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Collaborative Action to Achieve the Greenhouse Gas Emission Reduction Targets – Part 2

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This Plan of Action has been developed collectively by a stakeholders group of low carbon organisations and territorial councils around the opportunities that renewable energy and energy efficiency can contribute to achieving the greenhouse gas emission reduction targets announced by Government in Paris in late 2015. The content of the Plan of Action are the views of the contributing stakeholders with respective information provided by each.

For specific information contact should be made to the Individual stakeholders.

Hon Simon Bridges, Minister of Energy and Resources, addressing the “Yes we can!” symposium

Approved for Publication

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Bioenergy Association
NZ Geothermal Association
National Energy Research Institute
Energy Management Association of NZ
Pure Advantage
NZBIO
IRHACE
Business NZ Energy Council
Sustainable Business Council
Royal Society
Heavy Engineering Research Association
Sustainable Electricity Association of NZ
NZ Home Heating Assoc
Geothermal NZ
Aotearoa Wave and Tidal Energy Association
Sustainable Business Network
NZ Forest Owners
NZ Pacific Solar and Energy Storage Council
WasteMinz
NZ Farm Forestry
Forest Industry Contractors Association
Generation Zero
Wellington City Council
Venture Southland

1. Introduction

Currently New Zealand's primary policy for reducing emissions is the emissions trading scheme (ETS). Its effectiveness in reducing actual domestic emissions has been limited although it has raised the awareness of the need for GHG accounting and the importance of reducing emissions. The focus of this report is on the complementary measures to the ETS that could easily and fiscally be undertaken which would be less costly than purchasing trading units from international markets.

Government has introduced other measures which include supporting research and providing consumers with information. However few of the regulatory measures that are common overseas exist in New Zealand, such as motor vehicle fuel efficiency standards, mandatory biofuel requirements, green taxes, or renewable and energy efficiency portfolio standards .

This report is a collation by 21 low carbon stakeholder organisations of the contributions to greenhouse gas mitigation that can be made across the renewable energy and energy efficiency sectors and is submitted to assist central and local government policy makers and business decision makers identify "low hanging fruit" and priority opportunities. The report also outlines what would be achieved under a business as usual scenario and what could be done under encouraged and accelerated scenarios by Government and others which would speed up the achievement of the targets.

Part 1 of this report is an aggregation of the individual contributions by the low carbon stakeholder organisations that could assist New Zealand meet its climate change targets agreed in Paris in December 2015 under the United Nations Framework Convention on Climate Change. Part 1 also summarises their recommendations on mechanisms additional to the Emissions Trading Scheme which would increase the level of mitigation.

It is clear from the collated information in Part 1 that significant domestic emissions reductions can be achieved with minimal cost and that leadership from Government can provide a significant increase in mitigation thus avoiding the need for participation in international carbon markets.

Part 1 of this report not only shows how the greenhouse gas emission reduction targets can be achieved but also outlines the business, regional economic development, societal and environmental outcomes that can be gained. It therefore integrates with the enabling policies being developed by local government such as Wellington and Auckland's Low Carbon Plans.

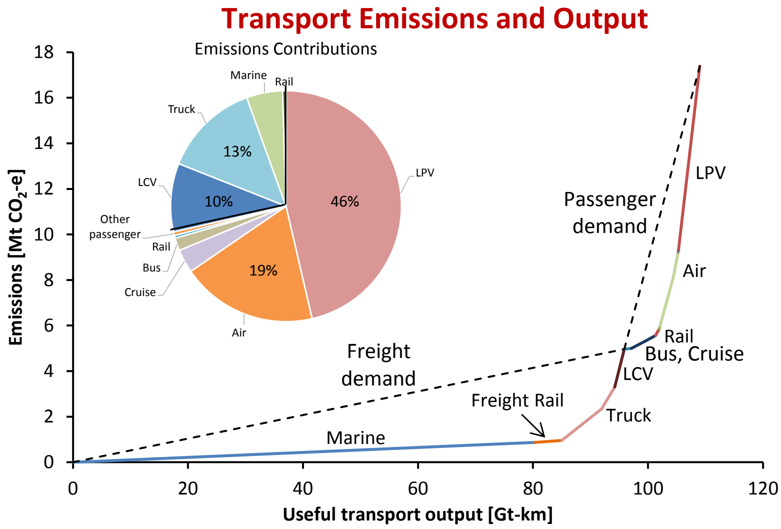
In Part 2 of the report the low carbon stakeholder organisations provided summaries of their respective areas of interest and what they expected to be achieved under each of the scenarios. This provides the detail behind the recommendations in Part1.

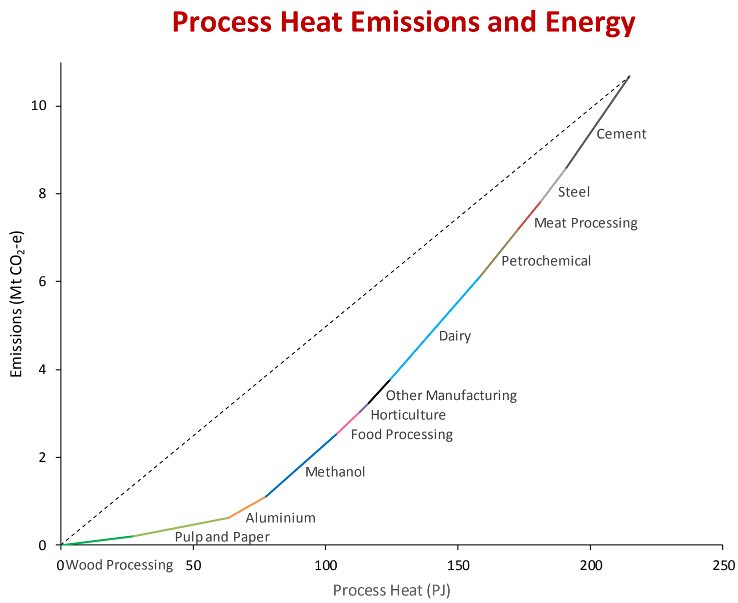
The report not only shows how the greenhouse gas emission reduction targets can be achieved but also outlines the business, regional economic development, societal and environmental outcomes that can be gained. It therefore integrates with the enabling policies being developed by local government such as Wellington[1] and Auckland's[2] Low Carbon Plans.

The common thread across all the stakeholder groups is "Yes we can!" achieve the climate change targets.

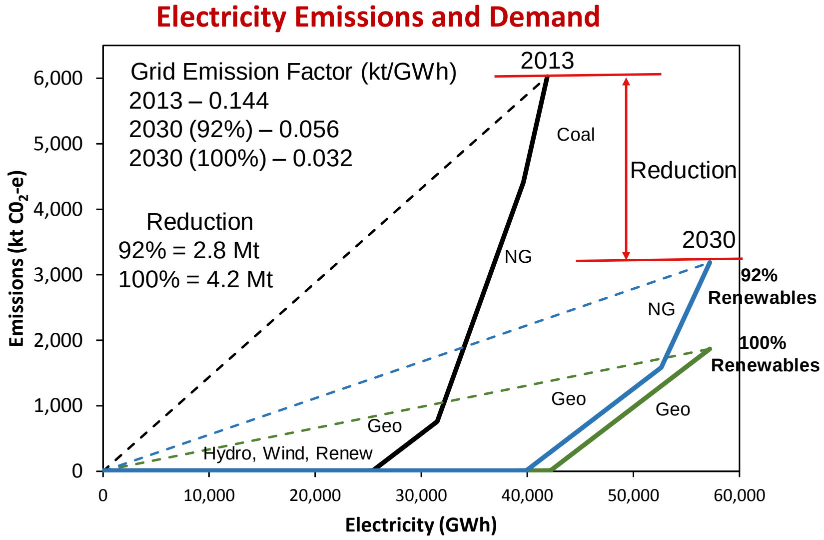
2. Identifying the Priority Areas for Action

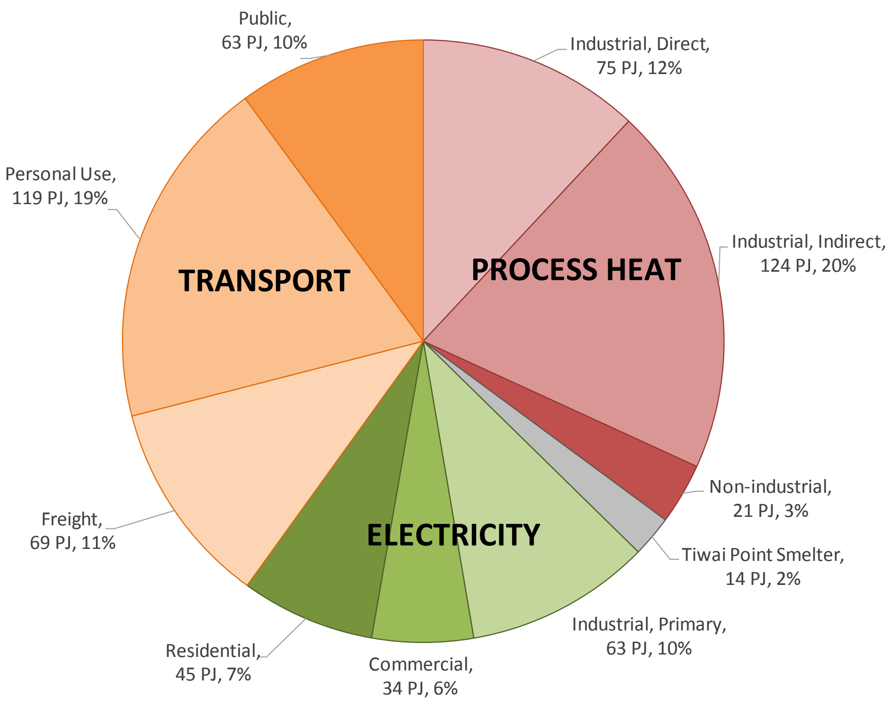
Dr Tim Walmsley and Dr Martin Atkins of the Energy Research Centre, University of Waikato undertook research to identify the priority areas for GHG mitigation action[3]. This provides a strategic macro planning approach and has formed the foundations for the work undertaken through this initiative.





[1] http://www.bioenergy.org.nz/resource/report-wellington-city-council-draft-low-carbon-capital-plan
[2] Auckland Council, Low Carbon Auckland - Auckland's Energy Resilience and Low Carbon Action Plan http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/theaucklandplan/Documents/lowcarbonauckactionplancoverandapp.pdf
[3] http://www.bioenergy.org.nz/resource/webinar-160509-understanding-nzs-ghg-emissions-profile





Transport Emissions Reduction Options

- Integration of **renewable electricity** into LPV
  - EV and PH-EV for LPV, 10 – 20 % uptake = 0.9 – 1.8 Mt CO_2 reduction (5 – 10% of target); 1.2 – 2.5 TWh_{ele} increase
- **Renewable biofuels** for air, ships and large trucks
  - Biofuel Roadmap (SCION)
- **Efficient engine technology** for LPV, Bus, trucks
  - Hybrid engine, new diesel & gas engines etc.
  - 20-40% uptake + 40% efficient = 1.7 – 3.5 Mt CO_2 (9 – 18% of target)
- Increased use of **public transport**

    - Excellent opportunity for Auckland with ongoing densification

Process Heat Emissions Reduction Options

- Industrial **energy efficiency** gains
    - Many opportunities using existing technology;
    - Lack of expertise, priority and capital
- Integration of **renewable electricity** using heat pumps
    - Upgrading of waste heat (chillers etc.) to useable temperatures
- Renewable **biomass and geothermal** for steam
    - Spatial distribution of supply/demand needs to match
- Coal to **natural gas** for transition
    - Emissions factor of NG is half that of coal!

Electricity Process Heat Emissions Reduction Options

- **Electricity efficiency** measures
    - ECCA leading the charge!
- **Displace fossil fuel** thermal generation
    - Need the right mix of geothermal, wind, hydro, PV, bioenergy
    - Variability of wind & PV is a challenge
    - Peaking plants using fossil fuels remain important
    - Migration to smart grid concepts
- **Carbon Capture and Sequestration** (Poor for NZ)
    - Only feasible to capture up to 90% of CO_2 from industrial sites
    - Not likely in timeframe, extremely expensive, not commercial yet

3. Contributions to achieving the climate change targets

Stakeholders were invited to contribute data (refer Part 2) which indicated what their sector could achieve over the periods of the climate change targets. The focus is on the near term targets but in some sectors such as transport biofuels the significant uptake is not expected to be until the latter periods so has been included for completeness.

For simplicity the data has been analysed into the following user groups:

Heat

Food processing – includes meat and dairy
Community facilities – includes schools, swimming pools, recreation
Manufacturing – excludes food processing, includes wood processing
Large build – includes accommodation, rest homes, prisons, universities, large commercial buildings
Domestic living

Transport

Marine (coastal only) and rail
Aviation (domestic only)
Heavy road vehicles
Light road vehicles

Electricity

Wholesale market
Large build
Distributed generation
Community facilities,

Manufacturing
Domestic living
Reduction of methane from waste
Landfill and waste water treatment

The initiative has been undertaken using existing information and that provided by the stakeholder organisations. Limited additional analysis has been undertaken. Only proven technologies or existing practices have been included. Technologies that are not currently proven or are at the commercial stage of development have in some cases been included in the latter years so that the scenarios are realistic as to what could occur during those years.

The wind sector scenarios do not include micro wind or wind turbines in marine locations. As there is currently a number of wind farms and geothermal power station options consented and ready for construction the availability of wind and geothermal for electricity generation is considered not constrained in the short term, but obtaining new consented sites for subsequent applications have issues which need to be addressed.

The direct use of geothermal energy is assumed to be pursued for commercial heating applications as it is based on proven technology and is readily available.

Geothermal heat pumps have been installed in large buildings such as Christchurch airport terminal and it is expected that there will be a steady growth in the use of this technology.

The demand for electric vehicles is expected to continue to grow at a steady rate which will increase the demand for electricity. This demand can easily be met from the generation of electricity from new solar, geothermal and wind generation facilities. As a GHG mitigation technology the reduction in the demand for fossil transport fuel and the use of electricity as the replacement fuel is likely to be the most significant GHG mitigation opportunity.

Wave and marine generation of electricity have not been included as the technologies are not yet at the fully commercial phase of their evolution.

While solar generated electricity is increasing at a fast rate in itself it is not a strong GHG mitigation technology if it is just backing out other renewable generated electricity, but as a replacement fuel for transport it is significant.

Technologies and improved energy use practices are significant GHG mitigation tools but improved use of energy is also likely to increase the demand for energy as productivity from energy use improves.

Bioenergy and liquid biofuels are assumed to be produced from biomass from forest harvesting, wood processing and municipal waste. As the availability of biomass for production of bioenergy and biofuels is likely to come under strong competition for other uses during the transition from a petroleum based to a bio-economy, it has been assumed that additional forest planting and additional added value processing of wood occurs in the latter years.

National inter modal transport switching of road to rail and coastal shipping has not been quantified and included but this is considered to be a very significant GHG mitigation opportunity. The increased use of electricity for rail instead of diesel would allow a major reduction in GHG emissions. Where log transport hubs have been established and log transport has moved from road to rail the GHG emission reduction as well as the significant social benefits are known to be large but unquantified.

Some known gaps in the data received as part of this project are with regard to micro, mini hydro (up to 50 kW) and small hydro (50 kW up to 10 MW), solar electric generation, urban transport energy, and residential end use energy. In each of these areas there is either no interested organisation or the organisation declined to collaborate. In each of these areas estimates of the contribution that could occur has been included where appropriate. It is likely that the GHG mitigation from urban transport energy, and residential end use energy has been significantly under estimated.

4. Emissions reduction from energy productivity

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Energy Management Association of New Zealand

The following actions will tip the scales in favour of New Zealand making wise investments:

- Establish an expert group to work with key export industries to ensure they are accounting for the carbon in their value chain and focusing on identifying the key opportunities to reduce their emissions,

3.1. Commercial Buildings

Following are the current energy sources used in the commercial sector and their related emissions.

	Non Transport Energy in Commercial Sector (GWh)	Total CO2 equivalent (Tonnes)
Electricity	9,334	1,460,313
Gas	2,125	412,443
Coal	406	134,476
Other (wood, bio gas, geo)	785	460,689
Total	**12,650**	**2,467,921**

Source: Energy End Use Database

The following three scenarios outline what is achievable by 2030

ETS price assumption. $25-$50 medium price by 2030 assumption provided by the Minister. Assume $25 by 2030 and $50 by 2040.

