economically recoverable biomass residuals will be sufficient to meet only a small amount of the projected demand for bioenergy products. Additional biomass, which may in fact be cheaper, better quality, and grown within an economic transport distance of the processing facilities, will be required to be sourced from new purpose-grown energy crops, forests, and algae. (refer Figure 4)

Liquid biofuels (refer Table 3 and Figure 7) may start to become economic from around 2020 (biodiesel) and could become a mainstream energy source in the decade of 2030. The Pathways analysis shows that the big opportunity is from new energy crops/forests and theoretically some 3.2 million ha of forests/crops could be planted, providing 100% of New Zealand's liquid fuels and some heat fuel. NZ has 9.6 million ha of hill country grazing, of which 0.8 million ha is highly vulnerable to erosion. There is also up to 1.4 million ha of marginal or low productivity pastoral land that may be available for short rotational fuel crops, offering increased returns to farmers, but this land must be relatively flat so mechanical harvesting can be used.

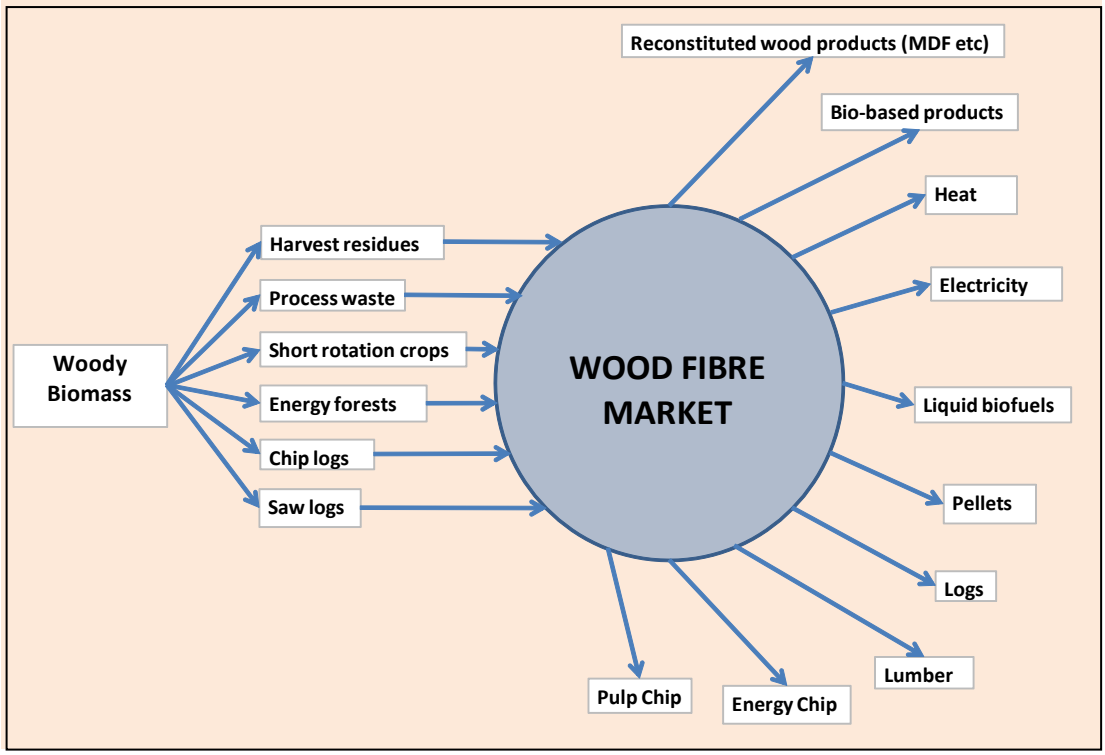
### 7.1 Fuel crops

The production of bioenergy from forests or wood/grass fuel-cropping is more efficient in terms of land use than the alternative of growing seed or nut energy crops as the entire biomass volume can be used, as opposed to just a specific part of the plant. The Options project shows that land owners should see financial and other benefits from using existing marginal or pastoral lands for the growing of energy crops such as Miscanthus which offers potentially higher conversion rates than woody-biomass crops. Energy crops have the potential to give landowners higher returns, revenue diversification and thus improved business outcomes and risk management.

Woody biomass supports, now and potentially, a variety of conventional timber and energy-related end-uses (refer Figure 6) including:

- Solid fuel for heat or cogeneration of heat and electricity
- Liquid fuel production
- Feedstock for gas production, and
- Production of bio-products eg lignin (potentially in conjunction with the production of liquid fuels)

**Figure 6: The wood fibre market**




Source: East Harbour Energy

## 7.2 Competition for wood-fibre

The potential production of bioenergy from wood-fibre will be strongly influenced by the alternative uses that producers can sell fibre for (refer Figure 6), and the value they receive from the uses in the market; at that point in time and as perceived for the future. There are already significant supply constraints in the fibre market in different regions throughout NZ.

The wood-fibre market is at an early stage of evolution with only pockets of sales occurring to wood processors (eg MDF), heat plant owners (e.g. Kinleith), firewood users, and wood pellet producers. Work by EECA and others have shown that there are other potential wood-fuel purchasers who are currently not proceeding with wood-energy projects because they cannot obtain secure medium to long-term contracts of known quality wood fuel at specified prices. The recognition of forest and wood processing residues as a valuable commodity by a range of potential users, and acceptance by producers of the need to enter into longer-term supply agreements are the first steps to increased trade and usage, and subsequently increased value for forest owners and wood processors. This in turn will lead to increased extraction of forest residues and the planting of fuel crops and new forests.

