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A Picture of Bioenergy Opportunities for New Zealand leading to A NZ Bioenergy Development Strategy

Executive Summary

Over the next 30 years the world, and New Zealand, is likely to face a substantial increase in oil and gas prices. This strategy covers the development, if a strategic decision is made to follow this path, of a nationally significant bioenergy business sector built on New Zealand's capability and expertise in growing and processing wood-crops and converting organic by-products to energy. This sees, by 2040, bioenergy supplying more than 25% of the county's energy needs, including 30% of the country's transport fuels.

This strategy builds on the findings of the Bioenergy Options project (Scion, 2007, 2008, 2009a, 2009b, 2009c). 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 in meeting New Zealand's future energy needs.

Biomass produced in New Zealand offers a very-large scale low-carbon energy scenario; building on the existing strengths of an already substantial bioenergy sector. The staged development strategy proposed has low risks and potentially large 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 the strategy is based on the increased utilisation of existing residues and wastes and the progressive development of a range of bioenergy technologies and products including biogas, wood-energy, biodiesel and bio-oil from existing organic residues. While confidence in products and processes is established, a comprehensive wood-fibre market is developed, and research continues into the development of liquid-fuel manufacturing processes.

In the longer-term the high bioenergy growth path is based on the planting of large areas of plantation forests and fuel crops and the production, in large-scale plants, of liquid fuels displacing hydrocarbon fuels in the market and other chemical products. A strategic decision to commit to this will be required by 2015 if the volumes are to be significant by 2040, given the long growth cycle for forestry crops. In addition to liquid fuels, biomass will continue to be used in direct heat production and the production of gaseous fuels and bio-oil while a world-wide projected shortage of wood-fibre offers potential for exports, offering alternative markets for the large biomass volume increases.

Alternatively the incremental bioenergy growth strategy could be continued, though this would forgo economic and other gains 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. Should large-scale liquid biofuel production not develop as expected biofuel exports are seen as a fall back option given a projected world shortage of these products.

In the transition period, while large-scale forestry, cropping and processing operations are established, the strategy sees the existing low-value export logs used to increase raw material volumes to produce transport biofuels and synthetic natural gas.

The Options study, on the basis of considerable financial analysis, assesses the cost of ethanol production at $2.96/litre (petrol equivalent) or 9.21c/MJ, and the capital cost of production facilities at 92c/litre of capacity. 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 37c/litre.

A simplistic analysis says that given a current price of oil at US$80/barrel and a price of petrol, ex all taxes at currently around 75c/litre (MED, 2009 average price) and a price of diesel of 79c/litre bioethanol may become economic at an oil price of US$315/barrel and biodiesel at an oil price of US$190/barrel. Clearly, further work is required on the economics, and the Options report does suggest potential biofuel price reductions of around 35%.

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 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 developed.

1. Introduction

The "Bioenergy Options for New Zealand" project (The Options project)[1] 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 a draft *New Zealand Bioenergy Development Strategy* will be developed.

The strategy development is a joint initiative of the Bioenergy Association of New Zealand (BANZ) and the Forest Owners Association, with the support of the MED, NZTE, MORST and EECA. This report includes feedback on the first draft from all respondents, to the degree possible.

The Options project was focussed on the utilization of forest residues and new forest plantings to produce bio-ethanol, and this paper therefore is also primarily focussed in these areas. However fuel crops and biodiesel production for biomass are options that seem to offer significant potential; both requiring significant additional research.

This document is intended to summarize the findings of the Options project, the current situation and the potential for biomass, offering some strategic options for consideration at the February meeting of key interested parties before a strategy is finalised.

Vision

A nationally significant bioenergy business sector, built on New Zealand's capability and expertise in growing and processing wood-crops and converting organic by-products to energy, which by 2040 supplies more than 25% of the county's energy needs, including 30% of the country's transport fuels.

This will be **based on** the progressive development of a range of bioenergy products including biogas, wood-energy, biodiesel and bio-oil from existing organic residues and new energy crops. The majority of the growth in energy production will be based on the existing strengths of the forestry and wood processing sector utilizing extensive planting of forests and farm-based energy crops, and the use of these fuels for heat and electricity generation and the production of liquid fuels and other biomaterials.