Commercial BAU: 10% reduction in energy use = total reduction of 1,265 GWh. Made up of:	
12 % electricity	1,120 GWh @ 156.45 CO2 = 175,225 T CO2e
5 % gas	112 GWh @ 194.09 CO2 = 21,738 T CO2e
8 % coal	33 GWh @ 331.22 CO2 = 10,930 T CO2e
Total	**1,265 GWH = 175,225 T CO2e**

Encouraged Growth: 20% reduction

Interventions:

- KPI for CEOs: Based on contribution made to increasing energy productivity and reducing carbon intensity / GHG
- Carbon Price of at least $25/tonne
- NABERSNZ: Make 4 star compulsory for all new central and local government accommodation and require existing space to be brought up to this standard by 2030. Signal that a NABERSNZ rating will be required on all space leased or sold by 2020
- Enable grants for upgrades of commercial plant, boilers, chillers and controls on basis savings are determined by EMANZ members, measured and building owner commits to EECA commissioning and review
- Upgrade the building code on insulation, shading and air tightness
- Make it mandatory for building owners to share energy information monthly and use of BMS systems with tenants. A requisite for any funding
- Continue to fund industry based training for practitioners through EMANZ

Commercial Encouraged Growth:	20% reduction
24 % electricity	2,240 GWh = 350,450 T CO2e
10 % gas	224 GWh = 43,476 T CO2e
16 % coal	66 GWh = 21,860 T CO2e
Total	**2,530 GWH = 415,786 T CO2e**

Accelerated Growth: 40% reduction

Interventions over and above those in the Encouraged Growth scenario above:

- NABERSNZ rating mandatory on all space leased or sold by 2020
- Moratorium on new coal boilers
- Enable funding of commercial plant upgrades to be registered on the title and collected through rates. Central government to provide security for the funds
- Accelerated depreciation on all energy efficiency upgrades certified by EMANZ members. Rather than straight line depreciation at 12.5% allow the spend to be written off over 3 years after implementation and commissioning
- EECA to fund EMANZ to develop standard documentation for Energy Performance Contracts.

- Develop a template energy efficiency green addendum for leases with a process for landlords and tenants to commit to working together to reduce energy use. A requisite for any funding

Commercial Accelerated Growth: 40% reduction	
48 % electricity	4,480 GWh = 700,900 T CO2e
20 % gas	448 GWh = 86,952 T CO2e
32 % coal	132 GWh = 43,720 T CO2e
Total	**5,060 GWH = 831,572 T CO2e**

4.2. Industrial Process Heat

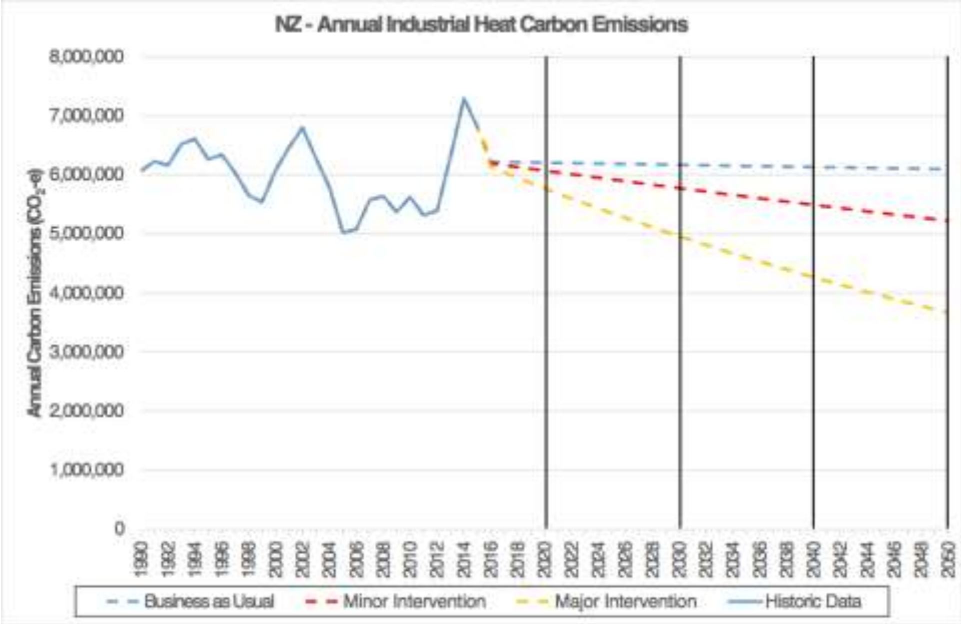
Current Situation

	Total Energy Consumption (PJ)	**2011 Emission Factor**	**Total Annual Emissions (tCO_2-e)**
Coal	22.82	2.08 $kgCO_2$-e/kg	2,260,000
Oil			
LPG	3.09	2.89 $kgCO_2$-e/kg	190,000
Diesel	13.72	2.66 $kgCO_2$-e/L	960,000
Fuel Oil	1.26	2.94 $kgCO_2$-e/L	90,000
Natural Gas	61.59	53.7 $kgCO_2$-e/GJ	3,310,000
Renewables	54.00	0	0
TOTAL	**156.48**		**6,810,000**

Numerous examples exist of meaningful and significant opportunities for carbon emission reductions through energy management. The following table summarises the implemented improvement opportunities by EMANZ members in three key NZ industrial sectors:

	Energy Productivity Improvement	**Carbon Emissions Improvement**
Meat Processing	14.5%	11.4%
Milk Processing	6.8%	6.7%
Wood Processing	9.6%	17.3%

The following graph summarises three process heat modelled scenarios, BAU, Encouraged Growth, Accelerated Growth:



Business As usual = 0% reduction.

Encouraged Growth =7% or 0.5% Per Annum

To improve industrial emissions by 0.5% beyond BAU (0% improvement) by 2030 the following actions are taken

- Mandatory reporting of energy consumption and carbon emissions in Annual Reports
- Mandatory carbon mitigation and management plan for all organisations with stationary carbon emissions exceeding 5,000 T per annum (~200 NZ industrial businesses)
- Development of “Best Practice Guides” for Industrial Boiler Efficiency
- Carbon cost of $25/T
- “Green Loans” or low interest loans for carbon reduction projects
- Promotion and awareness campaigns targeted at NZ Board Members highlighting the strategic “low-carbon” opportunity and global positioning potential
- Active stimulation of the biomass market
- Active stimulation of the ammonia industrial heat pump market
- Continued support of EECA, specifically the business programmes

Accelerated Growth = 21% reduction (1.5% reduction per annum)

To improve industrial emissions by 1.5% beyond BAU the following additional actions are needed:

- Mandatory carbon mitigation and management plan for all organisations with stationary carbon emissions exceeding 2,000 T per annum (~1,000 NZ industrial businesses)
- Mandatory industrial boiler efficiency targets
- Carbon cost of $100/T

- Development of Energy and Sustainability Engineer as a discrete study stream at New Zealand Universities
- Moratorium on new industrial coal boilers
- Active stimulation of the ammonia industrial heat pump market
- Major expansion of support of EECA, specifically the business programmes

3.3. Street Lighting

Accelerating New Zealand's adoption of LED street lights to 100% over the next ten years through Government leadership would save 96 GWh of electricity and 16,000 tonnes of carbon assuming no adoption of LED under BAU.

3.4. Waste Recovery

- 6-7 PJ of energy, in the form of methane, could be captured from municipal waste and converted to electricity onsite, or injected into the natural gas network (once treated to the NZ Standard).
- A further 2PJ of methane could potentially be captured from dairy waste from milking sheds and other buildings constructed to house dairy herds.

5. Emission reductions from Geothermal Energy

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the New Zealand Geothermal Association

4.1. Electricity

There is approximately 1000MW of installed geothermal capacity in the New Zealand electricity market. Typically stations generate around 840MW on average per week, and supply around 17% of all generation, second only to hydro. Geothermal generation is renewable, baseload, largely independent of weather, with low natural CO_2 emissions. Generation facilities (and future prospects) are focused in the Taupo-Rotorua area with some additional generation in Northland at Ngawha, all relatively close to the major load centre of Auckland.

In terms of future prospects, geothermal generation could be increased by about 800MW capacity using available geothermal resources not otherwise protected under Regional Council plans. There are some suggestions that this figure should be reduced further to account for the more conservative findings of recent exploration, while there are suggestions that the reserve should be increased as developers drill deeper into the proven reservoirs, so the 800MW future capacity increment has been retained. MBIE cost modelling has shown that much of this geothermal generation has lower unit cost than any other form of generation, although some premium wind sites may compete.

Contact Energy and Mighty River Power have developed staff with wide expertise in geothermal development and maintenance, together with companies such as Top Energy, Eastland, Norske Skog Tasman, Ngati Tuwharetoa Geothermal Assets and Nova Energy (not an exhaustive list). In addition, New Zealand has diverse supporting companies some of whose dominant work load is international geothermal work. New Zealand is recognised as a World Centre of Excellence in geothermal development and expertise, and attracts further high quality international expertise to work in this environment.

Regional Councils have developed plans and policy statements which enable the development of certain resources while protecting others. Consenting paths are available for the 800MW of additional generation mentioned above. Developers normally seek their consents close to development time partly as a strategy to avoid the attraction of competition to the resource, because it is a "use it or lose" process, and they may want to hold off on development.

Geothermal energy is a baseload form of generation, though arguably could do limited load-following. A comparison of baseload (and "must run") capacity with baseload requirement in the New Zealand electricity system will set a soft cap for future geothermal generation. This cap might be exceeded:

- If demand-side management can shift load to fill troughs in demand, or
- If load grows say through proliferation of electric vehicles (including further public transport electrification), or
- If geothermal developers can see advantage in load shedding, or
- If pumped hydro or large scale battery storage (potentially through EVs with night charging) is added to the grid.

Wind and geothermal electricity generation essentially compete to supply growing generation requirements, with differing electricity generation companies favouring differing technologies and retaining staff to implement these options when ready. An argument could also be developed for potential radical changes in geothermal costs with drilling to supercritical conditions or towards magma bodies. In the face of respective industry bias, it is recognised that in recent years a steady ratio of geothermal to wind generation has been maintained and is likely to continue in the medium term.

(From 2008 the ratio of geothermal to wind generation in terms of GWh/year has been fairly steady at around 3:1. Average geothermal load factor through this period has been a surprisingly low 82% while wind load factor has been 36%. Hence the ratio of geothermal to wind capacity (in MW) is likely to be about 1.35:1.

There are immediate plans for new geothermal generation. Eastland Energy is now proceeding with the Te Ahi O Maui 20MW project at Kawerau, initially drilling wells, but shortly to start construction with generation expected by 2018. Top Energy has secured consents for a staged 50MW additional development at Ngawha and now anticipates the first 25MW will be generating by 2020. Contact Energy has secured consents for the 250MW Tauhara II development for which consents need to be exercised by 2020, but may choose to stage its development or initially use consents for a heat project i.e. of the 800MW potential, 320MW is firm.

We can speculate that with the final retirement of Huntly (just reset to 2022) or Taranaki Combined Cycle plant (2 years older than the recently retired Otahuhu B) or Genesis's e3p Combined Cycle plant (7 years younger than Otahuhu B), provided that the Tiwai Point smelter continues to operate, there will be opportunities for geothermal to partially replace these plants.

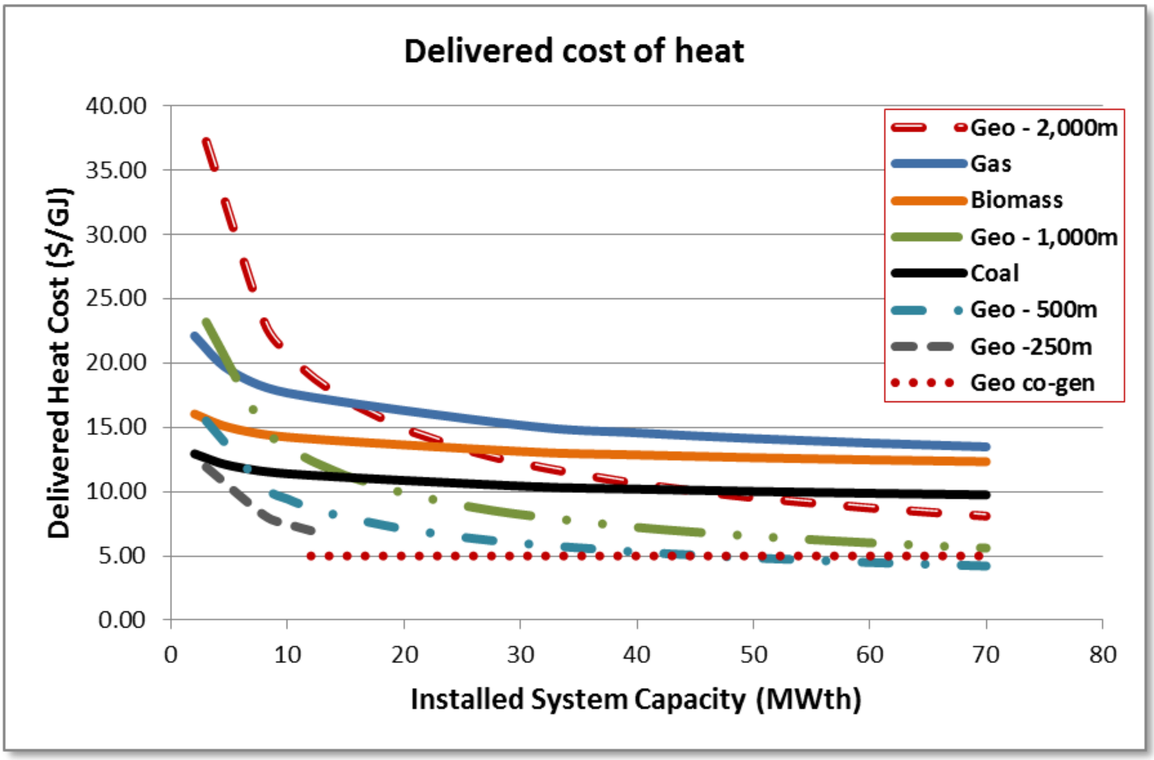
4.2. Transport

Geothermal generation can take up the growth in electricity demand associated with proliferation of electric vehicles. A recent Royal Society paper suggested that electric vehicle fleets (or hydrogen-fueled fleets) in New Zealand could lead to a 5% increase in electricity demand by 2050. This is equivalent to a 3,000GWh load on the system, but ideally recharging will be focused at night raising baseload demand requirements even more.

Geothermal fluids could help directly with the development of an electric vehicle fleet. Tesla has just set up a "Gigafactory" in Nevada for the manufacture of lithium-ion batteries. Our geothermal fluids contain lithium. Economic extraction of lithium on our producing fields as a co-product could stimulate a whole new industry, consistent with the Business Growth Agenda.

4.3. Direct Heat

Geothermal energy is an economically attractive form of energy at premium locations. Thus on the relatively rare high temperature fields through the Rotorua-Taupo region and in Northland at Ngawha geothermal energy can be a great source of energy for new energy intensive industries or industries prepared to relocate. Steam diverted from geothermal power stations could potentially undercut the cost of steam from any other source at any scale. Stand-alone heat plants may otherwise require a scale of the order of 10MWth to enable a competitive geothermal supply.



(Source: 2013 Report for Grow Rotorua by East Harbour Energy)

There is a strong correlation between major plantation forests and geothermal resources around the central North Island. Some of these forest resources are processed at Norske Skog Tasman's Kawerau plant into pulp and paper, this still being the largest geothermal direct use in New Zealand and the largest industrial application of geothermal heating in the world. The Kawerau geothermal steam supply undertaken by Ngati Tuwharetoa Geothermal Assets also supplies power stations at Kawerau, the Asaleo Care (formerly SCA) mill and two timber drying kiln operations. There are other geothermally-heated kiln drying facilities for forest products at Ohaaki and at Tauhara. Lower grade geothermal resources could potentially be used to dry biomass as an alternative fuel for kilns or boilers. Contact Energy has been involved with geothermal steam supplies for various purposes at Ohaaki, Wairakei and Tauhara and is known to be in discussion with other parties to use these resources. The Fenglin forestry group is one party mentioned in media, possibly using Tauhara resource and consents.

The following table shows a recent breakdown of geothermal direct use applications around New Zealand. Bay of Plenty and Waikato dominate currently, with a significant component associated with industrial process heat supplies at Kawerau.

A relatively recent development was that of the Miraka milk drying plant at Mokai. This has subsequently been expanded and represents a global first in terms of geothermal industrial heat application. Other milk processing plants may need to follow suit with geothermal application if clean low carbon products are going to be a selling point.