The establishment of forest residues as a major stepping stone to growth in the bioenergy sector, encouraging forest owners to collect and sell harvest residues rather than ignoring them as waste, is seen as a priority activity for both the bioenergy and forestry sectors.

## 7.3 Beyond Residuals

While unutilised residues have significant initial potential, future growth of the bioenergy sector will depend on purpose grown forests and crops, and to a smaller extent algae from waste water, as feedstocks for energy production. Biogas production will in the short to medium term depend on utilisation of municipal wastes. The growth of fuel-crops is seen as very promising, but little research and development has been done in this area. The key drivers for the growth of these crops will be:

- Development and commercialisation of technologies for the conversion of lignocellulose to liquid biofuels
- Recognition of the value that energy crops offer land owners
- Working with land/forest owners to maximise the use of their land for production of wood energy feedstocks, and to improve returns.

On a much smaller scale but important for supply diversity and niche environmental opportunities will be:

- Production of biogas from municipal organic waste, and from food processing residues
- Production and processing of algae into liquid biofuels, in particular the improvement in conversion efficiency and reduction in production costs
- Woody biomass gasification or conversion to bio-oil.

## 8. Large scale bioenergy from forestry

The Bioenergy Options project considered the potential of the existing forest estate to enable a transition from residues to a large-scale bioenergy supply from new forests, with the potential growth in fibre supply shown in Figure 4.

Using some of the existing forest harvest (industrial/chip logs) for energy production (displacing commodity export) provides an option for a stepping stone in supply to build on the use of the limited supply of residues before the high volume supply from a large new forest estate kicks in. However the use of these logs for energy is not currently economically rational.

New Zealand's liquid fuel demand is currently around 8.1 billion litres. The study considered the energy supply volume, cost, land-use changes and associated environmental and macro-economic impacts of four large-scale afforestation scenarios, for liquid biofuels production. The total extractable biomass and litres of petrol equivalent for a number of growth scenarios are summarised in Table 2. This assumes a sustained yield harvested on a 25 year rotation, but could apply for a number of forest and fuel-crop scenarios.

**Table 2: Summary of potential biomass and liquid fuel production by forest planted area**

| | **Scenario 1 / 0.8m ha** | | **Scenario 2 / 1.8m ha** | | **Scenario 3 / 3.3m ha** | | **Scenario 4 / 4.9m ha** | |
|---|---|---|---|---|---|---|---|---|
| | TEB p.a. $m^3$ millions | LPe, p.a. millions | TEB p.a. $m^3$ millions | LPe, p.a. millions | TEB p.a. $m^3$ millions | LPe, p.a. millions | TEB p.a. $m^3$ millions | LPe, p.a. millions |
| Total* NZ | 22.59 | 1964.2 | 73.55 | 7,039.1 | 126.63 | 11,011.2 | 168.67 | 14,666.1 |

- LPe = litres of petrol equivalent
- TEB = total extractable biomass

The potential for growing new forests (and in less detail fuel crops) was assessed, including the potential impacts on existing land-use. In terms of regional potential Manawatu-Wanganui was seen as having the largest potential followed by Canterbury, Hawkes Bay and Otago.

Potential tree species for bioenergy production identified in the Options study are Pinus Radiata, Eucalyptus fastigata, Eucalyptus nitens, Eucalyptus regnans, Eucalyptus saligna and Sequoia sempervirens. The hardwoods (Eucalypts and to a lesser extent Acacias) with their higher wood density and reasonable growth may offer greater productivity than many softwoods. However, despite its low wood density the high volume production from Redwood places it in the 10 most productive species, along with radiata pine, the eucalypts and some acacias. Energy crops such as Miscanthus have higher yields but need land at (indicatively) a slope less than $20^0$ for harvesting.

While some crops may be grown and harvested solely for energy use, in other forests lower value logs may be used for energy and S grade logs for sawn lumber.

## 9. Fuel crops or forest crops

The Options study focuses primarily on forest crops and residues with much less consideration of fuel crops, which have only recently been introduced into New Zealand. A range of short rotation "crops" such as Miscanthus, Salix and Phalaris arundinacea can be considered, with some trials completed or underway.

Fuel crops have the potential for increased yields, production potentially from year 2 or 3 and then as an annual crop and can grow on marginal land with few inputs and the product produced is homogeneous and may be much drier. They do however require relatively flat land for access for harvesting machinery.

## 10. Biodiesel or bioethanol?

The focus of Scion's research and the Options study has been on the production of bioethanol. However the bio-ethanol production process involved is complicated, expensive and yet to be proven at commercial scale. The Options study, on the basis of considerable financial analysis, assesses the cost of ethanol production at $2.96/litre (petrol equivalent) or 9.2c/MJ, and the capital cost of production facilities at 2.9c/MJ of capacity.

Biodiesel, on the basis of a less detailed assessment is costed in the Options report at $1.88/litre (petrol equivalent) or 5.8c/MJ, with the capital cost of production plant 39c/litre of capacity. The technology for biodiesel manufacture from biomass is also relatively well proven; involving gasification and then the Fischer Tropsch process. And the conversion efficiency, biomass to fuel, is also higher.