The planting (of wood-plantations and fuel-crops, including on marginal lands, will add value for landowners and wood processors while diversifying their revenue streams and mitigating economic risks. This value will be enhanced by the establishment of much broader and deeper markets for biomass products and a range of other environmental and employment benefits.

This **will require** the early commencement of a $6 billion programme of investment in forest and fuel-crop growing and in the progressive development of processing facilities; creating an industry with annual revenues greater than $3 billion.

Extending bioenergy's contribution to the county's energy needs from 8% to 25% by 2040 will significantly reduce New Zealand's dependence on fossil fuels and imported oil, improve national energy security, and reduce carbon emissions by around 1.5 million tonnes pa, making a substantial contribution to New Zealand's international obligations for net greenhouse gas emissions.

Note: numbers are provisional

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1 "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

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2. Situation Analysis

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). Table 1 shows the breakdown of the 45.9 PJ (8.5%) of consumer energy that is currently available from biomass and wastes, in addition to the current usage which is of similar magnitude; this unused resource is mainly in the forest processing industries.

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

Currently utilised bioenergy is derived almost entirely from process 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.

International energy trends

Forecasts (refer Figure 6) 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 $80/barrel. This is based on rapidly increasing 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

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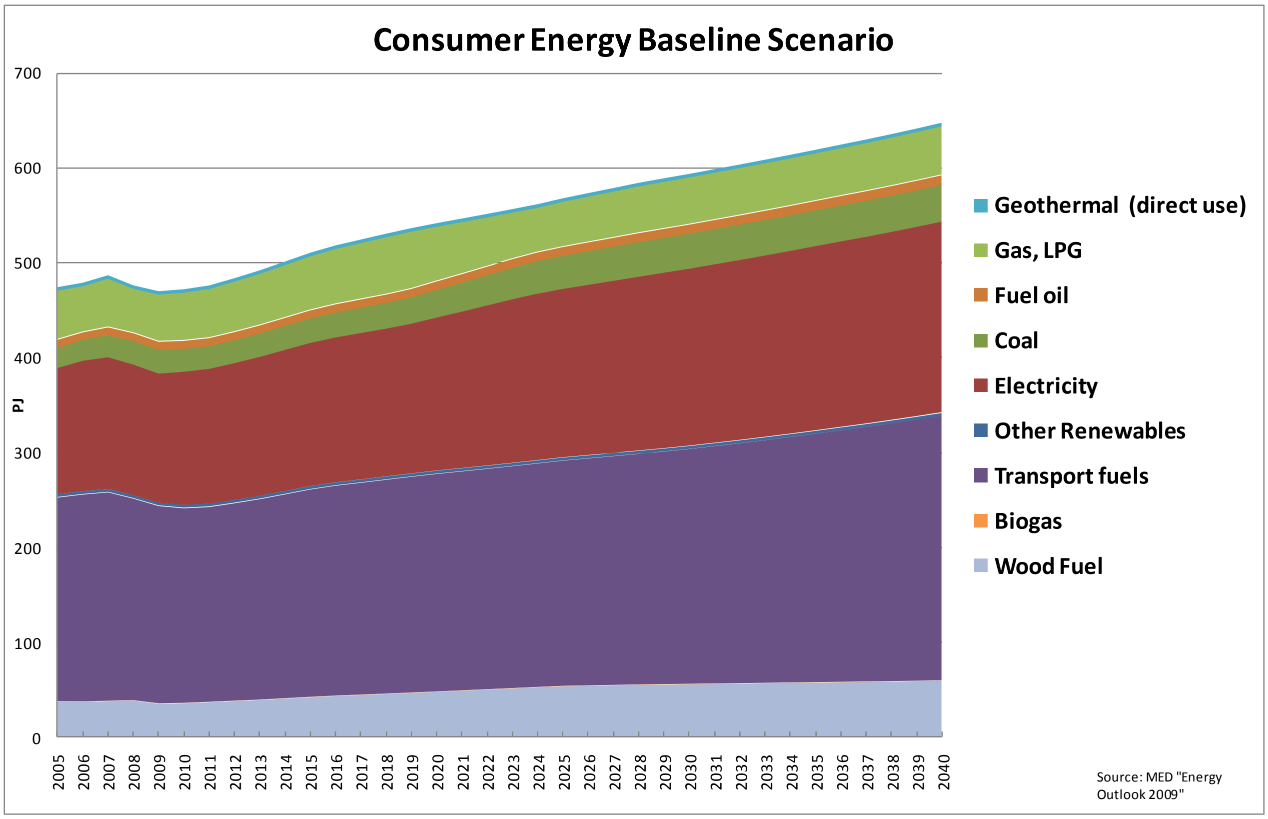
relative price competitiveness. There are some concerns over future gas supply and future prices will be determined by the size and location of any new gas discoveries.