Assessed Geothermal Direct Heat Use 2013 (TJ/year)

Council Regions	Space Heating	Water Heating	Greenhouse Heating	Fish and Animal Farming	Industrial Process Heat	Bathing and Swimming	Other Uses	Total
Northland						6		6
Auckland	2					56		58
Waikato	28	51	331	196	848	774	812	3,040
Bay of Plenty	290	213	34	2	4,196	521	179	5,435
Gisborne						0		0
Hawkes Bay						3		3
Taranaki						0	0	0
Marlborough	2							2
Canterbury	25					46		71
West Coast						12		12
Otago	8							8
Total	355	264	365	198	5,044	1,418	991	8,635

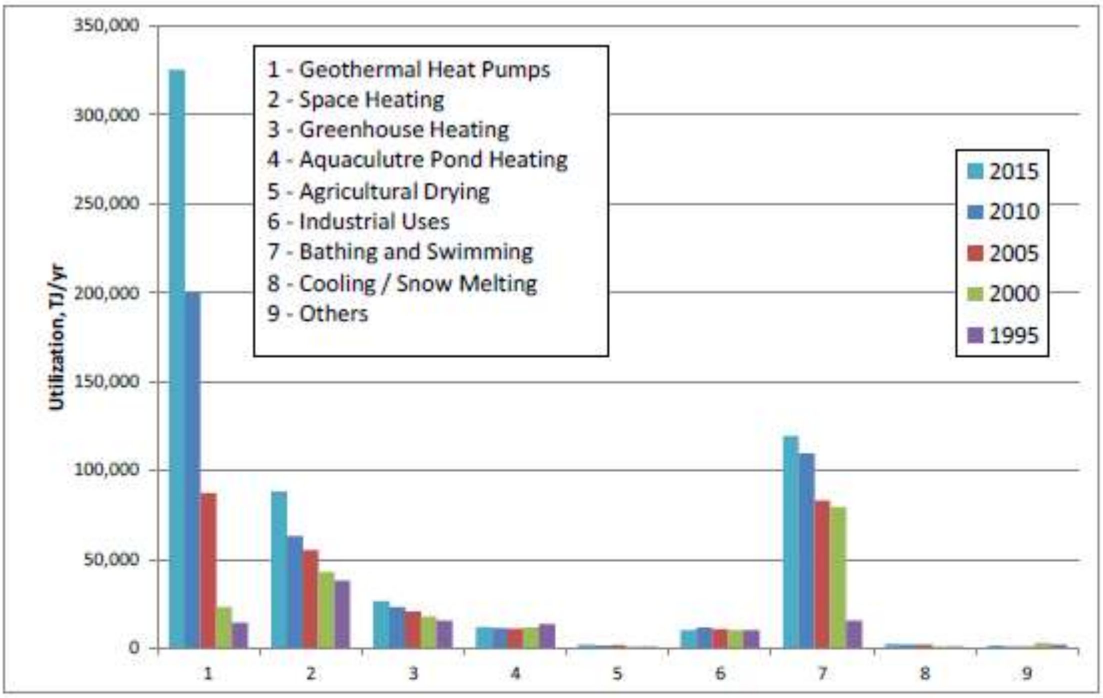
(Source: unpublished direct heat data for EECA by B White)

NZGA has been developing a GeoHeat Strategy targeting the greater uptake of direct use geothermal energy consistent with government direct use targets and with the government's Business Growth Agenda. This sets out a number of actions designed to stimulate growth and measure progress. There is a market failure in that industry is not aware that attractive geothermal options exist for industry. This needs funding to be effective. Once implemented, multipliers on the Business As Usual scenario of 125 TJ/year growth will apply. Growth could be at 2 or 5 times the current rates.

Geothermal heat pumps also come under the geothermal banner. These are like air-source heat pumps but exchange heat with the ground or groundwater. There are a growing number of competent designers and installers. In recent years, in addition to some minor domestic and commercial installations, there have been some major commercial installations including Christchurch and Dunedin airports. The Christchurch rebuild has seen a major uptake in geothermal heat pumps. This has been encouraged by:

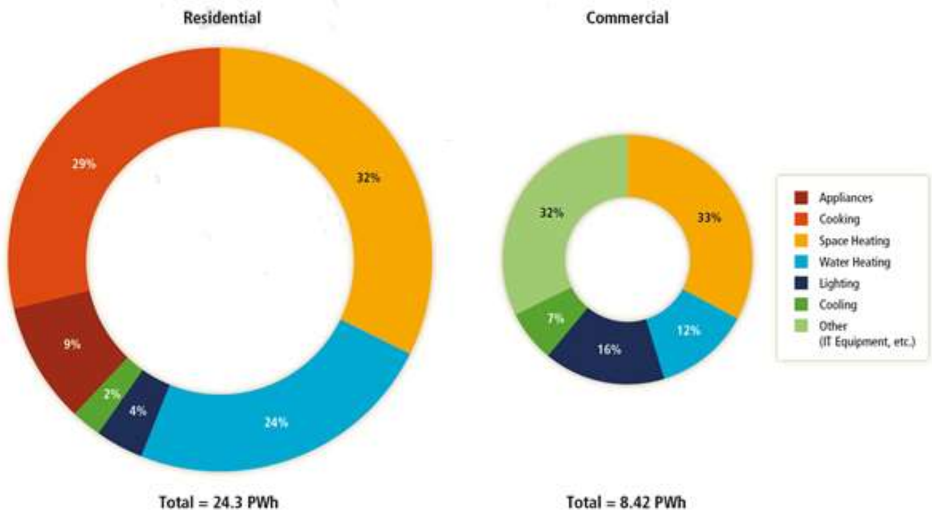
- Growing cluster of supporting consultancies
- Good information about Canterbury aquifers (this risk factor remains for other locations unless they tap into river, lake or sea water)
- Non-notifiable consents that mean these can be quickly approved
- Clean slate (in terms of leveled CBD) to enable possible interlinking with other users
- Slightly higher density people/m2 in the new buildings (now more like national average)
- EECA feasibility study assistance
- Limited renewables subsidies through Christchurch Agency for Energy (CAfE) and from EECA to demonstrate underutilized technologies
- Payback period of 5 years or less for projects over 6,000m2.

Where geothermal heat pump technology has been employed in other countries, its' growth has been exponential. Globally, geothermal heat pumps are now the largest category of geothermal direct use applications as shown in the following figure.



(Source: 2015 World Geothermal Congress paper by Lund and Boyd)

Geothermal heat pumps have been developed for space and water conditioning. The following graph shows that water and space heating are major components of New Zealand domestic and international commercial energy requirements and this is where ground source heat pumps are slowly being applied.



(Source: Royal Society of New Zealand report on "Transition to a low-carbon economy for New Zealand")

In New Zealand about 2/3rds of domestic space and water heating needs could be met by geothermal heat pumps either directly substituting for fossil fuels or biomass, or reducing domestic electricity consumption in each house significantly. Based on international commercial property figures, about 50% of commercial energy requirements could be met with heat pumps. Given these can have coefficients of performance (ratio of heat output to electricity input) of around 4, then substitution for simple heating systems of fossil-fueled systems will have major benefits in terms of reduced emissions. In New Zealand domestic electricity demand accounts for 32% of total electricity demand while commercial demand accounts for 24% of total electricity demand.

Interviews with industry practitioners indicates that New Zealand growth in geothermal heat pump usage has followed linear trends. Typically about 20 large houses have heat pumps are installed per year.

Commercial building growth is focused on Christchurch with about an additional 20,000m^2 of commercial building space being heated and cooled through geothermal heat pumps each year. For Christchurch, the GHPs mainly displace air-source heat pumps, while nationally they are likely to displace gas.

4.4 Emissions Reduction Possibilities from Geothermal Energy

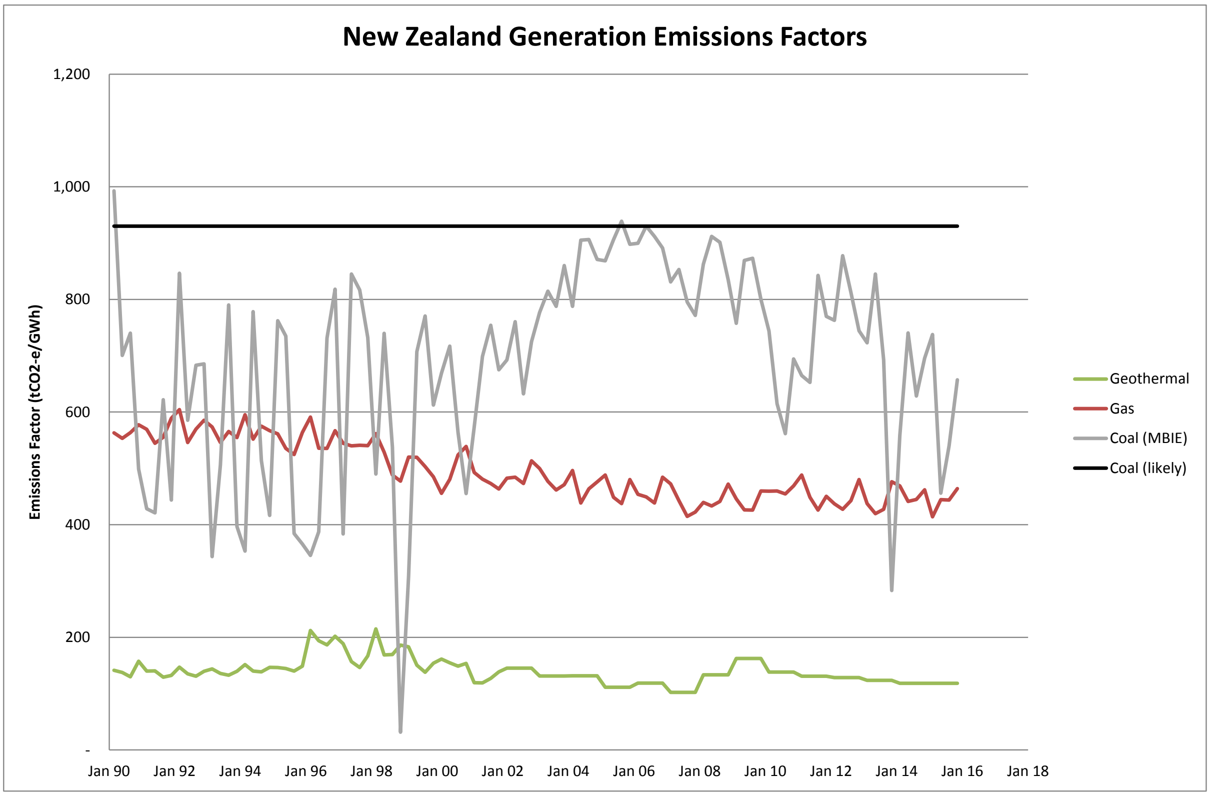
Geothermal energy is a renewable, low carbon energy form. However, it is associated with some CO_2 emissions. If we ignore the life cycle emissions that may be associated with every sort of generation form, and just concentrate on hard emissions, then geothermal emissions for electricity generation are as follows.

Data is taken from MBIE reporting and there are clearly some spurious coal emission data points. Coal-fired emissions are around 930 t CO2-e/GWh, gas-fired emissions are around 450 t CO2-e/GWh while average geothermal emissions are around 120 t CO2-e/GWh. The geothermal figures show typically declining rates with time because our fields are degassing. This is most noticeable for Ngawha which initially had emission factors between that of gas and coal, but now sits just over 200 t CO2-e/GWh.

Emissions factors for each field cover a wide spread, so in the absence of specific data it is assumed that the current levels of 120 t CO2-e/GWh will continue indefinitely for electricity generation.

Initially this will offset emissions from the Huntly coal station, but will later offset emissions from gas-fired plant.

In terms of heat plant, many of the major heat load growth opportunities will be on the same high temperature fields as the power stations are located on. As such a simple conversion from station emission factors is possible. Typical energy conversion efficiencies for geothermal power stations are in the range 10-12% taking into account thermodynamic limitations due to relatively low temperature and an economic requirement to reinject much of the heat initially extracted. Reinjection is still required for direct use applications so conversion efficiencies of heat provided versus heat extracted of around 50% apply. On this basis typical emissions factors for geothermal direct use will be around 26 t CO_2-e/GWh or 7 t CO_2-e/TJ of heat supplied. Equivalent emissions from a coal-fired heat plant are about 111 t CO_2-e/TJ and from a gas-fired heat plant are about 70 t CO_2-e/TJ[4] (). As can be seen, major reductions in emissions can be achieved through use of geothermal heat for industrial processes when compared with fossil-fuelled options.



(Source data: MBIE [5])

The other factor that may need to be taken into account in considering emissions reductions, is whether a renewable energy project is substituting for a fossil-fuelled project or represents an additional load due to new business. Many of the projects may be substitutionary e.g. milk treatment plants that follow the Miraka example will not represent an increment in milk production but a substitution for fossil-fuelled treatment plants elsewhere. The argument is not so strong for new timber kilns where there is an effort to have greater onshore added-value rather than exporting

[4] see http://www.eastharbour.co.nz/assets/pdfs/RenewableEnergyandtheEfficientImplementationofNZsCurrentAndPotentialFutureGHGasCommitmentsAugust2002.pdf with adjustments for recent figures

[5] website http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity and http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-greenhouse-gas-emissions

timber as logs. In any case, geothermal energy will be substituting for fossil fuels so represents a reduction on the emissions that would otherwise have resulted.

Based on the information above, the following emissions reduction possibilities have been assessed.

Electricity Generation Possibility

	1990	2000	2010	2020	2030	2040	2050
Geothermal MW	261	365	723	1,140	1,450	1,650	1,800
Geothermal GWh	2,011	2,756	5,546	9,823	12,494	14,218	15,510
Avoided CO_2 emissions kt CO_2-e/year	0	600	2,860	6,330	3,460	4,030	4,455

- Expected geothermal growth to 2025 can be achieved with the staged development of currently consented sites (Tauhara II, Ngawha and Te Ahi O Maui (Kawerau)).
- The apparent reduction in avoided CO2 emissions after 2025 results from the assumption that coal generation would have ceased so only emissions from gas are being offset.
- The effects of photovoltaics and electric vehicles are still likely to have second order effects on total generation by 2025, and will continue to offset each other beyond that.
- Closure of Tiwai Point will primarily impact thermal plant forcing the closure of Huntly and of gas combined cycle stations (if not already closed), creating a renewables-dominated supply, causing some delays in renewable plant construction, and has been assumed to occur before 2025.
- Beyond 2025 the approaching full usage of available geothermal resources, combined with improving wind costs will drive a slower uptake of geothermal energy than expected based on load growth.

Transport Possibility

Benefits are simply assessed in terms of generation contribution to electric vehicles. Because all significant electricity load growth can be satisfied by renewable energy (dominantly geothermal and wind), geothermal's contribution to transport electricity is assessed based on the relative contribution of geothermal relative to wind, combined with a mid-level scenario for EV uptake.

	2010	2020	2030	2040	2050
EV GWh	~0	190	585	1,465	3,000
Geothermal GWh	~0	145	400	960	1,830
Avoided CO_2 emissions kt CO_2-e/year	0	170	470	1,130	2,150

Notes:

1. For this estimate, emissions data for the NZ light vehicle fleet was sourced from MOT data, EV fuel efficiency was sourced from J. Leaver, EV uptake scenario curve was sourced from MBIE.
2. Note the very substantial avoided emissions for transport relative to electricity generation despite the small GWh contribution from geothermal. This results from the high emissions of road transport.
3. I have not subtracted emissions from geothermal as these have already been accounted for in the electricity generation scenario.

Direct Heat Possibilities

The following table shows growth in various sectors based on an assumption that the GeoHeat Strategy will double business-as-usual uptake, but with these gains starting from 2020 after a suitable campaign.

	1990	2000	2010	2020	2030	2040	2050
Space heating	386	375	358	402	536	669	803
Water heating	287	279	266	299	398	498	597
Greenhouse heating	62	79	391	413	551	688	826
Fish and animal farming	382	382	372	224	299	373	448
Dairy	0	0	0	306	407	509	611
Wood products	4,638	5,391	5,778	5,140	4,185	5,230	6,275
Bathing/ swimming	1,543	1,499	1,431	1,605	2,139	2,674	3,208
Other uses	30	33	554	1,122	1,495	1,868	2,242
Total TJ	7,329	8,039	9,150	9,510	10,010	12,510	15,010
Avoided CO_2 emissions kt CO_2-e/year)	0	45	114	138	169	327	484

- Emissions calculations have been undertaken on the conservative assumption that only gas will be displaced rather than coal.
- Assuming the newsprint production finishes in the 2020's, this will set the industry back, though growth across the decade is still expected.

For heat pumps, advice is that domestic installations are increasing steadily by about 20 large houses per year. As these houses often have swimming pools the total displaced heating per home is about 14,000kWh/year (0.05TJ/year). Outside of Christchurch this mainly displaces gas.