Large-scale ethanol production would require blending into petrol available at the pump, progressively increasing the level of the blend. At higher blends this creates a number of technical and commercial issues but is the practice increasingly in a number of other markets. Biodiesel is currently available in New Zealand and large scale production would increase the trend of conversion of New Zealand's vehicle fleet to this fuel. There seem to be no significant issues in diesel up to 100% but this requires further work.

The Options study assesses the cost of ethanol production at $2.96/litre (petrol equivalent) or 9.23c/MJ, and the capital cost of production facilities at $200 million for a 90 million litre capacity plant. Biodiesel, on the basis of a less detailed assessment, is costed in the Options report at $1.88/litre (diesel equivalent) or 5.8c/MJ, with the capital cost of production plant around two thirds of an ethanol plant.

High-level analysis indicates that given a current price of oil at US$80/barrel and a petrol price, ex all taxes and margins, of currently around 75c/litre (MED, 2009 average price) bioethanol may become economic at an oil price of US$315/barrel. For diesel however the current price is 79c/litre, ex taxes, which indicates that that biodiesel may be economic at an oil price of US$190/barrel. Clearly, further work is required on the economics, and the Options report suggests potential biofuel manufacturing price reductions of around 35%; requiring if achieved respective oil prices of US$205 and US$125/barrel.

(note: figures in the UK Bioenergy Strategy 2009 generally support the costs for biodiesel production in the Options report, but also indicate that the costs of bioethanol production may be lower than those for biodiesel).

## 11. Impacts of feedstock prices, taxes and exchange rates

The Options study plant sizing of 90 million litres of output per year, requiring around 750,000 cubic metres of logs annually for ethanol production, a little less for biodiesel. The plant sizing was based on the availability of biomass at a reasonable price and the study indicates that larger plant sizes may give better economies of scale. A plant of this size was estimated to have a capital cost of around $200m, in addition to the substantial investment required in developing the forests and fuel crops and the infrastructure for harvest, storage and transport.

Table 3, from the Options study assessment, and prepared on a different basis, shows the relationship between exchange rate, tax regime and feedstock price. The oil price is currently around US$80/barrel.

**Table 3: Impact of feedstock price, taxes and exchange rate on required oil "barrel" price**

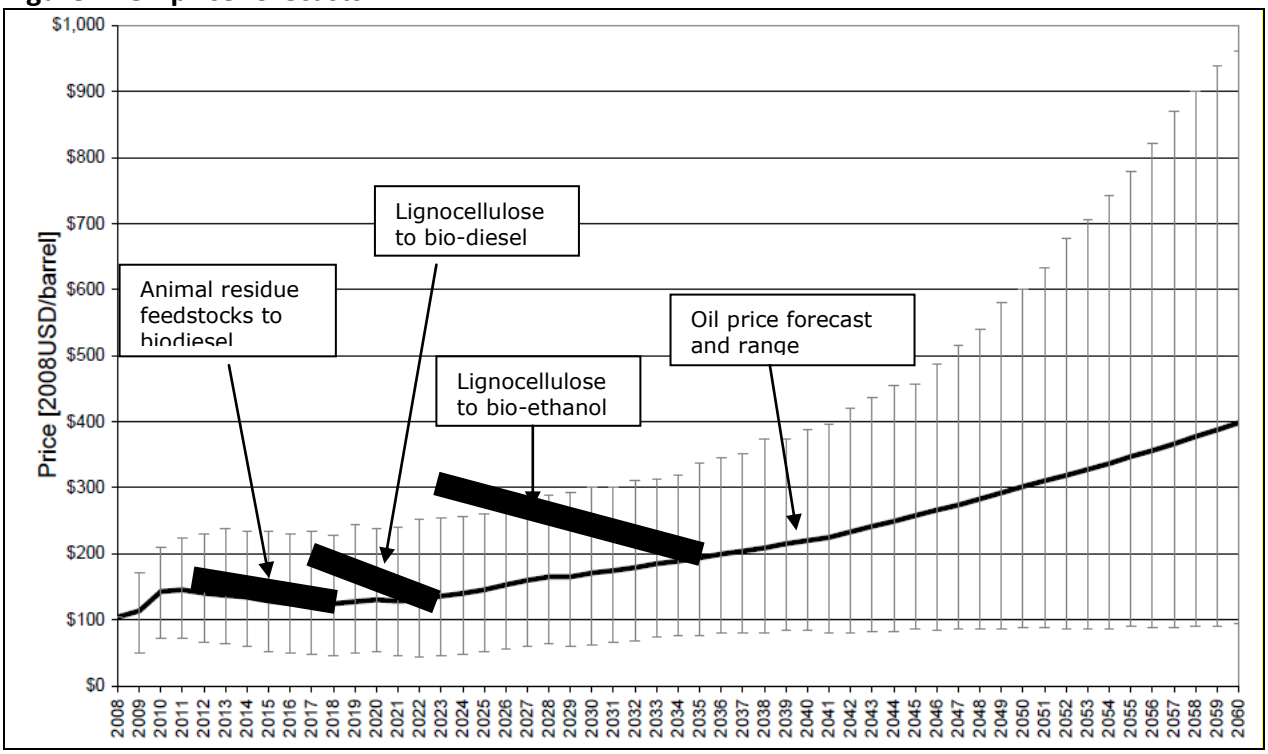
| | | Foreign exchange rates NZ$ to US$ | | |
|---|---|---|---|---|
| **Feedstock price** | **Tax applied to bioethanol** | **0.55** | **0.65** | **0.75** |
| $50 per $m^3$ | GST | US$117/barrel | 138 | 159 |
| $50 per $m^3$ | Excise + GST | 156 | 185 | 212 |
| $85 per $m^3$ | GST only | 144 | 171 | 196 |
| $85 per $m^3$ | Excise + GST | 185 | 216 | 249 |

Table from the Bioenergy Options study summary
Note: Figures are not reconciled to those in the text

New Zealand's long run historical average exchange rate versus the US dollar is in the 0.6 to 0.65 range and the current rate is over 0.70. A lower exchange rate increases the cost of fuel derived from imported oil.