3. The opportunities

Figure 1 shows the baseline "business as usual" Consumer Energy scenario from the Ministry of Economic Development's Energy Outlook 2009 publication. This scenario shows projected energy use and indicates the significant opportunity for substitution by bioenergy 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 type of fuel made such substitution may 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 demand and biomass supply may be viable.

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 and 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.

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

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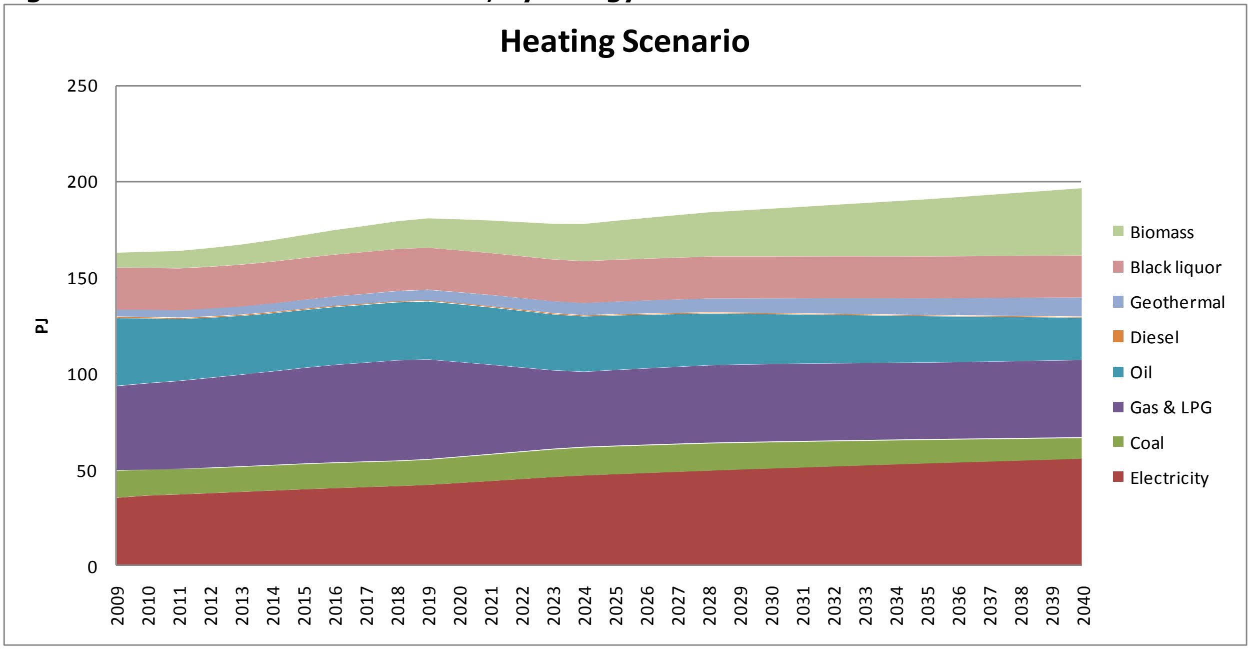
Fonterra plants, Huntly Power station and cement factories exist. Increased future oil and gas prices plus carbon charges will make those fuels more expensive, encouraging fuel substitution.