Commercial ground source heat pump installations are currently focused in Christchurch, but are likely to progressively disperse to other locations. With a simple space conditioning load of around 100kWh/m^2 and 20,000m^2/year installed, this leads to the following contributions:

	1990	2000	2010	2020	2030	2040	2050
Domestic	0	0	8	18	28	38	48
Commercial	54	54	69	157	229	301	373
Total TJ	54	54	77	175	257	339	421
Avoided CO_2 emissions kt CO_2-e/year)	0	0	1	2	8	13	19

Notes:

1. Note that this estimate is conservative based on modest linear growth, ignoring the normal exponential growth observed elsewhere and ignoring any impact of government or industry stimulation.
2. It assumes that half of the first five years the commercial growth displaces air-source heat pumps then displaces gas.

4.5. Actions that Would Assist GHG Mitigation from Geothermal Energy

1. *Energy Dating Service*. Some landowners and potential developers don't have the connections or expertise to realise geothermal aspirations. A service to connect these parties with industry and business interests seeking energy solutions can help to unlock this potential. This is done on an as requested basis currently, but funding would enable a more pro-active and involved approach. The International Geothermal Association has recently launched a similar programme.
2. *Maori Economic Development*. With increasing numbers of Iwi entering the post-settlement era, as well as existing large landholdings and the active pursuit of development opportunities, Maori economic development is expected to play a significant role in the New Zealand geothermal future. Already, Maori-owned trusts and companies are amongst NZGA's major financial supporters. As well as general knowledge sharing, there will be specific areas of help that may benefit these groups.
3. *Matauranga Maori*. Geothermal resources have been used by Maori for hundreds of years, over which time a rich body of knowledge, customs and practices has developed. Recognising that there are differences between Iwi and Hapu, there is significant opportunity and value in the greater integration of this knowledge base, where appropriate, in geothermal enterprise.
4. *Raised Public Awareness*. NZGA will lift communications and education of the public. This will include education material to be developed for schools and universities. NZGA should develop as a highly trusted sought after organization for the knowledge it represents through its membership. It will be the domestic and increasingly international pathway for enquiries, understanding the industry and the context in which it sits.
5. *NZGA Website*. The NZGA website (www.nzgeothermal.org.nz) will be maintained and reviewed to include latest studies and information. Some of the tasks below reflect current weaknesses in the website and NZGA's knowledge base. This is one of the principal means by which we educate the public and inform our own members.
6. *Geothermal Short Courses*. Short courses can give a broad overview of geothermal energy for consenting agencies, developers and other interested parties. This assists development directly.
7. *Development Guideline Report.* NZGA would like to implement a report on beginners guide to development, targeting small scale developers and potential direct heat users. At the smaller scale, the complexity of developing geothermal use can be a significant barrier. Plain language advice and information on regulatory requirements, technology and resource information can assist to reduce these barriers.
8. *Showcase and Share Lessons Learned*. Success breeds success. Actively show-casing existing success stories in geothermal energy use increases awareness and stimulates further development. In addition, by sharing lessons learned, future projects have greater chance of success.
9. *Direct Use Data.* Geothermal direct use data forms a measure of progress against targets for emissions reduction or under the Energy Strategy. Current MBIE data is incorrect. NZGA has industry knowledge to be able to derive more accurate data and to distinguish between electricity generation and direct use in the complex Kawerau supply situation. Collection of data across all industry is time-consuming so must be externally funded. EECA has funded three such studies in the past, but data collection is the responsibility of MBIE. NZGA is also concerned about the levels of assumption built in to the current estimates and would like

assistance to probe into this to better understand usage at the domestic and Small Medium Enterprise level. In turn this would enable a better understanding of growth opportunities.

10. *Specific Studies*. NZGA has coordinated specific studies in the past, with reports on cost of geothermal electricity generation, of current uptake of geothermal direct use and on heat pumps all being well-referenced on the website. One of the most referenced areas of the website is on our geothermal resources. There may be opportunity to expand that to cover lower temperature fields for direct use. Access to data on these low temperature resources will reduce the risk for potential developers (and was one of the contributing factors to heat pump uptake in Christchurch). Further specific studies can be undertaken.
11. *Specific Information on the Economics of Projects*. In this task micro- and macro-economic cost data will be collected to summarise the benefits of adopting new geothermal technologies. This can assist decision making. These calculations can be complex so access to tools and assistance to calculate pay back periods for geothermal energy could encourage uptake.
12. *Advice on Infrastructure*. NZGA has previously given advice on the concentration of geothermal development affecting Transpower's Wairakei Ring. It is recognised that other infrastructure development could be useful to accelerate direct use of geothermal energy. Direct use is not transportable over large distances; strategic transportation connections for products to reach markets for areas rich in geothermal energy opportunities will boost the competitiveness of businesses seeking to utilize this resource. In the case of the Christchurch rebuild, the opportunity for geothermal heat pumps has been kept before developers where there is now a significant uptake.
13. *Best Practice Resource Utilisation*. Accessing and using geothermal resources requires expertise. Ensuring that all users are operating to industry and regulatory standards will protect the resource, the user and the reputation of the sector. A recent survey of a selection of Rotorua bores found almost all had significant problems in terms of well safety, control or maintainability, so best practice guides would be immediately useful and should ensure that future wells and wellhead equipment will be adequate.
14. *Memorabilia and Industry Archive Facilitation*. New Zealand was a world pioneer in geothermal development and is a continuing centre of excellence. Key information and equipment could be lost if an industry archive is not established. NZGA is now working with industry to collate and preserve this material.
15. *Government taking strategic leadership*. The New Zealand Government can take strategic leadership through the funding of geothermal energy solutions for its own uptake, and consideration of greenhouse gas emissions. In many cases these are sound commercial options and can form case studies for wider industry to follow. If life cycle analysis is undertaken, rather than relying on least cost solutions then geothermal heat pump solutions could be applied in many locations such as in offices close to the sea, lakes or rivers, or to schools where heat pump networks in school grounds form the dual function of sustainable energy source and effective drainage, or in prisons or hospitals where high floor areas and high occupancy rates make these options particularly attractive. Other geothermal heating solutions may be possible for government premises located in the central North Island, Ngawha or over our low temperature geothermal fields e.g. near Tauranga. As an extension of this, Treasury should be instructed to assess wider and life cycle benefits when weighing proposals from these institutions for approval.

Though less obvious from a geothermal perspective, leadership could also be taken with the purchase of electric vehicles. Replacement of petrol vehicles has a major effect on net emissions. There are renewable energy electricity generation options available to supply the growing fleet.

16. *Loan Schemes.* New Zealanders have short term perspectives when it comes to investment and geothermal solutions tend to be high capital cost/low life cycle cost. Suspensory loans from central government, or restructured rates schemes at city council level could assist uptake of this low emission technology. There may be a role for a Clean Energy Fund to make money available to private sector projects to compliment the Crown loans available through EECA for renewable investment projects (currently rarely applied to geothermal solutions).
17. *Subsidies*. It was previously noted that subsidies from EECA and the Christchurch Agency for Energy were contributing factors to the uptake of geothermal heat pumps in Christchurch. While these have not been substantial sums, small amounts can tip the balance in favour of renewable developments.
18. *Investment in Renewable Energy Projects*. New Zealand is a world centre of excellence in geothermal development. The Government has already given some support through significant funding of aid projects (particularly in Indonesia), the establishment of Geothermal New Zealand for linked-up international marketing of these skills and funding of specific marketing ventures (e.g. attendance at the World Geothermal Congress 2015). A weakness with the GeoNZ grouping is the lack of financial backing. New Zealand companies must compete with, for example, groups from Iceland supported by their own investment banks. Establishment of an investment bank to directly invest in international low emission geothermal projects, using our national expertise, in projects which by themselves should be profitable would also ensure that money was linked to real emissions reductions rather than spurious international emissions credit purchases. Currently our consultants are involved with many projects globally that would go a long way to offsetting our national emissions if benefits could be captured.

6. Emission reductions from Wind Energy

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the New Zealand Wind Energy Association.

5.1. Wind in New Zealand

- 19 wind farms with an Installed capacity of 690MW which is around 7% of NZ's total.
- On an annual basis wind generates around 6% of total generation.
- Consents have been issued for over 2,000MW of new wind generation.
- NZ has the highest capacity wind site in the World and in general has capacity factors well above the international average.
- An assessment of New Zealand's wind resource identified that wind has the potential to generate over three times New Zealand's current annual electricity demand (approximately 40,000 GWh).

5.2. International Trends in Wind Energy

- Wind is the fastest growing means of electricity generation in the world with 63GW of new generation installed in 2015. Capacity is doubling every 3 years.

- In total there are around 200,000 wind turbines in operation with a total installed capacity of over 430,000MW.
- The United States and EU counties have traditionally lead the world in wind power development, however China now accounts for half of new installations.
- In 2015, 44% of all new EU generating capacity was wind power with wind comprising 11% of total generation.
- Denmark leads the way in wind production comprising 40% of its electricity generation.
- Wind is now approximately 4% of total worldwide electricity usage.

5.3. Wind's Advantage as a GHG Opportunity

- Is renewable, requires no fuel, and cheaper than any other form of new energy generation.
- Produces no greenhouse gasses during operation and uses little land.
- Achieves carbon closure, from manufacturing of turbines and deployment, within 6 months of operation.
- Windfarm investigation costs are lower and less risky than other forms of generation.
- Wind farms are scalable and can be built as a large national grid connected asset or smaller distributed network connected farms.
- Wind is a consistent resource from year to year and, when multiple geographically dispersed wind farms are operating, has the attributes of baseload generation.
- Technology improvements are increasing turbine performance and wind economics. New technologies such as battery storage could further increase the potential uptake.
- There is strong public support for wind power. Over 80% of EU citizens support development and the level of support in NZ is at a similar level.

5.4. Wind Challenges

- Wind farms can have significant variability over short timescales creating forecasting issues and requiring reserve generation support. This has historically created market integration issues and has required market rule changes.
- Improvements in forecasting capability coupled with a greater understanding of how wind actually performs, particularly when a series of farms are operating, have assisted in wind becoming more accepted.
- Historically noise has been an issue for those living close to wind farms. International standards have been agreed to mitigate the impact.

5.5. The NZ Opportunity for GHG Mitigation

- NZ's location and topography, combined with a high level of hydro generation, create a unique opportunity for wind development.
- Wind energy has a natural synergy with New Zealand's existing hydro resources which is regarded as the most economic reserve generation to manage wind's variability.
- In 2013, the latest available data, emissions from thermal electricity generation was 5,043 kt C02-e which was 16% of total energy sector emissions.
- On the basis of 2013 data for every GWh of thermal generation substituted for wind energy there would be a reduction in over 585 tons of greenhouse gas emissions.
- Expand the renewable electricity market to mirror the transformation that has occurred in the residential segment with the uptake of efficient heat pumps replacing other methods of heating:

- Renewable energy to replace the thermal fuels used by commercial and industrial consumers to provide heat. Total manufacturing emissions in 2013 were 5,955 kt CO_2-e of which the food sector (largely dairy processing) was 2,155 kt CO_2-e.
- Renewable energy to power electric vehicles to reduce emissions in the transport sector. Domestic road emissions totalled 12,688 kt C02-e.

5.6. What is Required to Fulfil the GHG Mitigation Opportunity

- Introduce an effective price on carbon. When initially introduced the ETS was expected to increase the retail price of electricity through higher thermal generation costs. The low cost of carbon credits has meant there has been no discernible impact on either wholesale or retail electricity prices. What is needed is an effective mechanism for pricing carbon emissions.
- Enhance policy settings for renewable generation. The 2011 National Policy Statement for Renewable Energy Generation (NPSREG) recognises the national significance of renewable electricity generation and sets a target of 90% of electricity generated should be derived from renewable energy sources by 2025. The NPSREG is currently under review and in order to meet climate targets change by way of domestic mitigation the target should be increased.
- Ensure the consistent use of the National Standard for wind farm noise limits. In 2010 a new standard NZS 6808 was developed to recommend limits on noise from windfarms. The standard reflects international best practice and is adhered to by all NZWEA members. There is however no requirement for local authorities to adhere to the Standard when making consenting decisions under the RMA. Incorporating NZ6808 into the RMA would provide greater consistency in wind farm consent decisions and provide certainty to applicants, thereby reducing consent timeframes and costs.
- Offer the renewables sector a similar level of subsidies and tax benefits that are provided to the fossil fuel industry.

5.7. GHG mitigation from wind

- While NZ already has an internationally high level of renewable electricity generation, wind as a source of electricity production, is lower than in many developed economies.
- NZ's unique advantage in having high wind farm capacity factors, combined with the internationally recognised environmental and economic benefits of wind, result in it being a key strategy in meeting greenhouse gas emission reduction targets by way of domestic mitigation in the electricity, heat and transport sectors.
- The specific opportunities are:
    - Wind to replace current thermal electricity generation which would reduce NZ's energy CO_2-e emissions by 16%.
    - Wind to provide the electricity to replace the thermal fuels used for commercial and industrial heat.
    - Wind to provide the electricity to power a replacement vehicle fleet of electric vehicles.

7. Emission reductions from solar heating

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the School of Architecture, Victoria University of Wellington

6.1. Solar Heating in New Zealand

- The sun is the greatest source of energy on Earth and yet in NZ its energy is not used wisely for heating purposes. We can use solar energy passively, or actively.
- Passive solar heating is simple: let the sun into the building, and retain the resulting heat with insulation. This is not that difficult, but benefits from good design.
- Active solar heating is: utilising solar gain in machinery, such as solar hot water heating, solar photo-voltaic (covered elsewhere), solar hydronic heating.
- NZ has some of the world's worst statistics on child health and rheumatic fever, which increasingly is being linked to poorly insulated, poorly heated, poorly ventilated houses. This can be greatly improved by better house design. (Source: Howden Chapman research)
- NZ can use natural, free, solar heat energy to help reduce greenhouse gases and simultaneously provide better living conditions for our citizens.
- NZ currently consumes 12,374 GWh of electricity per annum, which is about one third of NZ's total energy consumption. (Source: MBIE 2015 Energy figures).
- Of NZ's national energy bill, some 11% of our energy supply (TPES) goes to residential homes (Source: MBIE) and of that, over 50% goes on hot water heating and the rest for appliances, lighting, and for space heating of our homes.
- A large part of that water heating and space heating energy could be provided by a combination of passive and active solar heating, potentially saving a large contributor to NZ's total energy bill. This is an opportunity we should not ignore.

6.2. International Trends in Solar Heating

- New Zealand has plentiful sunshine, and many hydro-electric dams, but due to our comparatively low cost of energy, we have not been careful to conserve energy.
- We are grossly wasteful of energy in our homes, in comparison with other developed nations. Our walls, floors and ceilings are poorly insulated, and single glazing is still the norm for most houses in NZ. Our heating just goes out the window.
- Overseas, many other countries have adopted higher insulation standards, double or even triple glazing is utilised and in some countries, solar hot water heating is mandatory for all homes – not just new homes.
- Energy intensive heating systems such as ducted central heating are extensively used in the northern hemisphere (especially USA), but not so much in NZ. Instead, here we are increasingly using heat pumps – better, but still wasteful of energy, especially if the house is poorly insulated.

6.3. Solar Heating Advantages

- Sunshine is free, and in NZ, it is plentiful. It provides many many times more energy than we utilise.
- Orientation towards the sun (predominantly facing north) allows sunshine inside, through north-facing windows, and creates free solar thermal gain.
- Solar radiation freely enters homes through windows, but can be trapped using low-E glazing, and retained as a free source of heat.

- Ensuring that houses are well positioned and well insulated, permits controlled ingress and retention of heating gains, with zero running costs.

6.4. Solar Heating challenges

- Most of our housing stock is existing and therefore already grossly inefficient.
- Retrofitting new insulation has started in many Housing NZ homes – and needs to be continued, and needs to include private housing as well.
- Existing houses that are badly oriented towards solar gain should, over time, be modified or replaced with better designed houses.
- Existing windows should be replaced with double or triple-glazed windows wherever and whenever possible.

6.5. The NZ Opportunity

Our suburban housing standards are low, and energy efficiency is given little or no thought in most / all District Plans. This can be remedied:

- Mandate the orientation of living rooms towards the north in all new houses.
- Demand that large outbuildings, such as garages, are not placed on the sunny, northern part of new houses.
- Ensure that new houses have sufficient thermal mass in floors / walls to store solar energy. Require R4 insulation to the underside of all concrete floor slabs.
- Raise insulation standards in new houses to R5 for walls and R6 for roofs/ceilings as a minimum.
- Make solar hot water heating compulsory for all new NZ houses from Christchurch north. Build a NZ reputation as an innovator and manufacturer of solar hot water heating.