A future oil price forecast based on a study carried out by McCormick Rankin Cagney is shown in Figure 7. Overlaid on this is an indication of costs of producing fuel from animal residues feedstocks (noting the small potential volumes) and ethanol and diesel from ligno-cellulose. It can be seen that it will take around 15 to 20 years for bioethanol from wood to be competitive, though biodiesel is likely to be on a shorter timescale.

**Figure 7: Oil price forecasts**




Sources: Oil price projection (McCormick Rankin Cagney)
Biofuel trends – East Harbour Energy

There will not be a simple answer as to which is the most suitable biofuel for New Zealand as all will contribute to the move away from fossil fuels. Even bioenergy on its own will only be part of the future where it will sit alongside other bio-materials and bio-chemicals produced from bio-refineries to take advantage of our ability to grow and process suitable crops and forests. We must not consider bioenergy in isolation but must work closely with other interested parties to ensure that there will be no conflicts over land or feedstock use and that collaboration leads to New Zealand maximising the opportunities which our land availability and climate offer.

## 12. Research and development

Internationally a range of biomass-to-energy conversion technologies are under development, offering prospects of improved efficiencies, lower costs and improved environmental performance; the focus being largely on the production of bio-oil, bioethanol and biodiesel. With many countries investing heavily in the development of second generation bioenergy technologies, it is proposed that New Zealand position itself to be a fast-taker and adaptor of these advances, with modifications to suit local conditions as required. This will require a close working collaboration with international organisations with access to knowledge gained from this research.

There are many non bioenergy groups in New Zealand who are carrying out research on the use of biomass feedstocks to produce high value bio-materials. These may be for pharmaceutical use, components of bio-plastics or many other applications. This work should not be seen as a treat to the Bioenergy Strategy but rather as a potential bonus when energy and other production systems can be incorporated. The development of bio-refineries with multiple outputs promises huge potential for the bioenergy industry. Work by all parties must be co-ordinated and the government is probably best placed to provide this overview however BANZ will continue to play a large part in future developments.

Immediate term research programmes need to focus on encouraging the transfer of applied technology while longer term research needs to be on suitable energy crops and liqnocellulose to energy technologies.

While the strategy sees New Zealand as a taker and adaptor of overseas technology there is an immediate need for funding to support research to identify the most suitable crops and planting and harvesting regimes, and the appropriate technologies.

### 12.1 Biomass resources

The scenarios used as part of the Options project mainly considered the resources available for the forestry industry. There are other existing and potential resources which can be used in the development of bioenergy and these must also be part of this strategy.

New Zealand's current and potential bioenergy resources include:

- Conventional forestry harvests, including residues (with currently high volumes exported unprocessed). Predominantly Pinus Radiata, but with a wide range of other species available
- Short rotation forestry crops including Salix and Eucalypts
- Agricultural crops including oil-bearing plants such as Canola, and "grasses" such as Miscanthus
- Agricultural residues such as straw
- Municipal, agricultural and industrial wastes which may be burnt or digested to produce methane
- Algae (specially grown or as a by-product of waste treatment) as a basis for biodiesel production

Of all the resources woody biomass, including the biomass derived from fuel crops, has by far the highest potential for wealth creation however other resources will contribute to the overall growth of bioenergy.

### 12.2 Key technologies

The following technologies are considered options for future conversion of forestry and crop biomass to fuels, or for export:

- Bio-oil production by a pyrolysis process which is in the development phase, though proprietary systems are becoming available overseas and a pilot study is underway in New Zealand. This produces from woody-biomass a bio-oil that can be burned in very large diesel engines (ships) or potentially converted to biodiesel or jet fuel. It can be operated at small-scale, but may be scalable.
- Combustion of wood products to supply industry with process heat

- Gasification of wood has been used for many years and can be considered an established process at smaller scale. Extensive research is being devoted to scaling this process as a basis for liquid fuel production
- Plasma gasification of biomass and municipal wastes is an emerging technology and is likely to be a technology used in future waste to energy plants. While often not considered as biomass, the use of municipal waste combined wood fibre or energy crops will be used more as a source of heat and power while reducing the use of landfills
- Ethanol production is a process under development, and subject to a research project by Scion. It is seen as several years from pilot production. There is very large international research being carried out to develop cost effective conversion processes and this is an area where New Zealand can be a fast follower and adaptor of these developments. We must identify suitable companies and organisations and develop knowledge sharing agreements with them.
- Biodiesel can be produced by firstly gasification and then using the well established Fischer Tropsch process to convert the gas to biodiesel. A number of companies are developing this process and conversion figures of 90-100 litres of biodiesel per green tonne of woodwaste have been quoted
- Export products:
    - Pellet production. New Zealand has a number of pellet plants but, unlike Australia, has yet to develop export markets for this high quality fuel
    - Torrefaction is a thermo-chemical treatment of biomass that results in a product with a significantly higher calorific value and greatly improved physical properties, particularly in relation to size reduction for transport and storage. One New Zealand business is understood to be investigating exports of products using this process.
    - Liquid biofuels. The establishment of large targets for the used on biofuels in transport will provide an opportunity for NZ to export liquid biofuels within a few years.