Figure 2: Scenario – future heat use, by energy source

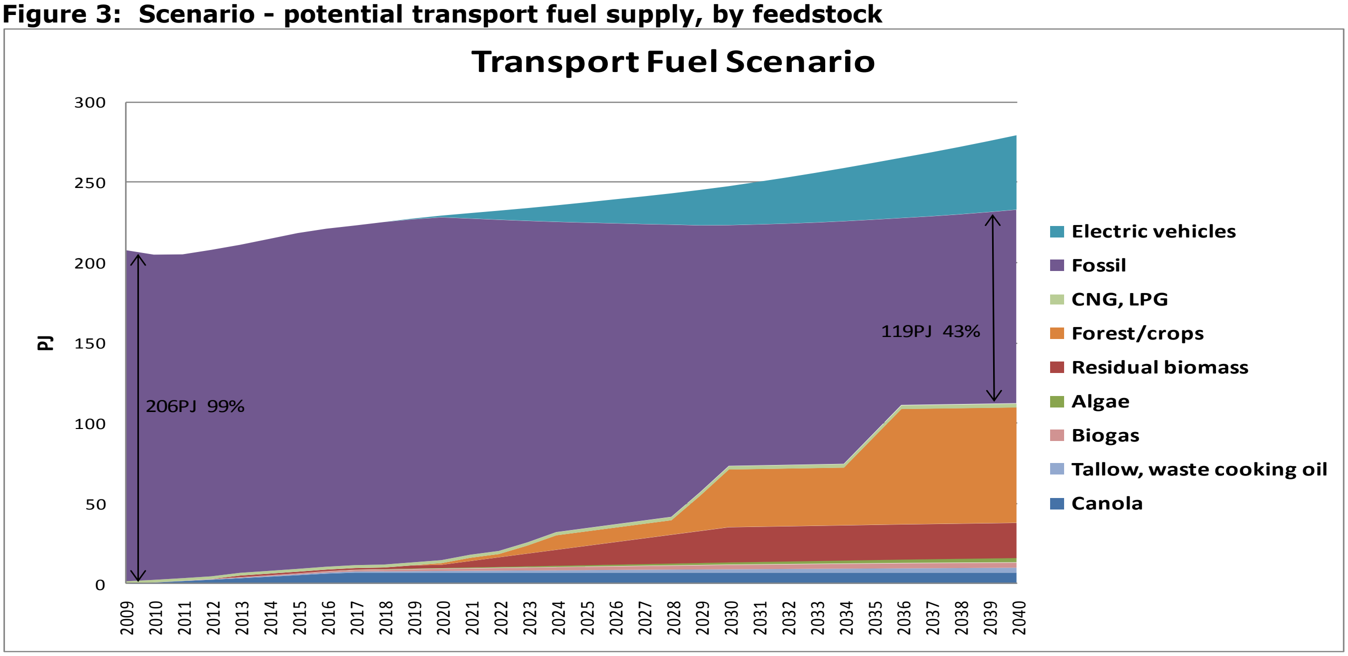


Interpretation by East Harbour Energy

Transport energy

Figure 3 shows a scenario, prepared by East Harbour Energy, showing transport heat use to 2040. As for heat the total fuel use is based on the energy forecasts in the Energy Outlook 2009, while the bio-energy components are based on an interpretation of the Bioenergy Options project, and the electric vehicle component on 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 5-year time frame and able to be be progressively introduced in New Zealand starting in 10-15 years, depending on economic drivers.

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



Interpretation by East Harbour Energy

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The Bioenergy Options project shows the theoretical potential for use of lignocelluloses for production of transport bio-fuels (refer Figure 4) is significantly greater than the figure of 72PJ shown in Figure 3, but the overall potential has been reduced for this report, to account for economics, the international fuel price data from Figure 6, and a range of practical and geographical considerations, to give the scenario in Figure 3.

4. Bioenergy Options analysis

The potential resource

The Pathways Analysis, the second part of the Bioenergy Options project, assessed available woody residues as currently the potential source of 46 PJ pa of additional consumer energy with this having the potential to rise significantly by 2030. 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.

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 (earlier and potentially higher returns) that are not available from long-rotation forests.