6.6. What is needed to take that opportunity

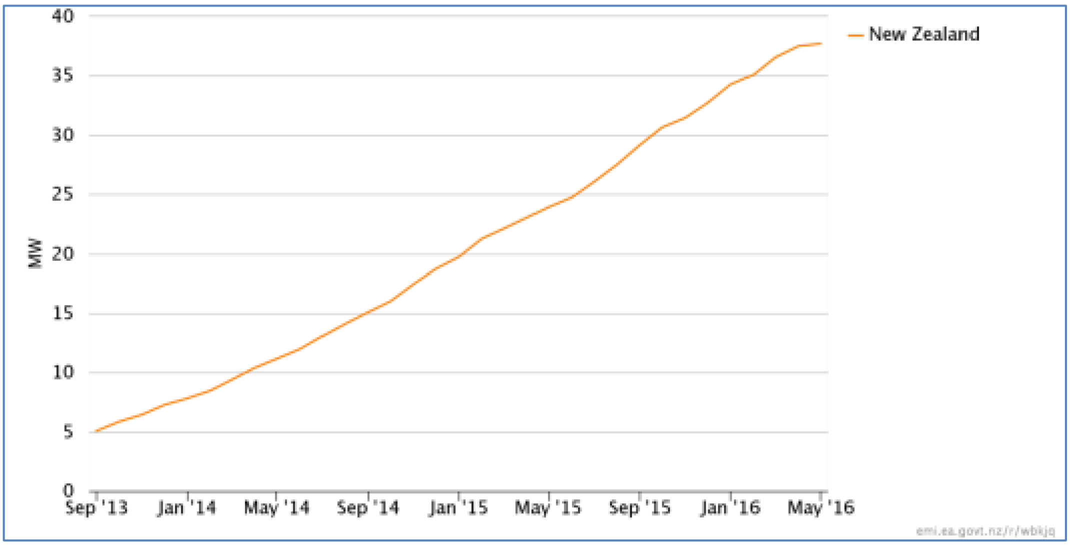
- Changes need to be made to the District Plans of every city or district – or an overall change can be made via amendments to the Resource Management Act. All new houses must be aligned with the sun, with living predominantly facing north. This will have a beneficial effect on all new houses built.
- Existing housing stock needs to be upgraded.
- Take action now on demanding good solar design for all new homes, via the RMA.
- Encourage strong uptake of solar hot water heating.
- Take action now on retrofitting insulation and double glazing to all existing homes.

8. Emission reductions from solar electricity

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the New Zealand and Pacific Solar and Storage Council

7.1. Solar and storage snapshot

a. Within current policy settings, solar installed capacity is experiencing a compound growth rate of over 110% p.a. currently, based on Electricity Authority data (measured from 31 Aug 2013 to 30 Apr 2016)[6]:



b. Solar customers are able to access "low user" line charges, and at the same time reduce their energy costs once they go solar, by the two fold benefit of purchasing less energy, as well as getting paid a nominal buyback price for any exported electricity;

c. Any registered electrician is legally allowed to install solar power systems, resulting in potentially a large pool of tradesman able to undertake solar installations, without any mandatory additional competence training;

d. New battery technologies are entering the market, resulting in significant price reductions on a "$/kWh storage capacity" basis. The speculation of when these figures will achieve grid parity dominate utility sector commentary;

e. The introduction of harmonised AS/NZS standards for solar and storage hardware and installation allow New Zealand to leverage the experienced labour resources as well as volume pricing enjoyed by Australia, a perceived major market for solar and battery storage suppliers;

f. No consents are required for solar and storage systems, and connection to networks may or may not be required depending on the topography sought by customers.

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[6] Source: http://www.emi.ea.govt.nz/Reports/VisualChart?reportName=GUEHMT&categoryName=Retail&reportGroupIndex=4&eventMode=Async&reportDisplayContext=Gallery#RegionType=NZ&MarketSegment=All&Capacity=All_Total&FuelType=solar&Show=Capacity&DateFrom=1/9/2013&DateTo=30/04/2016&reportName=GUEHMT&condensedView=false

This snapshot paints a picture of easy to install systems with falling costs structures, unconstrained access to products, supported by a readily available pool of labour.

7.2. Policy settings for encouraged growth and accelerated growth

Current annual electricity demand is approximately 43,000GWh, of which renewable generation represent 80.7% (34,643GWh). Of this 43,000GWh, approximately 32% is consumed at residential level in 2015 (12,500 GWh), and 24% at commercial level (9,472 GWh)[7].
On its own, without storage, a characteristic of solar power is that it has highest production during daylight hours in summer, tapering off in autumn and lowest in winter, rising again in spring. In terms of getting more "renewable electricity", solar arrays generate electricity in the time and seasonal band where it is more likely to offset hydro than thermal plant. Where the need for thermal generation is highest, during winter evening power system peaks, solar systems are not generating at any significant level. In the New Zealand context, the prospect of solar power to reduce the power generation carbon footprint is therefore limited in this narrative, while there is no energy storage.

Energy storage is rapidly approaching economic viability, both in terms of stationary batteries as well as "mobile" batteries in electric vehicles.

The scenario then becomes the deployment of much larger solar arrays with capability to store excess generation in the home and to charge EV's, significantly reducing transport fuel purchases and their commensurate annual carbon footprint, as well as to reduce winter thermal power generation at peak times.

For example, at 1kWh travelling between 5km and 8km depending on vehicle chosen, a daily commute of 30km can be easily provided by a solar array on the home consisting of 8 modules, for almost all year.

Policy settings that will encourage and accelerate growth are required to be put in place now, in order not to stifle solar and storage technologies as they rapidly approach economic mass deployment.

The policy settings required include providing:

a. Clarity and certainty in distribution line charge recovery:

   Changes are expected in the way distribution companies will charge for network connection and line charge recovery. The current uncertainty in what is likely to apply going forward is preventing new and existing service providers from offering new and innovative products. A rigorous and sustainable line charge regime will provide the certainty needed to both new entrants and existing players alike, who are waiting in the wings to offer solar/storage products into the market today.

b. Support for industry training initiatives:

   Solar and battery storage introduce new competencies required for installers and inspectors. The solar and storage industry has the capacity to provide training and ongoing professional development. Support for industry led training needs to be put in place, allowing the industry to keep practitioners up to date with safety issues as well as the rapidly changing technology landscape.

[7] Source: http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity

c. Continue harmonisation of standards and more urgency in the adoption of standards:

The promulgation of joint AS/NZS standards will allow New Zealand to benefit from significant savings in regulatory oversight by sharing the costs of establishing safe, industry best practice deployment of solar and storage technologies. Once established, these standards need more certainty of when they will apply. The current practices in this area are sluggish and creates uncertainty and confusion for both installers and electrical safety inspectors alike.

7.3. Opportunities for GHG Mitigation

Solar array installations are experiencing significant rates of growth, albeit from a low base. On a business-as-usual basis, falling equipment prices are likely to continue, resulting in ongoing high rates of growth in the numbers of installs. The fall in prices of batteries will make these systems economic in the short to medium term also. Solar plus battery storage are expected to be the game-changer leading to households being able to provide a significantly larger proportion of household energy requirements, both in terms of electricity and transport fuels.

The challenges for New Zealand are to ensure regulatory oversight and training in competency keeps pace with the introduction of new technologies. Expected changes in distribution line charging regimes need to be bedded down as soon as possible, to provide certainty for commercial decision-making, and to not hinder rapid provision and uptake of these technologies.

As the prices of solar and storage falls, households will find it more economic to invest in these technologies. For the government, policy settings that allow households to have confidence to invest in solar and battery storage represent very low-hanging fruit to achieve a significant reduction in household greenhouse gas emissions. These reductions come from directly reducing the fossil fuels used in vehicles, and by directly reducing the amount of power a household requires during winter power system peaks provided by thermal power stations.

9. Emission Reductions from Residential Wood Heating

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Sustainable Energy Forum

8.1. Bring back home heating with wood[8]

Wood is a true renewable resource. When used for home heating, it displaces fossil fuels and electricity generation, especially at peak heating times which drive the "need" to build new power stations and power lines.

The potential of wood heating is ignored in MBIE's electricity demand and generation scenarios.[9] MBIE's "low carbon" scenario predicts that eight gas peaking stations will be needed by 2050. Transpower has calculated that if Huntly had not been retained, 600 megawatts of new peaking electricity generation would have been needed as early as 2019 to avoid electricity shortages!10

[8] Author - Molly Melhuish, melhuish@xtra.co.nz, 3 May 2016

[9] http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015/resolveuid/a142b44e883d4f1d823d041b02a97b89

[10] https://www.systemoperator.co.nz/activites/current-projects/impact-thermal-generator-decommissioning

Home wood burning could replace those gas peakers; it is a key to a low carbon future. New Zealand's households got 45% of their useful space and water heating energy from wood in 2005, according to HEEP, the Home Energy End-use Project, by BRANZ.11

This vital study has never been updated, but the proportion had fallen to 12% in 2015 according to MBIE's recent submission to the International Energy Agency.

Two main factors have driven this decline in wood burning: -

- the extensive marketing and rapid rise of heat pumps, and
- the policy, "remove log burners", directed by Ministry for the Environment to be implemented in polluted airsheds.

This "removal" policy is taken to the extreme in Christchurch, where even approved low-pollution wood burners are required to be removed once they reach 15 years of age – after which the householders have supposedly gotten their required return on investment. What a travesty of economic reasoning!

This one-sided policy appears to be driven by a conviction that wood smoke particles lead to early deaths which outweigh the health problems caused by cold houses. Yet problems of cold and mouldy houses feature in the news, more and more every winter.

Many people strongly prefer wood burning – for its ambience, affordability, resilience to blackouts, and indeed its direct reduction of climate-changing electricity emissions. In Government's Warm Homes Clean Heat scheme, 70% of the recipients chose wood burners over heat pumps.[12]

Our national air quality policies should focus on setting appropriate heater combustion standards and education of wood heating users. Incomplete combustion arising from use of wet wood fuel is far more significant than the use of old but still efficient wood burners.

SEF concludes that wood burning has been actively suppressed, and it will take active measures to return it to its former role in New Zealand's energy portfolio. Home wood burning will be an essential part of the systems that enable New Zealand to meet any reasonable carbon reduction target.

Lets focus on policies based on good science and education on home heating rather than easy-to-adopt policies that are not in the national interest nor individual interest of home owners.

8.2. Policies to overcome barriers to wood burning

Wood supplied 45% of useful space and water heat in New Zealand's houses in 2005 according to the BRANZ research, the Household Energy End-Use Project. Ten years later, MBIE told the International Energy Agency that an estimated 12% of household heat energy came from wood burning

This decline has had many causes, not the least being the extensive advertising of heat pumps, the regulated removal of wood burners in polluted airsheds especially Christchurch, and the refusal of the electricity industry to offer residential tariffs that reward using alternative fuels during the months, weeks, and hours when electricity is costly to supply.

[11] http://www.branz.co.nz/cms_show_download.php?id=b1ab61dd06f50e83e6a184b29b68a989472502ed
[12] from an OIA request to EECA

To enable genuine consumer choice between the convenience of heat pumps and ability of wood burning to provide high heat levels at low cost and near-zero carbon emissions, polices are needed in the following areas:

1. **Control the smoke, don't ban the wood burner.**
    - Change the national environmental standard on air quality to focus on cumulative exposure to PM2.5, instead of sporadic exposure to PM10 which is much less correlated to mortality from air pollution.
    - Adopt a test method for flue gas emissions that reliably characterises the quantity and toxicity of the particles and gases emitted.
    - Or better, simply adopt the more stringent of today's European air quality standards, all of which are far less restrictive than New Zealand's.
    - Withdraw the bans (which some regions have) on wood burners more than 15 years old whether or not they meet emissions and efficiency standards.
    - Allow pilot trials of appropriate numbers of wood burners in both homes and larger-scale facilities to give real data on emissions and not artificial laboratory test results.
    - Measure air quality in a range of sites, not just (for example) two sites over the entire Christchurch airshed.

2. **Require availability of time-of-use power tariffs that encourage fuel switching from electricity to wood at times when it could assist reduction of coal- and gas-fired generation.**
    - Critical peak pricing – notifies consumers when the typically 100 hours per year of true electricity system stress are likely, and appropriately rewards their response in sharply cutting their demand.
    - Price-responsive demand – targets normal high-price periods with a tariff which reflects actual supply costs[13].
    - The case for such tariffs needs to be supported by modeling of the effect on peak electricity demands, and therefore on greenhouse gas emissions, of significant increases in wood burning, (MBIE was requested to do this a year ago, without success to date.)

3. **Fund development, commercialisation and research on wood burning.**
    - Assist commercialisation of advanced gasifier burners which ensure smoke is gasified and the clean gases burnt before reaching any heat exchanger – these are widely used in Europe.
    - Research and development on fuel preparation, including pellets, from various feedstocks for wood heating.
    - Research on wood combustion which could reduce or eliminate formation of NO2 and other toxic gases and enable improved automation.
    - Social research on barriers to domestic wood burning
    - Trials of multiple-use firewood forestry with amenity values for near-urban area planting, including restoring native trees and fauna.

4 **Encourage the widespread uptake of wood pellet and chip for commercial and industrial heating applications by:**
    - Overhauling the resource consent requirements in the light of point 1 to make the installation and operation of wood energy plant simple and bureaucracy free.
    - Remove the annual "compliance" fees on commercial and industrial plant.

[13] http://blog.rmi.org/blog_2016_05_17_moving_to_better_rate_design

5 **Adopt standards and procedures for wood burning and wood burning equipment which are in harmony with "best practice" countries, i.e. most of Europe. By so doing we:**

- Enable our people to purchase from the massive range of European plant and equipment from the small domestic to the large commercial.
- Remove a major "non-trade barrier" to the widespread use of wood burning and related equipment (by recognising equipment that has been tested elsewhere as being accepted in NZ)
- By putting our own manufacturer's on the same footing as Europe enabling them to compete more easily in the European market, driving jobs in NZ.

10. Emission reductions from geothermal capability

Summary of greenhouse gas mitigation options and what would achieve greater uptake from Geothermal New Zealand

9.1. Using our geothermal capability abroad to strengthen our domestic GHG mitigation capabilities

The New Zealand geothermal community has always played an important role in building the geothermal industry worldwide. Many in our community have spent time working internationally, often based for extended periods within project teams or in advisory roles to governments or international agencies.

In the 1960s New Zealand geothermal experts from (the then) DSIR in particular led early reconnaissance visits into fields in Latin America and East Africa. From the early 1970s GENZL and KRTA began to establish strong international operations, focused initially on Indonesia and Philippines. In the intervening years there are few geothermal projects that have not seen a New Zealand hand in part or all of their development:

- Kenya
- Mexico
- Azores
- Ecuador
- El Salvador
- Chile
- Comoros
- Ethiopia
- Japan
- Colombia
- Kamchatka
- Nicaragua
- Caribbean
- And the list continues to grow…………

These engagements are mutually beneficial; we have been able to build experience across all types of resources in a range of countries, sharing our knowledge with those with whom we work; learning through this process and, together with our international colleagues, applying fresh skills and innovation to a growing number of new developments.

An essential element of our New Zealand approach is to share information and experiences. We are proud to have built an alumni network of colleagues through our international collaborations, project experience and the post graduate programmes at the Geothermal Institute in Auckland.

The New Zealand Geothermal Association (NZGA) was formed in 1990 and is central to the interests of the New Zealand geothermal community. With a scientific and educational focus, the NZGA promotes coordination and collaboration with activities related to New Zealand and worldwide geothermal research, development and the application of geothermal resources.

Formed in 2012, Geothermal New Zealand Inc. (GEONZ) is an industry association that has an export focus, promoting and marketing New Zealand companies with particular geothermal capabilities and interests in international markets. The current focus is on engagement as part of major EPC operations, moving beyond our ongoing role as leading international geothermal consultants. Drawing from this wide industry base, GEONZ members have built teams that are now partnering with international contractors to bring major projects on line. This has been achieved in Indonesia and opportunities are being explored in East Africa.

The benefit for New Zealand, beyond the current activities and obvious export earnings is that this work is helping us maintain an experienced and engaged geothermal workforce. We all recognise the cyclic nature of the energy sector – the geothermal industry has invested some $2.5 billion into new plant in New Zealand in the last 10 years; while development of additional generation facilities is unlikely in the next few years, given the flattening of demand growth, our attention is being directed at optimising the operations of existing installations. This domestic focus strengthens our skills and experience in these areas; in parallel the opportunity to export the skills developed during the heavy construction activities, in the last ten years, is allowing us to reinforce these competencies, continuing to share our experience with others through this exposure to international developments.

There is no question that geothermal will continue to be a key part of our national energy mix going forward; international engagement helps ensure that we maintain the skills and experience that saw such a significant growth in our domestic geothermal production in recent years.