## 13. Industry parameters and economic impacts

The Options study included two “general equilibrium” studies by Infometrics covering an “analysis of bioenergy options” and “bioenergy supply from New Zealand’s forests estate and the impacts of volatile fuel prices”. This work assessed the effects of the various bio-energy scenarios on the allocation of resources in the economy and through these variables the effect on measures of economic welfare such as the standard of living of households.

As biomass derived fuels have the potential to materially affect national outcomes and overall economic performance, requiring specific Government/policy consideration, the impact of these products have been identified as requiring further analysis.

To put the numbers and scale of the potential opportunity in perspective a very high-level picture, based on the Options study numbers, is shown in Appendix 1.

## 14. Sustainability and Biosecurity

Sustainability is a critical issue for the bioenergy industry internationally and in New Zealand. Many Governments and market segments now consider that quantitative, robust and independently verified (or certified) sustainability credentials are vital in order for the bioenergy industry to expand globally.

This is already translating to government policies in some countries and there is a need for New Zealand to be part of these developments and to have input to them. With the need for export to play a large part in our bioenergy future it is important that the country will be able to prove the use of sustainable resources and that our products are not a biosecurity treat to other countries. We must also be sure that any import or development of new crops into New Zealand does not threaten our existing bio-diversity. Australia has already commissioned research on the establishing of suitable standards and controls relating to the growing and production of bioenergy and New Zealand should joins with Australia on this work.

There is the need for policies to limit market access and government support to only those crops and biofuels which meet specified sustainability criteria. It must also be shown that there are controls so that large areas of land presently used for the production of food are not converted to the growing of energy crops Policies will also need to ensure that other existing or future industries and land use are not threatened by support of bioenergy.

Within new Zealand EECA has established a voluntary sustainability reporting regime and BANZ is establishing an Accreditation Scheme.

International research, particularly in Canada, has shown that the development of bioenergy processes in conjunction with existing industries such as pulp and paper mills and sawmills is not a threat to these industries but actually greatly enhances their profitability and sustainability. It is likely that bioenergy will be the key to many existing companies surviving in tough economic times. With the present treat to many sawmills, and even pulp and paper plants in New Zealand it is important that all sectors of the wood fibre industry work together in the development and actioning of this strategy to their common benefit. Bioenergy must not be seen as a treat to established industries or wood fibre use.

## 15. NZ Bioenergy Strategy

This background paper should be read in conjunction with the 'New Zealand Bioenergy Strategy' which sets out a framework for action. The Strategy has been developed with support from government as there is recognition that the development of a viable bioenergy industry is important for New Zealand in that it introduces alternative uses for marginal land, reduces carbon emissions and lessens the county's dependence on imported fossil fuels, but most significantly can provide substantial economic growth.

### 15.1 Principles of the strategy

The following are some of the key points on which the NZ Bioenergy Strategy has been based:

- Initial industry development based on existing residues/feedstocks
- Retention/expansion of the wood processing sector as a source of quality wood fibre
- Development of wood fibre and feedstock markets
- Recognition of the value of bioenergy in the achievement of climate change targets, and as a basis for effective climate change policies
- Government assistance for the establishment of biofuels markets, the expansion of biomass plantings and for the development of processing facilities
- Development of NZ Biofuel brands
- Demand stimulation
- Fuel standards
- Public education on biofuels
- Recognition of other benefits, including:
    - Waste reduction
    - Environmental protection (areas such as air quality, nitrogen oxides...)
    - Security of energy supply
    - Lowering the carbon footprint of exports and tourism through the use of biofuels in manufacture, shipping and transport
    - Enhancement and protection of Brand NZ
    - Maintenance of market access to international markets
    - Enhancing regional development, employment and resilience of communities

The strategy progresses to outline the sector's full potential via:

- Assistance to land/forest owners to gain value from wood fibre by increased demand

- Incentives to encourage investors in forest planting, crop growing and processing facilities
- Incentives to encourage commercial / industrial heat users to use wood chip as an energy source
- Provision of NZ biofuels marketing assistance
- Assistance for R&D for lignocellulose and algae to liquid biofuels process development
- Use of short rotational crops (SRC) and then long rotational crops (LRC) in the production of heat and transport fuels

### 15.2 Strategy phasing

The vision will be achieved via a three-phase strategy:

The primary focus is on the **Foundation Building Phase (2010 to 2015)** in which preparation for growth will be based on existing resources, processes and markets while consolidating expertise, creating a basis for broader acceptance and utilisation of mature technology and products, and increasing understanding of the market drivers for wood-based energy, wood fibre, and other products. Biogas from municipal wastes provides opportunities for waste reduction.

Develop the wood fuel market providing quality feedstock with forward contracts to heat market and position for later expansion as feedstock for production of transport biofuels and bio-chemicals extraction in later Phases. Commencement of wood pellet export market, including torrefied wood pellets.