Environmental benefits

A life cycle analysis of the use of biomass feed stocks for energy production shows that they generally give an excellent return in the range 4.5 to 10.9 on the basis of energy produced in relation to energy inputs. 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 the material, and reductions in other emissions from fossil fuel combustion, such as sulphur, and also reductions in solid waste volumes with major impacts on waste disposal.

Environmental drivers aimed at reducing disposal of residuals as waste eg farm effluent, will encourage the production of biogas for embedded use, e.g. farm vehicles.

Other benefits

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

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 lignocellulose 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.

Key drivers in the growth of the sector are:

- The planting of extensive areas of energy forests and fuel crops
- Building a comprehensive bioenergy market from the existing wood-energy market so as to underpin and enable growth
- Wood processers recognising the value of wood fibre residues for uses other than combustion, or export
- Forest owners recognising the value of wood-fibre for a wide range of uses, and receiving appropriate returns from these uses

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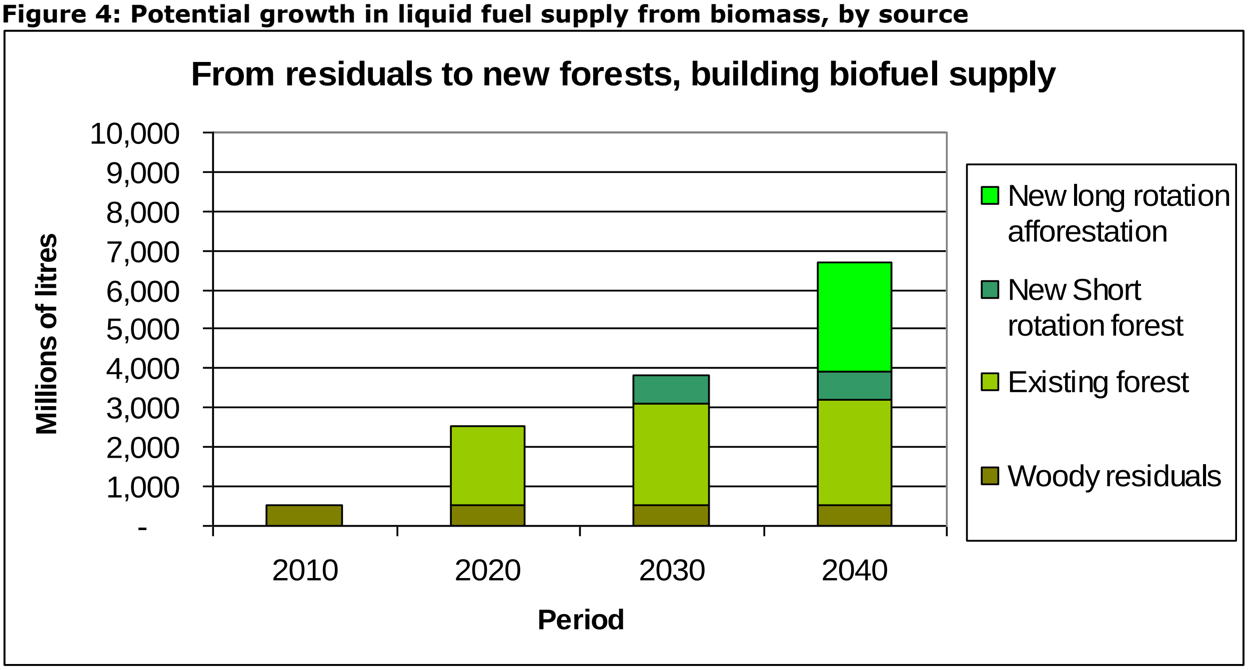
- Wood processors selling high quality wood fibre for high value uses such as wood pellets or ethanol production, and purchasing-in lower value wood fibre for combustion
- Increased use of biomass for direct heat by non wood processors
- Biogas generated from municipal and food processing residues used 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
- A relative price for hydrocarbon fuels (with a carbon cost or price rises) that makes biofuels economic.
- Industry developing a cohesive common message
- Industry creating a community of interest for lignocelluloses conversion to energy

Early adopters, regardless of whether through wood fuel, biogas or transport biofuel, will get the opportunity to develop best practices so that when substantial market growth occurs from purpose grown energy forests/crops they are ready to take full advantage of this.