11. Emissions reduction from heavy electric vehicles

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Zero Emission Vehicles

10.1 GHG Mitigation from Heavy Electric Vehicles

Converting the entire New Zealand vehicle fleet to electric achieves 50% of New Zealand's greenhouse gas emission reduction requirement:

- The energy sector represents 40% of gross emissions
- Transport represents 45% of the gross emissions from the energy sector
- The heavy vehicle sector represents only 4% of the national fleet – but 21% of the transport emissions

Converting the heavy vehicle fleet to battery electric provides a cost effective technological solution for the reduction of greenhouse gas emissions. The technology is already available and proven and is able to be deployed in the 14 years available to New Zealand given appropriate policy support.

The heavy vehicle fleet is unique within the transportation sector as economies of scale are easily achieved when compared to the light vehicle fleet. As few as 10 heavy vehicles being manufactured at a time achieves the necessary economy of scale required to realise a commercially acceptable market cost.

The shortage of proven battery electric solutions and the perception of risk are the primary barriers to the adoption of heavy battery electric vehicles in New Zealand. Risk includes factors such as maintenance cost and timeliness, operational costs, performance in the New Zealand environment, resale value and initial capital purchase cost.

Within the transport fleet, the heavy vehicle sector offers the greatest potential for emissions gains for the smallest investment. Despite only comprising 4% of the total national vehicle fleet, heavy commercial vehicles account for 21% of the total greenhouse gas emissions from transport. Each heavy battery electric vehicle is the equivalent of from 6 to 20 electric passenger cars in terms of emissions savings.

This document outlines the importance of the heavy commercial fleet and proposes policies that maximise the deployment of battery electric commercial vehicles in the shortest time possible.

Current Application Examples

Nine Tonne Compacting Rubbish Truck on the Kapiti Coast

The ZEV 9000 battery electric compacting rubbish truck is a 9 tonne vehicle with 160 kW of motive power, 104 kWh battery pack and which has an average daily energy consumption of 0.48 kWh per km. Using off-peak electricity at 10 cents per km, the energy costs are 4.8 cents per km. The ZEV 9000 is already cost of ownership comparable to its internal combustion equivalent at a unit price of $240,000. This price is achievable in production quantities of just 10 such vehicles.
The ZEV 9000 operated by Kapiti Coast District Council (KCDC) has already accumulated in excess of 60,000km of zero emission use.

Possible Application Examples Utilising Existing Technology

High Productivity (H) Milk Tanker in the Waikato

A battery electric tanker truck and trailer combination carrying 26,000 litres of milk on an average route distance of 125km six times per day would have 550 kW of motive power, be fitted with a 507 kWh battery pack and consume around 3.5 kWh per km. The total cost of ownership is already cost comparable to its internal combustion equivalent at a unit price of $1,000,000. This price is achievable in product quantities of just five such vehicles.

Urban Bus Battery Electric Refurbishment and Conversion for Christchurch

A New Zealand built Euro VI diesel powered urban bus costs in excess of $400,000. Refurbishing and converting existing Euro I, Euro II, Euro III or Euro IV diesel buses to battery electric may cost as little as $250,000. The refurbished and converted bus would have a range of 150 km on a single charge with range extension of another 200 km per day when utilising fast charging. The total cost of ownership of a refurbished and converted bus would be around 50% of the cost of its equivalent internal combustion vehicle.

Multi Modal Logging Rail Vehicle in the North Island

A logging operator hauling logs from the volcanic plateau to the port at Wellington currently transports all the logs via road. The use of an electrically powered rail dolly attaching to conventional road truck logging trailers towed by a 'light' battery electric rail tractor achieves long haul energy efficient transportation of consolidated loads of up to 500 tonnes. This has benefits of reducing road traffic, while creating major cost savings for the logging operator.

10.2 Effective Policy Initiatives

Six policy areas have been identified as having the greatest impact in order to achieve the transition of New Zealand's commercial heavy vehicle fleet to zero emissions renewable energy power.

1 Regulations on Fine Particulate Emissions

Diesel emissions have been classified as carcinogenic by the World Health Organisation to the same extent as cigarette smoke and asbestos. New Zealand has neither emissions standards that take into consideration fine particulates nor any public health policy initiatives relating to exposure to the fine particulates from diesel combustion. By actively monitoring and seeking reductions in the volume of harmful particulates from fuel combustion in the atmosphere, especially in urban environments, both public bodies and fleet operators will be encouraged to seek clean alternatives for their heavy vehicles.

2 Industry Sector Solution Funding

Commercial heavy vehicles are designed or modified for specific industry sectors and applications (see examples). To cut emissions across industries, solutions must be provided and proven for each segment. Funding assistance to organisations providing, proving and promoting solutions is required to accelerate the transition of the commercial heavy fleet to battery electric.

3 Consolidated Orders

Larger orders of heavy electric vehicles create economies of scale and accelerates the development of expertise and infrastructure around such vehicles. A policy providing appropriate financial support to organisations that consolidate existing and forecast orders into one supply commitment would encourage this.

4 Multi-modal Rail Network

Rail represents an important opportunity to provide existing road transport operators with additional options for long haul, heavy freight where factors such as battery weight and range remain problematic. Rail in New Zealand has four characteristics that make it a part of the transportation mix of existing road transport operators.

1. The long haul rail network is not suffering congestion problems
2. Rail has significantly lower rolling resistance, significantly increasing electric vehicle range
3. The North Island main trunk line is already electrified and is able to be used to recharge batteries

4. Rail accommodates much greater weights which is able to be used for larger payloads and battery packs.

Opening up the rail network to multi-modal use by existing road transport operators reduces the amount of very heavy loads required to be transported long distances by road.

5 Electric Vehicle Depreciation

As no market currently exists for second hand battery electric commercial vehicles, the risk associated with the resale value of the vehicle needs to be adequately mitigated. One means of achieving this is the provision of more aggressive depreciation rates than is currently used for internal combustion vehicles.

Higher depreciation rates mean the second-hand sell price of heavy electric vehicles may be lower, which in turn stimulates the second-hand market for such vehicles.

6 National Emissions Accounting

Introducing a policy of emissions accounting for public and private bodies creates the ability to set goals and restrictions at finer levels than just the national accounting can achieve. This provides a measure for councils, corporates, industry sectors and geographical regions to quantify emissions reductions progress and performance and hold such groups accountable.

10.3 Scenarios

With the heavy commercial vehicle transport sector representing a clear and direct path to emissions reductions, there are three scenarios where the level of action directly impacts the level of reductions achieved.

Scenario 1: Business as Usual

- Heavy vehicle operators continue to be frustrated by the lack of practical, proven and affordable options for electrification.
- Engineers and service personnel have no qualification framework to train in the maintenance and construction of electric heavy vehicles.
- Heavy vehicle operators struggle to understand the true value of any battery electric vehicles they may operate
- There is only minimal investment in the design and manufacture of heavy electric vehicles.
- There is only minimal investment in alternative low carbon logistics scenarios.
- A policy of facilitating consolidated orders is insufficient to encourage significant take-up of heavy electric vehicles.
- A policy of RUCs exemptions remains only while the fleet of electric commercial vehicles is less than 2% of the heavy vehicle fleet
- The number of heavy electric vehicles does not increase in any substantial numbers relative to the overall diesel heavy vehicle fleet, resulting in no measurable reduction in emissions.

Urban buses start to be converted to battery electric from 2020 with 5% (250) battery electric by 2030, 30% of the fleet (1,800) battery electric by 2040 and 50% (3,000) battery electric by 2050. A much smaller number of specialist urban vehicles such as compacting rubbish trucks are battery electric with 10 by 2020, 100 by 2030, 500 by 2040 and 1,000 by 2050. By 2050, the heavy vehicle fleet is saving 210,000 tonnes of CO_2, but total heavy vehicle emissions have still increased.

Scenario 2: Encouraged Growth

- A public policy position from Central Government acknowledging the carcinogenic nature of the fine particulates in diesel emissions shifts responsibility for the emissions related health and safety of employees and the public to the fleet operators. This leads to a change in safety policies for organisations nationwide and further stimulates demand for zero emission solutions.
- Co-funding of industry-specific solution projects sees viable options for heavy electric vehicles become available to select industries. This leads to greater private sector investment into design, manufacturing, marketing and support.
- A more aggressive consolidated orders policy leads to take up from numerous commercial fleets nationwide as heavy electric vehicles become near-comparable from a cost perspective when compared with their internal combustion counterparts.
- A policy of RUCs exemptions on electric commercial vehicles is extended to at least 5% of the heavy vehicle fleet
- More aggressive depreciation rates for battery electric commercial vehicles reduce the resale value risk to the vehicle owner.
- Emissions accounting is brought in to report on the emissions for individual bodies to empower them to make measureable changes.
- The increased market sees domestic and international vehicle manufacturers develop heavy electric vehicle solutions for New Zealand industry sectors.
- Expertise and experience in the maintenance of electric vehicles is slowly built to support the growing vehicle base.
- Around 10% of the national heavy vehicle fleet is fully battery electric by 2050, but emissions from the New Zealand heavy transport sector have still increased.

Urban buses start to be converted to battery electric from 2018 with 10% (500) battery electric by 2030, 40% of the fleet (2,400) battery electric by 2040 and 60% (3,600) battery electric by 2050. Specialist urban vehicles such as compacting rubbish trucks are battery electric with 20 by 2020, 500 by 2030, 2,000 by 2040 and 5,000 by 2050. A small number of large niche market vehicles are battery electric, with 5 by 2030, 10 x 2040 and 20 by 2050. Light duty battery electric trucks and buses are imported with 5 by 2020, 100 x 2030, 1,000 by 2040 and 5,000 by 2050. By 2050, the heavy vehicle fleet is saving over 460,000 tonnes of CO_2, but total heavy vehicle emissions have still increased.

Scenario 3: Accelerated Growth

- A more aggressive policy of regulating particulates sees a nationwide staged changeover of heavy internal combustion vehicles to electric, most notable in public and urban transport fleets. This policy sees the steady phasing out of older diesel vehicles for electric, creating a secondary industry for electric conversion of existing vehicles.
- Fully-funding and targeted funding of industry-specific solution projects sees compelling options become available for all targeted industries. Private sector investment into the industry becomes significant.
- Attractive consolidated orders with financing means the cost of ownership of an electric heavy vehicle solution is clearly less than that of diesel. Under this scheme, all new heavy vehicles purchased are electric.
- A policy of RUCs exemptions on electric commercial vehicles is extended to all heavy electric vehicles.

- Aggressive depreciation rates for battery electric commercial vehicles provides an added incentive to heavy commercial vehicle operators to use battery electric solutions.
- Public and private bodies are set quantified emissions reduction targets to achieve within set Governmental timeframes.
- A rapid ramp-up of capability in expertise and infrastructure for heavy electric vehicles would occur nationwide, including the advent of specific qualifications for maintenance personnel.
- Opening up the rail network to existing road operators allows them to actively minimise their cost of transportation for very heavy or long haul goods in industries such as forestry. This solves any current technical issues such as battery weight impacting on range, so long-haul without any need for charging becomes immediately viable with current commercially-available technology.
- Over 60% of the national heavy vehicle fleet is fully battery electric by 2030, with around 13% of the total emissions from the New Zealand transport sector eliminated.

With the average vehicle life in New Zealand being around 15 years, this conversion could be completed by 2040 if every new vehicle purchased from now on was electric. To accelerate growth to these levels requires more aggressive policies.

Urban buses start to be converted to battery electric from 2018 with all urban buses battery electric by 2040. All medium duty trucks (less than 25,000 kg GVM) start to convert from 2018 with 90% of all medium duty trucks battery electric by 2050. By 2050, 60% of heavy trucks will be capable of battery electric operation. By 2040, the heavy vehicle fleet has started reducing its total emissions and by 2050 total heavy vehicle emissions have been reduced to around 500,000 tonnes, a saving of over 400% on the business as usual scenario.

10.4 Emission Changes to 2050 by Scenario

The chart *Figure 1 - Heavy Vehicle Emissions by Scenario* extrapolates the heavy vehicle emissions between 2009 and 2014 through to 2050 under the three different scenarios. Results indicated here are likely to be conservative as the newer heavy vehicles in the national fleet are more heavily utilised than the older vehicles in the fleet.

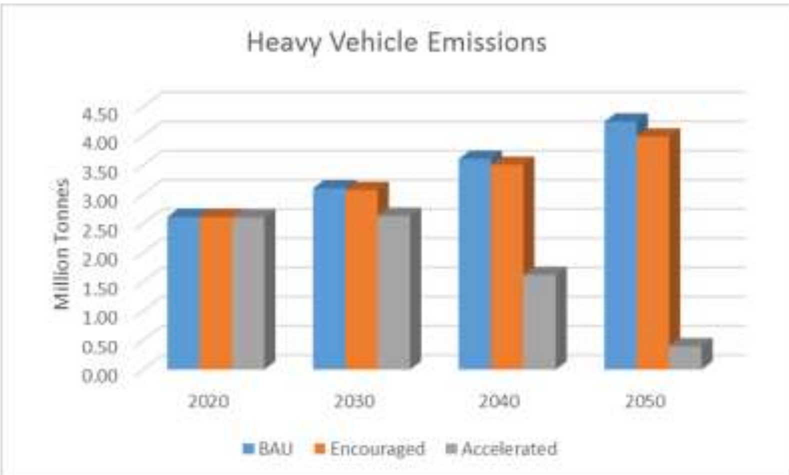

Figure 1 - Heavy Vehicle Emissions by Scenario

10.5 Answers to Commonly Asked Questions

Do batteries have enough energy to drive a heavy commercial vehicle?

The energy density of diesel is around 35.8 Mj/L, while lithium batteries are only 0.9-2.63 Mj/L. Surely this means that a battery electric commercial vehicle would require 40 times the volume of batteries as the diesel fuel in an internal combustion vehicle?

Modern lithium battery electric drive is much more efficient than traditional diesel fuel combustion. So this ratio has already reduced to less than 15:1 when the actual energy consumption of heavy battery electric and internal combustion vehicles is compared. Ongoing improvements in lithium battery technology and how they are engineered into commercial heavy vehicles will further reduce this ratio to less than 5:1. But even this does not take into account the extra space and weight required by modern internal combustion vehicle engines, transmissions, exhaust treatment systems, and air intake and filtration systems suggesting that the effective ratio may soon approach 2:1.

Will the number of batteries needed make the vehicles too heavy?
Battery electric vehicles are heavier than internal combustion vehicles. Surely this increase in the tare weight reduces the payload the vehicle can carry?

Because the energy density of electric heavy vehicles is less than an equivalent internal combustion vehicle, it does require more batteries than diesel fuel in order to achieve the same daily workload of an equivalent internal combustion vehicle. For example, a 14 tonne internal combustion vehicle may have as much as one tonne extra payload when compared to a first generation battery electric vehicle. Three initiatives recapture this lost payload:

1. RUCs exemption. The exemption for battery electric commercial vehicles from RUCs charges reduces the commercial significance of the payload reduction.
2. High Productivity. Battery electric commercial vehicle manufacturers are able to configure the vehicle design to take advantage of the High Productivity classification available in New Zealand, and so recover the lost payload.
3. Better vehicle design. New battery electric commercial vehicle designs incorporate the battery pack as an integral part of the chassis design, and so recover much of the lost payload.

Will battery electric vehicles have enough range for commercial applications?
Battery electric vehicles cannot go as far on one battery charge as an equivalent internal combustion vehicle can go on one tank of diesel. Surely this decreased range reduces the usefulness of the battery electric vehicle?

The battery capacity is the key determinant of the vehicle range. The battery capacity is determined by the range requirement, the payload requirement and the capital cost requirement. Consideration of all three factors is required in order to achieve the optimum utility of the battery electric commercial vehicle. Battery electric commercial vehicles already have a range in excess of 150km on a single charge with 200km to 250km range with nominal opportunity charging – sufficient for all urban applications. The challenge of range for battery electric commercial vehicles is further mitigated by:

- Battery electric commercial vehicles are capable of in-service recharging during loading, unloading and normal driver rest periods which significantly increases the “refuelling” frequency, and so extends the effective range. Fast charge opportunity charging can increase the battery electric vehicle daily range to more than 400km.
- Battery electric vehicles recharge while parked – so are always “ready to go”. The equivalent internal combustion vehicle must be driven to a gas station and manually refuelled every few days

12. Emissions reduction from reducing methane emissions

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Bioenergy Association

11.1 Introduction: Green House Gas reduction and Biogas

The NZ Greenhouse Gas (GHG) inventory accounts the global warming potential (GWP) of one tonne of methane as 25 times that of 1 tonne of fossil CO_2. Methane is produced from organic matter placed in landfills, waste water treatment facilities, and decaying agricultural and food processing organic residues. Removal of methane emissions is therefore a key greenhouse gas mitigation opportunity.