In this phase the supply-chain infrastructure will be developed and the technical and economic platform for growth will be confirmed as well as decisions made around crops, processes and future fuel production: based on expanded and commercially focussed research into fuel crop growing, processing technologies, and trial plantings. Establishment of applied technology transfer programmes based on being fast followers and adaptors of overseas research.

Establishment of regulatory environment and experience of production within it. Development of suitable standards and controls to ensure that new crops can be shown to be sustainable and are not a threat to New Zealand's bio-security. Secure Government and investor support.

The activities in the Foundation Building Phase are critical to success in subsequent phases.

The **Development Phase (2015 – 2020)** will see demonstration plants for transport fuel production and plantings of energy forests and fuel crops in selected regions. Heat use growth will continue to maximise available opportunities. Growth in fuelwood demand, and the export of wood chip and pellets will build on the infrastructure of the wood processing sector and provide economies of scale for expansion of planting and harvesting technology developments allowing economical harvesting of forest residues. This will see growth in value to landowners with energy crops a co-product with other land uses. Development of a new market for low grade (chip) logs will add value for existing forest owners, who have an increasing annual volume of potential cut in the period 2020 to 2030 and some challenges in marketing this material.

This phase sees the commencement of an investment programme estimated to be in excess of six billion dollars, requiring a mix of lignocellulose to transport fuel initiatives.

In the **Expansion Phase (2020 – 2040 and beyond)** investment in bio-refineries for the production of transport fuel and other associated bio-materials will be supported by expansion of fuel crops and energy forests on marginal land and on-going research and development.

Specific Action plans for implementation of the Strategy are under development.

## 16. References

a. Scion 2007 Bioenergy Options for New Zealand – Situation analysis

b. Scion 2008 Bioenergy Options For New Zealand – Pathways Analysis

c. Scion 2009a Bioenergy Options For New Zealand – Bioenergy Research and Development Strategy

d. Scion 2009b Bioenergy Options for New Zealand – Large scale bioenergy from forestry

e. Scion 2009c Bioenergy Options for New Zealand – Transition analysis

f. NZ LBI 2008 New Zealand Lignocellulosic Bioethanol Initiative – Feasibility Study Short Report, April 2008

g. Clean Energy Trends 2010, Clean Edge Inc

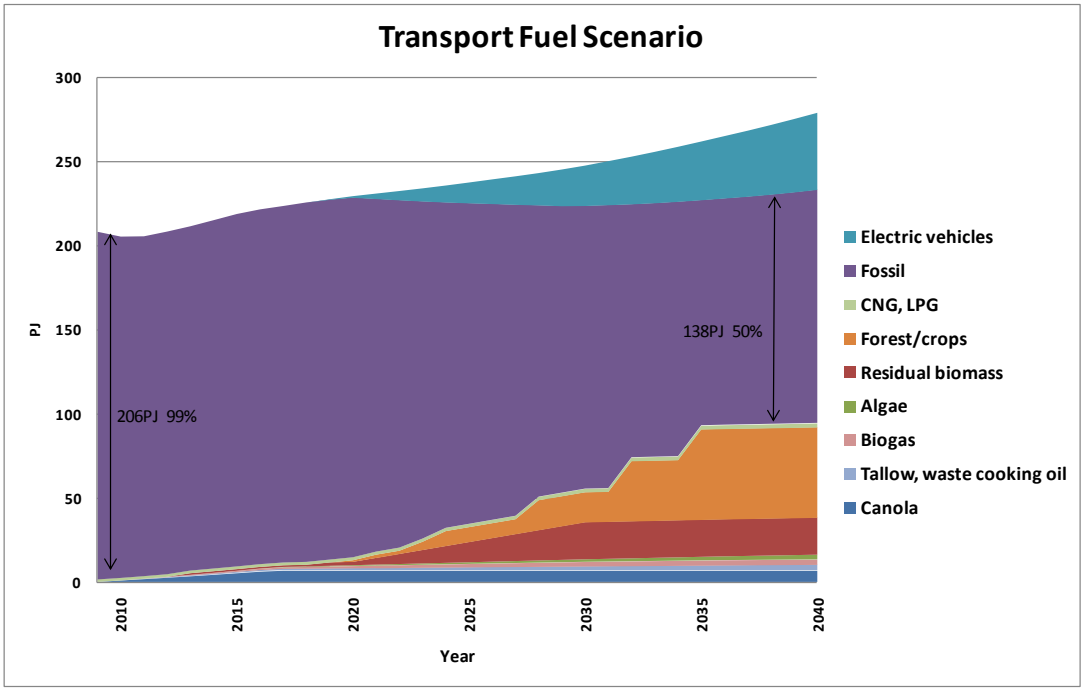
h. Energy Research - Roadmaps for Science, Dec 2006

i. New Zealand's Energy Outlook 2009/10 – Changing Gear, Ministry of Economic Development,

j. Transforming Canada's Forest Products Industry, Forest Products Association of Canada, February 2010

## Appendix 1: Transport fuel scenario assumptions

The transport fuel scenario shown in Figure 3 is based on the following assumptions.




**Demand**

- Energy demand for transport is the Reference Scenario from MED's Energy Outlook 2009.
- Is BAU in terms of broad trends in key economic drivers, policy settings, technology and fuel choices. Uses central forecasts of population, GDP, NZ$ exchange rates and continuation of enacted government policies such as the emission trading scheme.