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.

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



Source: Bioenergy Options for New Zeland – Transition Analysis

Residues alone are not enough

As energy prices (especially for oil and gas) rise in the future, economically recoverable biomass residuals will be sufficient only to meet 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

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processing facilities for economic energy production, will be required: to be sourced from new purpose-grown energy forests, crops and algae.

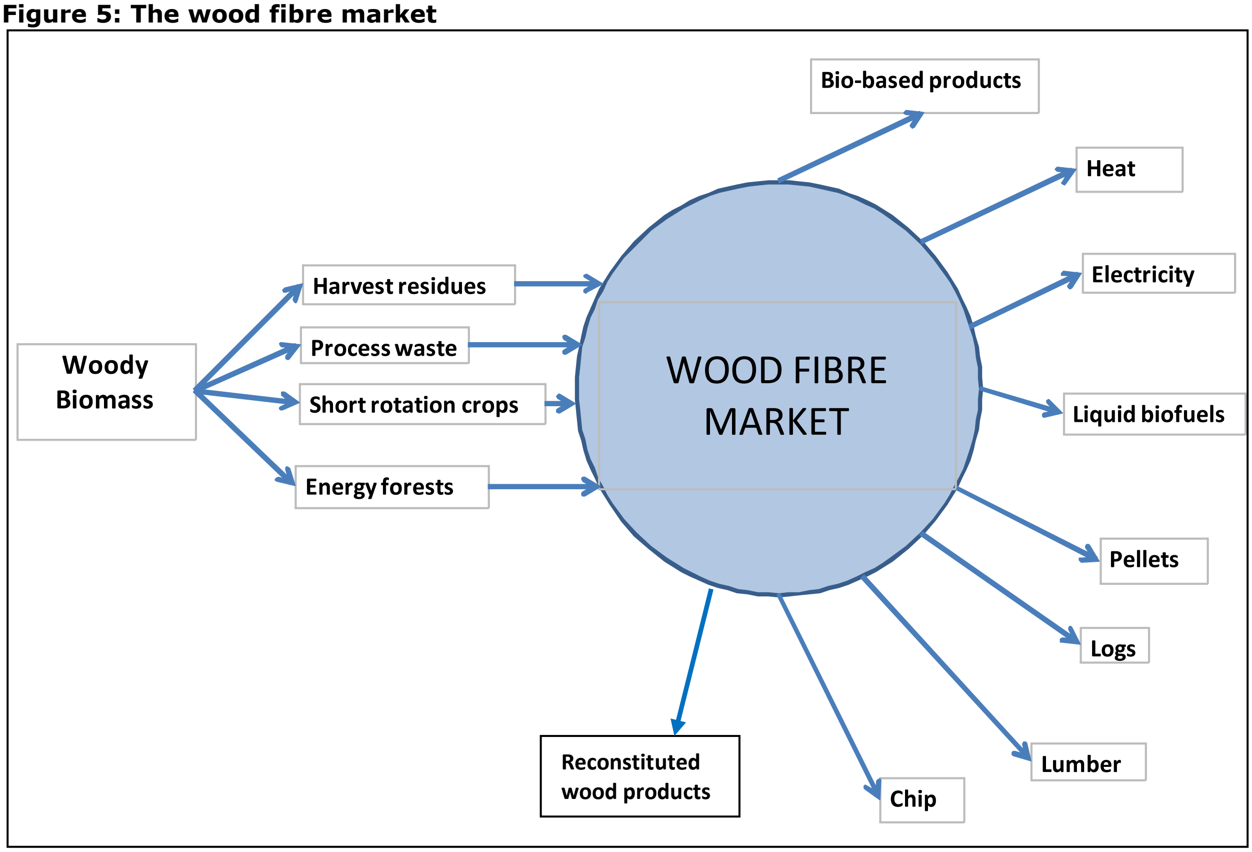
Analysis (refer Table 3 and Figure 6) shows that liquid biofuels may start to become economic from around 2020 and could become a mainstream energy source in the decade of 2030. The Pathways analysis shows that the big opportunity is from new energy crops/forests and theoretically some 3.2 million ha 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.