The waste sector produces mainly methane emissions (96.4%)[14]. There are significant additional emissions of CO_2 from disposal of solid waste but these are of biogenic origin and are not reported.

In 2013 there were 49 landfill sites and 367 waste water treatment facilities and emissions from the waste sector contributed 5,054 kt CO_2-e or 6.2% of NZ's total greenhouse gas emissions.

Table 1: Greenhouse gas emissions from waste

Source	2013 emissions[15] (kt CO_2-e pa)	%
Solid waste disposal	4600.3	91
Biological treatment	0	0
Incineration	3.1	0.06
Wastewater	450.5	8.9
TOTAL	5054	

23 landfill sites had operational methane recovery systems (17 operating and 6 closed sites). These 24 sites accounted for 84% of waste disposed to municipal landfills. The 25 smaller sites have no methane recovery system. 68% of methane produced is recovered at sites where gas is collected, and over all landfill sites 40% of methane is collected. Most municipal landfills accept locally produced industrial waste as well as municipal waste.

Most municipal landfills are mandatory participants in the NZ ETS with obligations to report and surrender emission units for their methane emissions

Table 2: Estimated composition of waste to municipal landfills in 2013

Food	Garden	paper	Wood	Textile	Nappies	Inert
17%	8%	11%	12%	6%	3%	44%

There are[16] 15 waste processing facilities collecting methane and using it as fuel to generate electricity:

- 11 landfill facilities with 29.4 MW electricity generation capacity. The facilities produce electricity only. Heat is discharged to atmosphere.

[14] . Source New Zealand's Greenhouse Gas inventory 1990-2013, Ministry for the Environment
[15] Net emissions after methane recovery. In 2013 1354.25 kt CO2-e methane was recovered.
[16] As at 31 December 2012. Source New Zealand's Greenhouse Gas inventory 1990-2013, Ministry for the Environment.

- 4 waste water treatment facilities with 11.3MW electricity generation capacity. These are all cogeneration facilities with heat and electricity all consumed on-site for the processing of sewage.

In 2013 waste water treatment and discharge contributed 450.5kt CO_2-e of emissions from the waste sector (8.9%).

Domestic and commercial wastewater contributed 254.5kt CO_2-e (56.5%) of emissions from 317 municipal wastewater treatment facilities and approx. 50 government or privately owned treatment plants. Although most of the wastewater treatment processes are aerobic there are a significant number that use partially anaerobic processes such as oxidation ponds. Small communities and individual rural dwellings are served mainly by simple septic tanks. 10 municipal treatment plant accept large amounts of industrial wastewater.

8 domestic wastewater facilities remove methane via flaring or for energy production resulting in zero methane emissions.

Industrial waste water contributed 196.1kt CO_2-e (43.5%) emissions from wastewater facilities. The major source of industrial wastewater comes from the meat processing, and pulp and paper industries, and dairy processing. Most industrial waste water treatment is aerobic and most methane from anaerobic treatment is flared. However there are a number of anaerobic ponds that do not have methane collection, particularly in the meat industry.

There is no methane recovery from the meat processing, wine, and pulp and paper sources. Since 2012 the wool processing industry has used aerobic treatment of wastewater and thus methane emissions are no longer produced.

The dairy industry predominantly uses aerobic treatment. There is only one dairy processor (Tirau) using anaerobic treatment and the methane is used directly as a heating fuel. Consequently there are no methane emissions from the dairy processing sector.

An estimated 5% of manure from dairy cows is stored in anaerobic lagoons[17].

There are 4 agricultural facilities processing liquid waste through anaerobic digestion plant where methane is collected and used directly as energy:

- 1 piggeries
- 3 dairy farms

Tools to collect the methane and process it so as to avoid GHG emissions and thus avoid the need to surrender emission units are proven and already available in NZ but are presently under-utilized. These processes produce and capture biogas which can then be used to generate electricity; be a source of heat; or used as a replacement fuel in vehicle engines. Once used (burnt), the biogas converts back to carbon dioxide which is GHG neutral, as it is from atmospheric carbon dioxide that had been recently converted to organic matter and is just being re-released. It does not come from long sequested fossil fuels (Oil and Coal) which add more fossilized carbon dioxide to the present total atmospheric GHG inventory. Many of these applications are economic for facility operators when the released energy is used to reduce on-site operating costs.

[17] Ledgard and Brier 2004

11.2 Drivers

The use of biogas technologies to remove methane emissions can have a wide range of drivers, but it is often not until the lifecycle costs and benefits are considered that the collective benefits from the opportunities become economic. (Energy is only one of the benefits and not always the primary driver. Many of these benefits are public goods and not able to be captured by the facility owner/investor). These drivers can include:

- Reduction of GHG from the methane that would otherwise escape from waste treated or disposed of by other means (from landfill in particular) (Affects NZ's ETS position)
- Reduction of the ultimate waste disposal volume and chemical oxygen demand (COD) when finally disposed of back into the environment. (thereby extending disposal facility use (e.g. landfill) and complying with the Waste Minimisation Act)
- Production of energy (biogas, which can be used for heat, electrical energy, cooling, or as a replacement transport fuel)
- Digestate which is a good, stable fertilizer (closes the nutrient loop cycle)
- Reduction of the odours associated with disposal facilities (reducing social unacceptability of disposal facilities)
- Reduction of vermin at disposal facilities (rats, mice, birds, hedgehogs)
- Reduction of disposal facility land instability post facility closure
- Deals with organic wastes accountability with a quick treatment (typically 21 days) as opposed to 20 years or so in disposal facility (long term methane leakage) with consequently much harder accounting for GHG emissions
- Provides employment
- Can provide CO_2 enrichment for horticulture hothouse crops.

As shown in Figure 1 New Zealand is already a world leader in processing municipal solid and liquid waste to energy using anaerobic processes and has the capabilities to cost effectively treble the amount of methane currently collected and processed into energy using proven technologies.

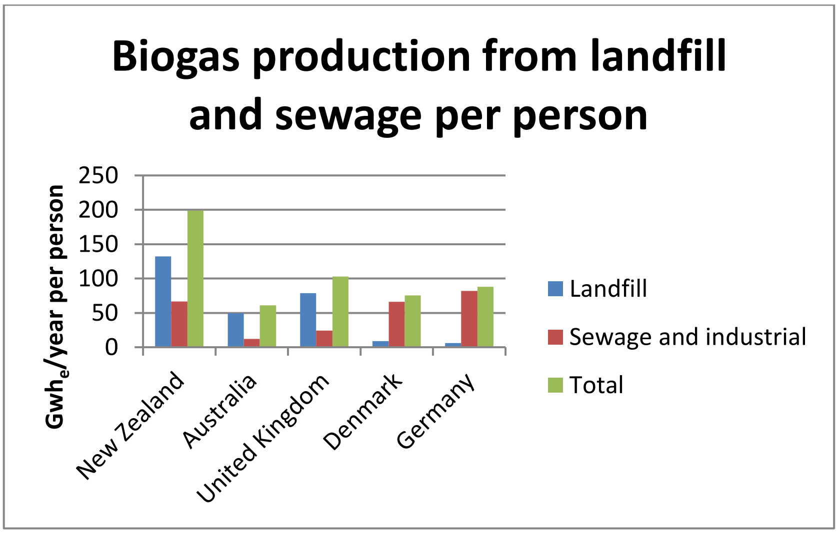

Figure 1: International comparison of municipal biogas production Source; IEA Biogas

11.3 GHG reduction opportunities

Methane is the major constituent of biogas (between 40 and 70%, the balance is Carbon dioxide).

Biogas is the natural result of organic material decaying in the absence of oxygen (anaerobically) and occurs anywhere organic material is left to rot, particularly in landfills. Landfills provide a large, generally biologically uncontrolled place for the dumped organic material to decay. Piles of organic matter, left untreated will naturally produce methane-containing biogas.

If organic waste from municipal, agricultural and industrial sources is not processed appropriately the methane (CH_4) produced is a much more significant greenhouse gas emission than carbon dioxide (CO_2), by a factor of 25.

Investment in appropriate disposal facilities or waste management/ treatment plant can nearly eliminate the methane discharged into the atmosphere by converting it into CO_2 in an electricity generator, boiler or flare. This CO_2, being of biomass origin, is accounted for as GHG neutral, resulting in an almost complete elimination of GHG emissions from that source. The captured biogas, however, is valuable for the generation of electricity, heat and use as an engine fuel substitute. When the waste is treated in an anaerobic digester to produce biogas, the digestion residue (digestate) is a valuable fertilizer.

11.4 GHG reduction scenarios

The barrier for greater uptake of the use of biogas technologies to reduce GHG from methane appears to be the lack of ‘desire to make it happen’, and the relative cost benefits of other use opportunities eg composting municipal waste, and distribution of untreated dairy effluent onto pasture. There are no technology barriers. In many situations the lack of desire to make projects happen are because of a lack of access to capital finance.

The focus for the reduction in methane discharge to atmosphere and thus GHG emission reduction is on maximizing the value available from our organic wastes through use of biogas technologies.

The priority areas for methane reduction, in order, are:

1. Food processors and municipal waste water treatment plant operators, who produce organic waste and to economically convert this into biogas for energy, to reduce on-site energy costs.
2. Ensure all significant landfill operations collect and use the landfill gas naturally produced (biogas) and / or maximize the value of the biogas they already collect.
3. Assist agricultural businesses that produce large volumes of organic waste (eg; manure) to process this into biogas for on-site energy use before recycling waste nutrients back to the land.

Three scenarios (Business as usual, Encouraged Growth and Accelerated Growth) show the robustness of the opportunities to reduce methane emissions from organic waste.

11.5 Scenarios

The scenarios for growth in the production and utilization of biogas are:

Scenario 1: Business As Usual (BAU)

Conditions:

- Based on existing policies and market conditions. No policy changes
- Uses existing technologies and an extension of current trends
- No 'maybes'. Only realistic activities based on existing sector participant's activities.
- Assumes current ETS 2 for 1 policy is deleted and the ETS administration is improved, with no other significant changes.

Scenario 2: Encouraged Growth

Conditions:

- Government signals that it wants to encourage domestic mitigation and avoid the need for the purchase of international units
- Based on BAU conditions plus:
  - Limited number of complementary measures pursued and implemented.
  - Central Government introduces policies that change Government procurement procedures so that renewable energy, efficient energy and all additional benefits are included in a full life cycle cost analysis of options.
  - Local councils introduce policies for local government procurement, similar to central Government procurement policies and that these must be considered when making investment decisions.
  - Government adopts a collaborative growth strategy with each renewable energy sector

Scenario 3: Accelerated Growth

Conditions:

- Government seriously considers and adopts some complementary measures to the ETS
- As for Scenario 2 above, plus:
  - Low cost policies introduced to address specific barriers across renewable energy sectors and within each sector.
  - Government does an annual cost-benefit analysis of forward offshore ETS purchase obligations vs acquiring domestic mitigation through a capital fund.

Figure 2 gives the expected additional GHG emission reduction for the three scenarios based on the methane capture scenarios shown in Figure 3.

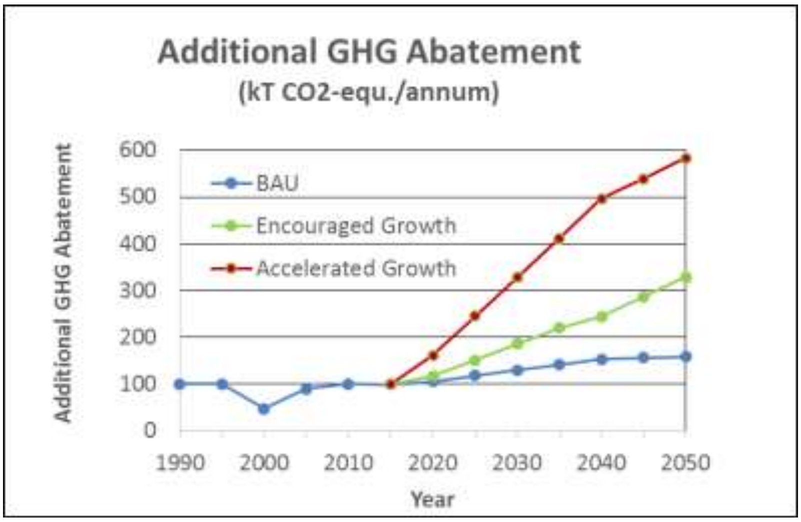

Figure 2: GHG abatement in the 3 scenarios

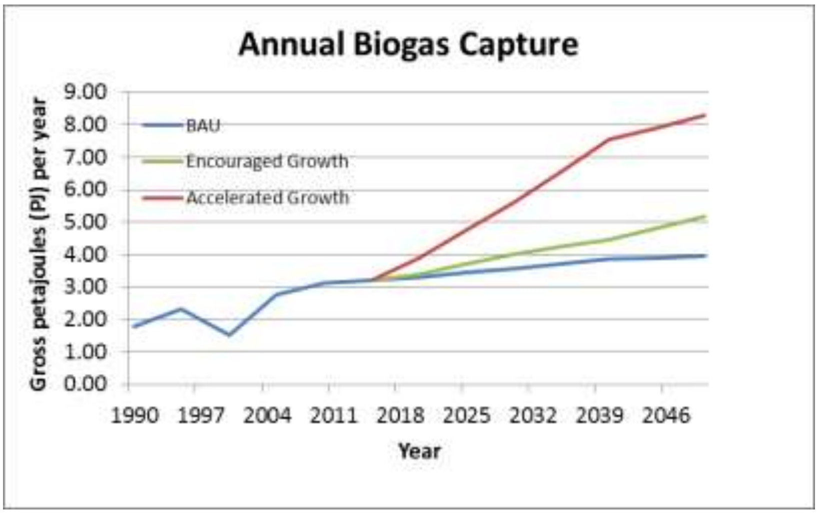

Figure 3: Scenarios for annual biogas capture

Analysis of the opportunities in the liquid and solid waste sectors shows that collectively, by 2050, with encouragement policies, there could be:

For scenario 1-Encouraged Growth:

- A 2 fold increase in the annual waste treatment for production of biogas (refer Figure 2), with a consequent 230 kt CO_2-e per year reduction in emissions compared to 1990 (refer figure 1).

For scenario 2 – Accelerated Growth:

- With the adoption of the appropriate acceleration policies, as set out in section 3, increased waste treatment and consequent biogas production could increase by 4 times, providing a 500 kt CO_2-e per year reduction in emissions, when compared to 1990.

Table 3 shows were methane reduction can come from by 2050.

Methane reduction sources	PJ/annum	%
Electricity, direct use and CO_2 enrichment from landfill gas (biogas)	3.01	36
Electricity, direct use and CO_2 enrichment from dedicated on-site digestion of putrescible industrial waste	1.7	21
Electricity from co-digestion of industrial waste in municipal WWTP	0.9	11
Electricity municipal sludge digestion optimized for energy recovery	0.74	9
Direct use, CO_2 enrichment, or use as vehicle fuel of biogas from WWTP.	0.33	4
New dairy farm uses	1.61	19
Total max methane (from biogas) 2050	8.29	100

Table 3: Sources of methane reduction (2050 Accelerated Scenario)

On a lifecycle costs and benefits basis, the investment cost to facility owners is around zero. Central and local government costs used to encourage methane reduction are estimated at around $200,000 p.a. for 3 years, and for the accelerated methane reduction scenario is estimated to be less that $800,000 p.a. for 5 years, excluding any investment in suspensory loans and the fiscal cost of deferred depreciation.

11.6 Assumptions

The assumptions for the biogas GHG reduction scenarios are that:

- Economies of scale and steady biogas plant operation are achieved by the sourcing of trade wastes, and supplementary feedstocks
- Gate fees for taking trade waste into a waste treatment plant reflect the cost of otherwise disposing/processing of such waste. (eg by landfill)
- Local government encourages separation of organic matter from municipal solid waste in Scenario 2 and requires it in scenario 3.
- There is no new technology and no new anaerobic digestion research needed.
- Existing waste treatment facilities continue to be utilized or upgraded.
- A very high proportion of the current municipal organic waste which ends up in a landfill, will then be disposed of in an anaerobic digester, so capturing and burning the biogas (~60% methane)
- Because discharge of 1t of methane to atmosphere has a 25 times greater global warming potential than 1t of fossil CO2, methane capture and use should will be a logical priority for municipal waste management policies.
- In scenario 2, a target is set for the production, capture and use of methane at waste water treatment plants which provides an incentive to collect and use the biogas for on-site electricity generation, on-site heat utilization and / or use as a transport fuel replacement.
- In scenario 2, landfill operators use a greater portion of the biogas collected for replacement of fossil vehicle fuel.
- GHG emission reductions (CO_2–e) are based on:
    - Comparison to the 1990 discharge of methane from municipal, industrial and agricultural waste to atmosphere
    - On site electricity: the difference between use of methane to generate electricity compared to the discharge of methane to atmosphere and the alternative purchase of electricity from the grid
    - Vehicle fuel: Use of biogas as a replacement for vehicle fuel instead of discharging the methane to atmosphere and the use of fossil fuel (usually diesel)
    - Heat: combustion of biogas in a boiler compared to the discharge of methane to the atmosphere
- Where appropriate in scenario 2 urban bus transport utilizes available biogas from waste water treatment plants as a fuel (biogas then becomes CNG). (eg, as already used by “Go Bus” in Hamilton)
- There are presently only weak GHG drivers for the capture of dairy effluent biogas in scenario 2 and scenario 3. But increasing demands for better farm effluent management for the protection of waterways or odour emissions can result in a moderate increase in the production of biogas for on-farm electricity, heat and replacement of vehicle fuel.