**Supply**

- Electric cars energy use based on estimates from Electricity Commission report and Meridian/Contact report of October 2009. Approximately midway between the two reports.
- Algae derived fuels will reach 1% of transport energy by 2040.
- Canola derived fuels will reach 7PJ around 2020 and remain at this level until 2040 (due to competition from cheaper biofuels)
- Residual biomass derived fuels will reach 22PJ around 2022 and remain at this level until 2040 (limited resource)
- Biogas for transport use will reach 3.15PJ around 2035 and remain at this level until 2040 (this being 70% of total biogas produced.)
- Energy forest and fuel-crops derived fuel volumes are based on a modified version of a SCION (Peter Hall) estimate.

**The numbers in perspective**

The examples below are intended to illustrate, based on a very high-level interpretation of numbers taken from the Options study, the scale and scope of a high-growth bio-energy strategy.

Scion estimated in the Options study the costs for ethanol and biodiesel production, and this included an assessment by Infometrics of the potential impacts on New Zealand's economy. However the scenario shown in figure 2 is for lower volumes, reflecting a range of assumptions and the examples below are for a lower volume still.

In order to quantify the economic and other parameters the following scenario is considered:

- Six larger facilities sized at 9PJ pa (260m litres pa) of production, rather than the 90m litres in the Options report:
    - Affording economies of scale, and equating to what is seen as a more "typical" size of plant
    - Production costings assumed to be at the lower end of the Options Study range
    - Located in areas identified in the Options report as having the potential to supply the required biofuel: Manawatu (two plants), Gisborne, Wellington and Otago/Southland (two plants)
    - Producing in total around 1.6 billion litres of fuel (ethanol or diesel) per annum, this being around 20% of New Zealand's requirements

**For one 9PJ (260m litre) production facility**

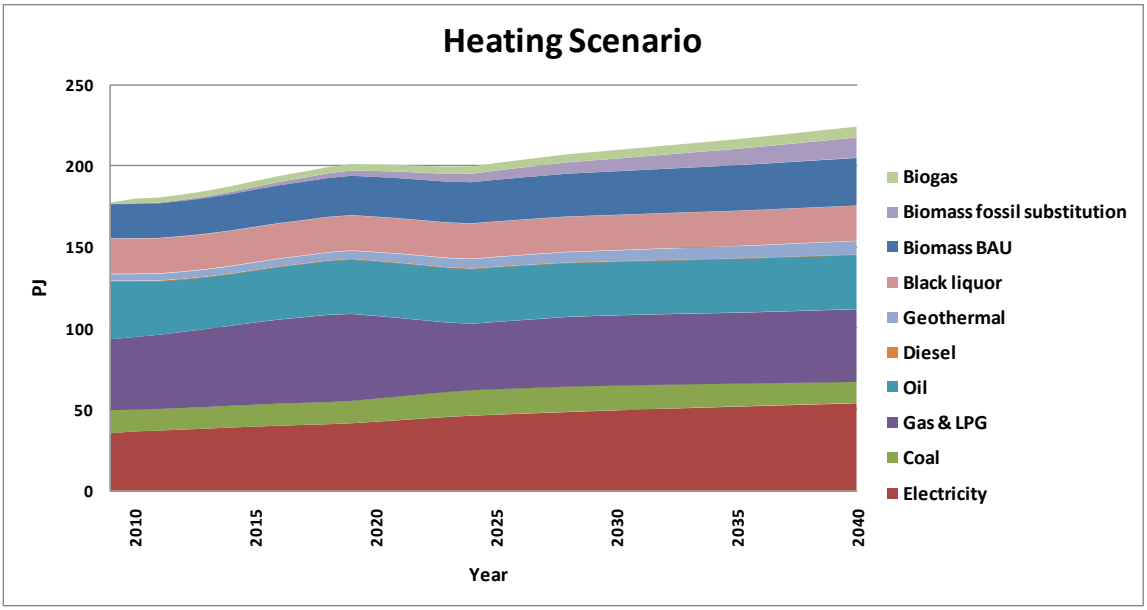
- Each plant will require indicatively:
    - 2.7m tonnes pa of pinus radiata chip or 900,000 tonnes pa of Miscanthus (or a mix of these, and potentially residues)
    - This equating to around 60,000 ha of miscanthus, or perhaps twice that of forest; equivalent to between 2 and 4% of the land within a 100km radius of the facility depending on the crop mix
- Financial parameters:
    - Capital
        - Ethanol plant – around $1 billion including $600m for the processing plant (the balance infrastructure and crop establishment costs)
        - Biodiesel – around $750m overall
    - Cost of production  around $400m pa
- Carbon dioxide reduction around 550,000 tonnes pa, excluding sequestration effects
- Employment not known, but very substantial
- Timescale: the scale would require extensive planting of fuel crops with new forestry not available for circa 25-years.

**For six plants**

The establishment of six plants and associated infrastructure and cropping by 2035 would involve the investment of around $5 to $6 billion depending on the fuel mix, over 20-years, produce around 1.6 billion litres of fuel pa, or 20% of New Zealand's projected liquid fuel requirements, reduce CO2 emissions by 3.5m tonnes, and require the use of around 600,000 hectares of land.

## Appendix 2: Heating scenario assumptions

The transport fuel scenario shown in Figure 2 is based on the following assumptions.