Liquid fuel production from wood residues and purpose grown forest-derived wood gives significant reductions in GHG emissions which can materially assist New Zealand achieve its climate change targets, and such crops also sequester carbon adding additional benefits.

Fuel crops

The production of bioenergy from forests or wood/grass fuel-cropping is more efficient in its land use than the alternative 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.

Figure 5: The wood fibre market



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Competition for wood-fibre

Woody biomass supports a variety of conventional timber and also energy-related end-uses (refer Figure 5) 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)

The production of bioenergy from wood-fibre will be strongly influenced by the alternative uses that producers can sell fibre for (refer Figure 5), and the value they receive from the uses in the market at that point in time. There are already significant supply constraints in the fibre market in different regions throughout NZ.

The wood-fibre market is at its early stage of evolution with only pockets of sales occurring; these 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, increased usage, and subsequently increased value being accrued by 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.

Beyond Residuals

While unutilised residues have significant initial potential, future growth will depend on purpose grown forests and crops, and to a smaller extent algae, as feedstocks for energy production. 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

5. Large scale bioenergy from forestry

The Bioenergy Options project considers 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 2.

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 economic.

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.

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The potential for growing new forests and 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.

Table 2: Summary of potential biomass and liquid fuel production by 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

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 high yields but need land at (indicatively) a slope less than 20^{o} for harvesting.

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

Biodiesel or bioethanol?

The focus of Scion's research and the Options study has been on the production of bioethanol. However the 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 $2.96c/litre or 9.2c/MJ, and the capital cost of production facilities at 29c/MJ of capacity.

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 37c/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.

Assuming large-scale production ethanol would require initial blending into the petrol available at the pump, progressively increasing the level of this blend. This creates a number of technical 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.

A very simplistic analysis says that given a current price of oil at US$80/barrel and a price of petrol, ex all taxes at currently around 75c/litre (MED, 2009 average price) and a price of diesel of 79c/litre bioethanol may become economic at an oil price ofUS $315/barrel and biodiesel at an oil price of US$190/barrel. Further work is required on the economics, and the Options report does suggest potential biofuel price reductions of around 35%.

Economics of bioethanol production

A New Zealand (NZ LBI, 2008) study considered also the economics of biofuel production, though there remain considerable uncertainties in this area. They modelled a plant 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 they indicate that larger plant sizes might give better economies of scale. A plant of this size was estimated to have a capital cost of around

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$200m, in addition to the substantial investment required in developing the forests and fuel crops and the infrastructure for harvest, storage and transport.

The assessment of the price of oil (US$ per barrel) required to make biofuels from wood competitive, by exchange rate, tax regime and feedstock price is shown in Table 3. The oil price is currently around US$80/barrel.

Table 3: The price of oil (US$/barrel) required to make bioethanol from wood competitive

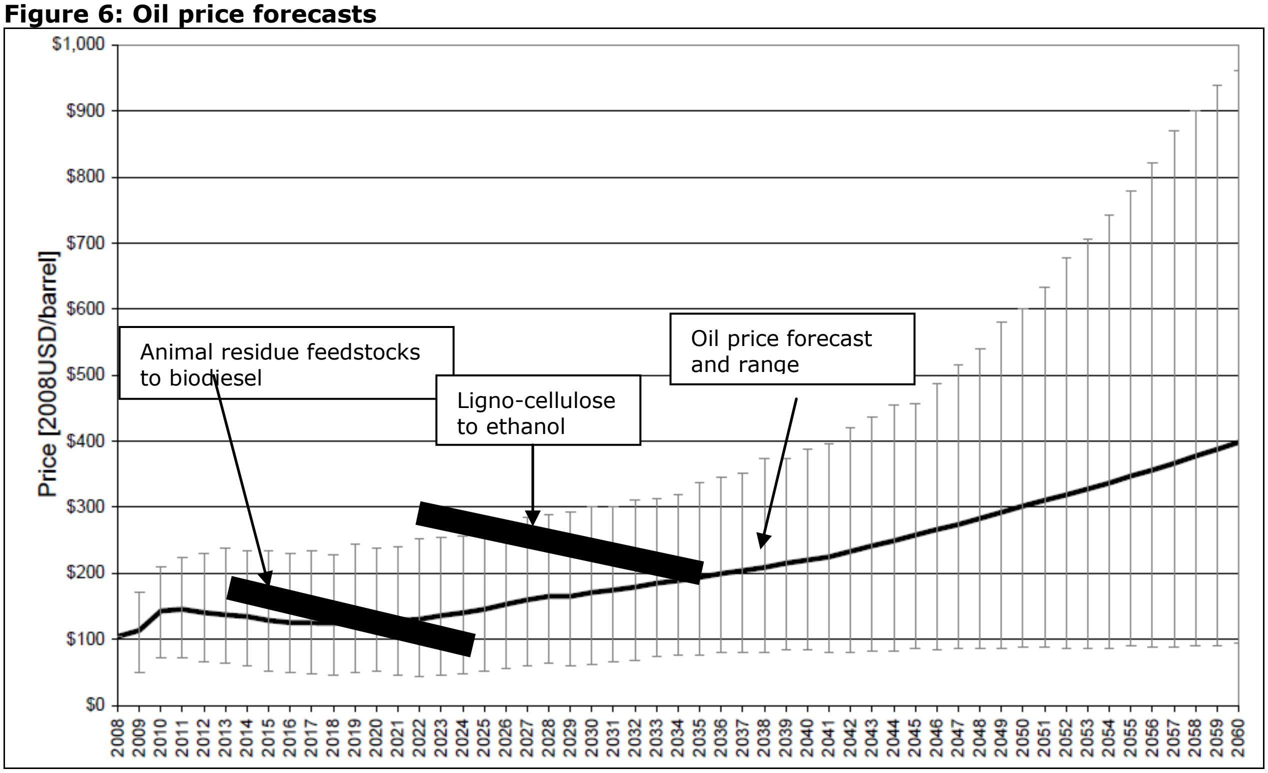
		Foreign exchange rates NZ$ to US$		
Feedstock price	**Tax applied to bioethanol**	**0.55**	**0.65**	**0.75**
$50 per m^3	**GST**	US$117/barrel	138	159
$50 per m^3	**Excise + GST**	156	185	212
$85 per m^3	**GST only**	144	171	196
$85 per m^3	**Excise + GST**	185	216	249

Note: Figures indicative only and 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 6. Overlaid on this is an indication of costs of producing fuel from animal residues feedstocks (noting the small potential volumes) and ethanol 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 may be on a shorter timescale.

Figure 6: Oil price forecasts



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

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6. 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.
- Gasification of wood has been used for many years and can be considered an established process at smaller scale. There would appear to be few difficulties in scaling this process
- Ethanol production is a process under development, and subject to a research project by Scion. It is seen as several years from pilot production.
- 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:
  - Pellets. 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.

7. 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 were reviewed economically, and this analysis was almost exclusively confined to bioethanol.

An additional paper will be prepared for the February 10 meeting covering these areas, to the extent possible given limited information.

8. Developing an industry strategy

The following are some of the key points on which a cohesive bioenergy industry development strategy could be 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:
  - Waste reduction
  - Environmental protection (areas such as air quality, nitrogen ...)
  - 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

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- Maintenance of market access to international markets
- Enhancing regional development, employment and resilience of communities

Progressing to 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
- 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) & then long rotational crops (LRC) in the production of heat and transport fuels

These points are tabled in this draft as a basis for discussion/agreement at the forum in February at which it is hoped that more specific measures will be developed.

A diagram showing a pathway approach to the development of the industry will be prepared for the February 10 meeting.

REFERENCES

Scion 2007 Bioenergy Options for New Zealand – Situation analysis

Scion 2008 Bioenergy Options For New Zealand – Pathways Analysis

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

Scion 2009b Bioenergy Options For New Zealand – Large scale bioenergy from forestry

Scion 2009c Bioenergy Options For New Zealand – Transition analysis

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

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Appendix 1: Transport fuel and heating scenario assumptions

1. Transport fuel scenario 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 moddified from a SCION (Peter Hall) estimate.

2. Heating scenario 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