**Demand**

- Energy demand for Residential, Commercial and Industrial Sectors is the Reference Scenario from MED's Energy Outlook 2009.
- Is BAU in terms of broad trends in key economic drivers, policy settings, technology and fuel choices. Uses central forecasts of population, GDP, NZ$ exchange rates and continuation of enacted government policies such as the emission trading scheme.
- Heating demand for residential sector derived from HEEP, 10 year analysis for Household Energy End-use Project No. SR 155 (2006).
- Heating demand for commercial and industrial sector derived from EECA's online Energy End Use database.

**Supply**

- Over time as fossil fuels will become more expensive there will be fuel substitution by renewable fuels, and reduced demand
- The percentage of electricity used for heating will be unchanged through to 2040 with heat pumps offsetting substitution
- The percentage of coal used for heating will be reduced by 50% by 2040
- The percentage of natural gas and LPG used for heating will be reduced by 20% by 2040. (gas in some cases will be substituted for coal, some gas replaced by electricity)
- The percentage of fuel oil used for heating will be reduced by 50% by 2040
- The percentage of diesel used for heating will be reduced by 50% by 2040
- The amount fuel energy substituted is replaced by renewable fuels in the following proportions:
    - Electricity will take 10% of the fuel substituted offset by 10% reduction in use - efficiency etc)
    - Gas and LPG will take 10% of the coal, fuel oil and diesel substituted
    - Geothermal will take 15% of the fuel substituted (geographically constrained)
    - Biomass will take 65% of the coal, gas and diesel fuel substituted

## Appendix 3: Demand side drivers and potential risks and barriers

### Demand side

The demand for bioenergy fuels and products will be driven clearly by a range of economic and other factors. These are summarised (primarily with respect to woody-biomass) in the table below:

| Demand driver | Comment | $'s |
|---|---|---|
| **Shortages and price rises; alternative fuels** | | |
| World and New Zealand demand for wood-fibre (forest and crops) is expected to increase significantly. Opportunity areas:<br>• NZ heat supply<br>• Export<br>• Biofuels | Based on increasing demand for green fuels as a result of shortages of oil and gas and moves to a low-carbon world economy | Opportunity is for billions in investment in growing and processing, and for the profitable production of high volumes of product |
| Pricing is expected to follow (generally) oil prices | With a carbon charge bioenergy is expected to become economic in time; depending on the fuel displaced | |
| **National benefits** | | |
| Displacement of hydrocarbon fuels, coal and gas | Potential is to displace high percentages of coal currently used in heat supply, and a significant percentage of petrol and diesel use | Requires a significant carbon cost, and high oil prices, as forecast |
| Enhanced national security of energy supply | Potentially replaces a significant percentage of liquid fuel imports with indigenous production | Potentially a range of benefits associated with lower risks |
| Economic growth, other national economic benefits | Infometrics studies indicate potential for macro-economic benefits depending on hydrocarbon-fuel and carbon costs | |
| Reduced greenhouse gas emissions and national commitments and costs associated with carbon emissions | Primary areas:<br>• Displacement of fossil fuels<br>• Carbon sequestration | Potential very large national benefits from the avoidance of associated payments |
| Skills development for processing operations | Manufacture of pellets, but particularly liquid biofuels will require high level technical | Significant enhancement of NZ's industrial |

| | | |
|---|---|---|
| | skills | skills base |
| Reduced emissions of other products such as sulphur, NOx | Biofuels offer significant reductions in a range of emissions | Potential $ benefits from increased health and wellbeing |
| **Benefits to landowners** | | |
| Increased revenues and improved revenue resilience | The costings in the options study are based on higher and more consistent returns to landowners, compared with current land uses | A land rental of $280 per ha has been assumed in the Options study modelling |
| Shorter harvesting rotations and production lead-times (from fuel-crops) | Fuel-crops offer annual crops after (say) two or three-years | Higher investment returns |
| Potential for cropping on marginal lands | Offers economic returns from poor land | |
| Diversification of farming outputs and revenue streams | Fuel and forest crops offer alternative income streams | |
| Nitrate management, reduced erosion and reduced run-off from agricultural operations | Forests, and fuel crops, generally require low inputs and reduce run off | |
| **Regional benefits** | | |
| Regional and rural job creation | Liquid biofuel production will require considerable regional employment | |
| Stimulation of rural infrastructure and economic development, with increased rural community resilience | | |

**Potential barriers and negative impacts**

| Potential impact | Comment |
|---|---|
| Economic costs if hydrocarbon fuels costs do not increase as expected | Potential risk given that the economic case for bioenergy depends on predicted higher prices for alternative fuels |
| Technology risks | Technologies are relatively unproven (especially ethanol) with attendant risks |
| Impacts on current wood processors and exporters | May reduce supply of raw materials but does also provide potential alternative markets for their wood fibre |
| Negative impacts on agricultural exports | Energy crops may use land presently growing for export. However most land used for energy crops or forests will be marginal land which is presently unproductive |

| | |
|---|---|
| | Refer Options study for detailed analysis |
| Potential increased food prices | Would only happen if returns from energy crops are higher than producing food. |
| Liquid bio-fuels will require changes to transport fleets and fuel infrastructures | Production of bio-diesel will require less infrastructure than production of bioethanol |
| Potential impacts on biodiversity | It could also be argued that biodiversity would increase |
| Huge investment requirements over long time horizons | Outside normal commercial investment parameters and risk profiles<br>This can only be managed with Government involvement |