11.7 Complementary measures

The following measures complementary to the NZ ETS would encourage increased GHG reduction from biogas applications under scenario 2 and 3.

1. **Government, Local Government New Zealand, and Bioenergy Association agree targets to reduce emission from organic municipal and industrial waste by 2020, 2030**.
    - The objective is to encourage the reduction of methane emissions from landfills, waste water treatment plants and industrial processes.
    - The Bioenergy Association, Local Government and New Zealand Government will agree a specific target for the reduction of methane from landfill and waste water treatment plants.
    - EECA and Bioenergy Association, under a Collaboration Agreement, will agree on a strategy and action plan including: target facilities, promotion, education and information programme: value proposition information, collection and dissemination of demonstration project information.
    - MfE to extend the existing mechanism for the collection of data from all landfill and WWTP and to provide an annual report on methane capture and emission presented by region.
    - The Bioenergy Association will assist to achieve the targets by:
        - Establishing a working group with MfE and LGNZ to develop a work programme for methane emissions reduction from waste.
        - Preparation and promotion of regional methane reductions and opportunity plans that provide guidance to the respective organic waste sector suppliers.
        - Collating and publishing useful information from any demonstration facilities into a Technical Guide.
        - Collating information from local govt on their existing policies with regard to methane reduction. Reviewing the information and report back to local govt as a whole with useful information.
        - Hosting regional meetings to assist liquid and solid waste facility owners to be up-to date with methane reduction opportunities and practises.
    - Government to review the present use of the landfill Waste Disposal Levy and the criteria for grant allocations from the Waste Minimisation Fund, so as to include methane emission reduction opportunities.

2. **Central Government introduces procurement policies so that waste to energy or other renewable energy options must be considered when making capital investment decisions and all costs and benefits are included in a full life cycle analysis of options and reasons provided for not adopting a renewable energy solution.**
    - EECA and the Bioenergy Association develop Technical Guides:
        - Methods and evaluation of options for methane collection and processing at WWTP.
        - Methods and evaluation of options for destruction of methane from landfill.
    - Government's project appraisal model uses a CO_2 cost profile assumption published by EECA from time to time. This profile takes account of assumed movement over time as a result of the ETS (This approach/modelling will also demonstrate that the Government is taking clear long term decisions that reflect the likely real price of carbon over the life of the methane-fuelled plant i.e. 20 years plus).
    - Local councils be required to introduce procurement policies similar to those adopted by central Government.

3. **EECA extends the repayment period for Crown Loans**
   - Extend the period of Crown Loans for biogas facilities beyond the current 5 years to better reflect the economic lifecycle costs and benefits of a waste processing facility.

4. **Government introduces policies to allow for accelerated depreciation of renewable energy, waste to energy and energy efficiency capital investments.**
   - Renewable energy and energy efficiency equipment is more capital intensive but often has lower on-going operating costs than alternatives.
   - Access to capital is a major barrier to investment in renewable energy and energy efficiency solutions. Allowance of accelerated depreciation is fiscally neutral to Government except for timing. However accelerated depreciation can provide a significant assistance to plant investors.

5. **Government establishes a GHG Reduction Fund to provide suspensory or low interest loans or similar for renewable energy and energy efficiency capital investments.**
   - Many renewable energy projects may be potentially financially attractive but access to capital is a major barrier. Having provision for suspensory loans which are paid back out of operating profits once the project is operational can assist potential projects get underway.
   - Suspensory loans from central government, or restructured rates schemes at city council level could assist the uptake of this low emission technology.
   - There may be a role for a GHG Reduction or a Clean Energy Fund, similar to that in Australia, to make money available to private sector projects to compliment the Crown loans available through EECA for renewable investment projects.
   - A GHG Reduction Fund managed in the way the NZ Super Fund or ACC manage their funds should be established to make loans, similar to Crown Loans, available to private sector projects.

     The Australian entity, is the Clean Energy Finance Corporation (CEFC) whose role is to overcome market impediments and help accelerate Australia towards the transformation to a low carbon economy, minimise its ultimate cost and create positive adjustment for the economy, including through new forms of clean technology business, new jobs, development of new or expansion of existing businesses and development of new technological know-how. However, the NZ version of such a fund would need to be scaled to a NZ project size.
   - The CEFC places priority on its investments generating economic, social and environmental benefits, including building capacity and capability within the renewable and low carbon energy sector, demonstrating applications and financing for new technologies, development of new or existing businesses and the development of new technologies and know-how.
   - CEFC investments to date - even at this initial phase - are demonstrating the potential to expand Australia's manufacturing capability and create new industry and employment opportunities across the country, particularly in regional areas.
   - The CEFC's portfolio of contracted investments is expected to earn an average return of approximately 6.1 percent (as reported in their 2014-15 Annual Report). While New Zealand's lower population density may not produce such attractive returns, their participation in the market provides liquidity to ensure efficient pricing. CEFC's lower cost of funds, flexible structuring and capacity to match the term of the financing to the life of the assets has allowed them to de-risk transactions so that private financiers become involved.

6. Assistance to industrial and agricultural organic waste producers to reduce methane emissions

- EECA and the Bioenergy Association to work with other industrial associations to establish programmes for reducing methane emissions from industrial and agricultural organic residues.
- EECA and the Bioenergy Association develop the following Technical Guides:
  - Methods and evaluation of biogas technology options for methane collection and processing at industrial waste water treatment facilities.
  - Methods and evaluation of biogas technology options for processing agricultural residues so as to reduce methane emissions
  - Replace Code of Practice NZS 5228.1:1987, Code of practice for the production and use of biogas, farm scale operation - Production of biogas,
  - NZS 5228.2:1987, Code of practice for the production and use of biogas, farm scale operation - Uses of biogas.
  - Guide to using biogas as a vehicle fuel

13. Emissions reduction from transport biofuels

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Bioenergy Association

12.1 Introduction

In 2014, transport used 36% (256PJ) of New Zealand's energy supply and released 12.7 million tonnes of CO_2-e, which amounts to 40% of the GHG emissions from the New Zealand energy sector. Domestic fuel consumption in 2015 was: petrol (3.1 Billion litres); diesel (3.2 B litres); aviation fuels (0.33 B litres); and marine fuels (0.21 B litres). Nearly all this fossil fuel is currently imported, either as crude oil for processing at Marsden Point, or as a finished fuel.

Biofuels provide an opportunity to reduce transport sector emissions as transport moves to be a mix of electric, biofuels and fossil fuels, with each fuel type being most suited for different applications. Biofuels are particularly suited to reducing emissions in the strategically-important heavy transport, marine and aviation markets, where there are few other renewable alternatives.

Some retailed vehicle fuels already include a component of bioethanol or biodiesel and bulk purchases are available throughout New Zealand.

Currently bioethanol is produced in New Zealand from whey by Anchor Ethanol and biodiesel is manufactured by Greenfuels NZ from used cooking oil, and by Z Energy from tallow. Gull produce their biodiesel in Australia. Gull and Z energy retail bioethanol blended petrol and/or biodiesel blended diesel. Some biofuels are also imported. However, biofuels still only satisfy a small portion of New Zealand's transport fuel demand.

Biomethane, from biogas production, can also be used as a vehicle fuel, but its use as a fuel has reduced in recent years, despite it being readily available at waste water treatment plants and landfills.

Large-scale production of biofuels in New Zealand will depend on access to large volumes of biomass feedstocks. While whey, tallow, used cooking oils and agricultural wastes represent attractive feedstocks for initial deployment, quantities are limited and large-scale deployment will require purpose-grown feedstocks. For New Zealand, forests have been identified as the best feedstock option for large-scale deployment of biofuels.

There is potentially enough biomass available to kick start the production of advanced biofuels in New Zealand, particularly from increased forestry and wood processing residues. However, the development of dedicated bioenergy/biorefinery forests should enable the secure supply or low cost feedstock in the longer term.

Future opportunities using biofuels produced from woody biomass and organic waste are likely to be based on advanced biofuel technologies which produce a "drop-in" fuel which allows 100% use with some vehicle retuning. However, advanced technologies for the conversion of woody biomass to drop-in fuels are still being developed and are not yet commercially proven. Bridging the gap between research and commercialisation (usually referred as bridging the technological "valley of death") for technologies in their pioneer status requires significant Research, Development and Demonstration (RD&D) efforts. Much of the uncertainty about the performance of new technologies can only be resolved through large-scale production, so learning during the first 3-5 years of new projects is crucial for evaluating the implemented technologies and for optimizing process parameters to drive down costs. Furthermore, the impact of different feedstocks and different feedstock production techniques on the environment and the feedstock supply chain can only be fully evaluated once production reaches a commercial scale. Early opportunities may lie in fuels for less sophisticated applications such as for larger scale engines or heat applications, even though they are competing against cheaper grades of fuel.

The extraction or production of biochemicals from biomass and organic waste, such as resins, lignin etc., could also catalyse the production of transport biofuels through the production of higher value co-products. This effectively lowers the feedstock cost for biofuel production and is expected to be a significant driver for biofuel production.

The barriers for greater investment in domestic biofuels production are the low international price of oil, low carbon price and the lack of a stable long-term package of policy measures to support investment in liquid biofuels.

National security of fuel supply risks indicate that development of the biofuels sector as a strategic contingency measure would be prudent.

This information sheet sets out what the Bioenergy Association's Liquid Biofuels Interest Group believes is achievable under a business as usual situation and under an accelerated scenario if advocated strategy and policy options are adopted.

12.2 Scenarios for Wood Energy Expansion

Scenarios assumed by the Bioenergy Association for growth in the production and utilization of wood energy to reduce carbon dioxide emissions are:

Scenario 1: Business as usual

Conditions:

- Based on existing policies and market conditions. No policy changes
- Uses existing technologies and an extension of current trends
- No 'maybes'. Only realistic activities based on existing sector participant's activities.
- Assumes current ETS but 1 for 2 policy is deleted and ETS administration is improved. No significant other changes.
- Government continues low level support for biofuels R & D

Scenario 2: Encouraged Growth

Conditions:

- Government signals that it wants to encourage domestic mitigation so as to avoid the need for purchase of international units and seriously adopts some complementary measures to the ETS
- Government sets targets for a low carbon transport market.
- Government R, D & D funding increases for:
    - Advanced biofuels research (including fuels for marine and aviation applications)

- Coproducts of the production of biofuels
- Commercial companies to evaluate biofuel production and/or support demonstration scale facilities

- Government provides appropriate financial support to companies to invest in domestic biofuel production to develop new supply chains and deliver the technological learning required to drive down costs and reach cost competitiveness.
- Government encourages growth in the forestry sector with support for additional domestic added value processing of wood including biofuels and the coproducts.
- Government encourages use of biogas from landfill and waste water treatment plant as a transport fuel instead of generation of low value electricity
- Increased consumer education on the suitability of biofuels in existing vehicles and the development of appropriate fuel quality standards.

Aviation and international marine fuels are not considered in this analysis, even though they are nationally critical.

Analysis of two transport biofuel scenarios (Figure 2- Business as usual and Figure 3 - Accelerated) show that there can be 700-1000kt CO_2-e reduction in emissions compared to 1990 by 2040 and 1300-3500 ktCO_2-e by 2050.

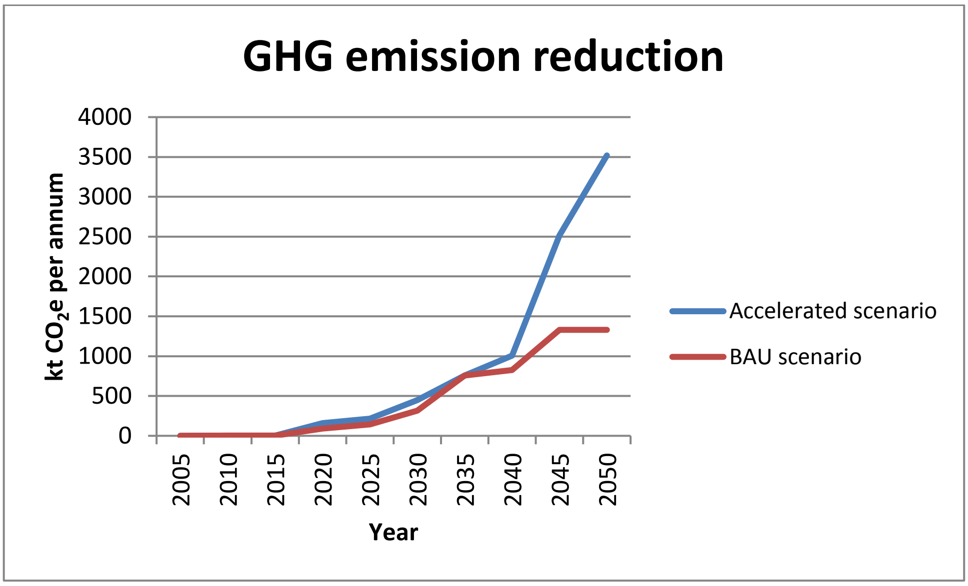

Figure 1: GHG emission reduction under business as usual and accelerated scenarios

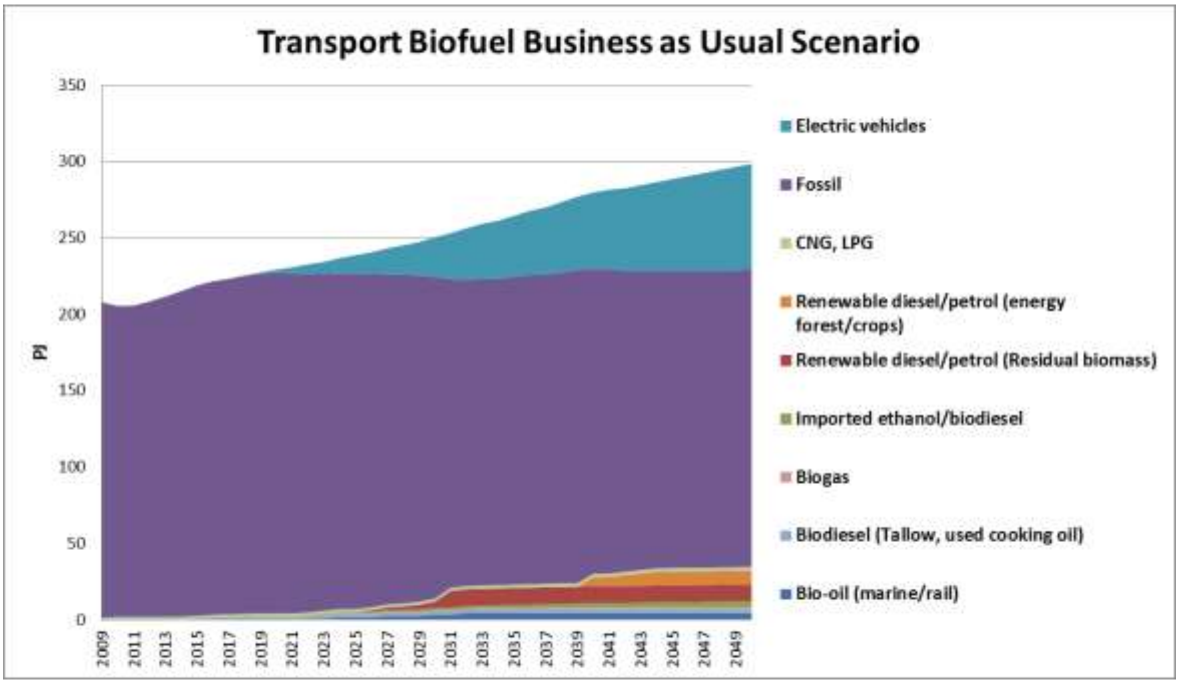

Figure 2: Business as usual scenario of annual transport biofuel production

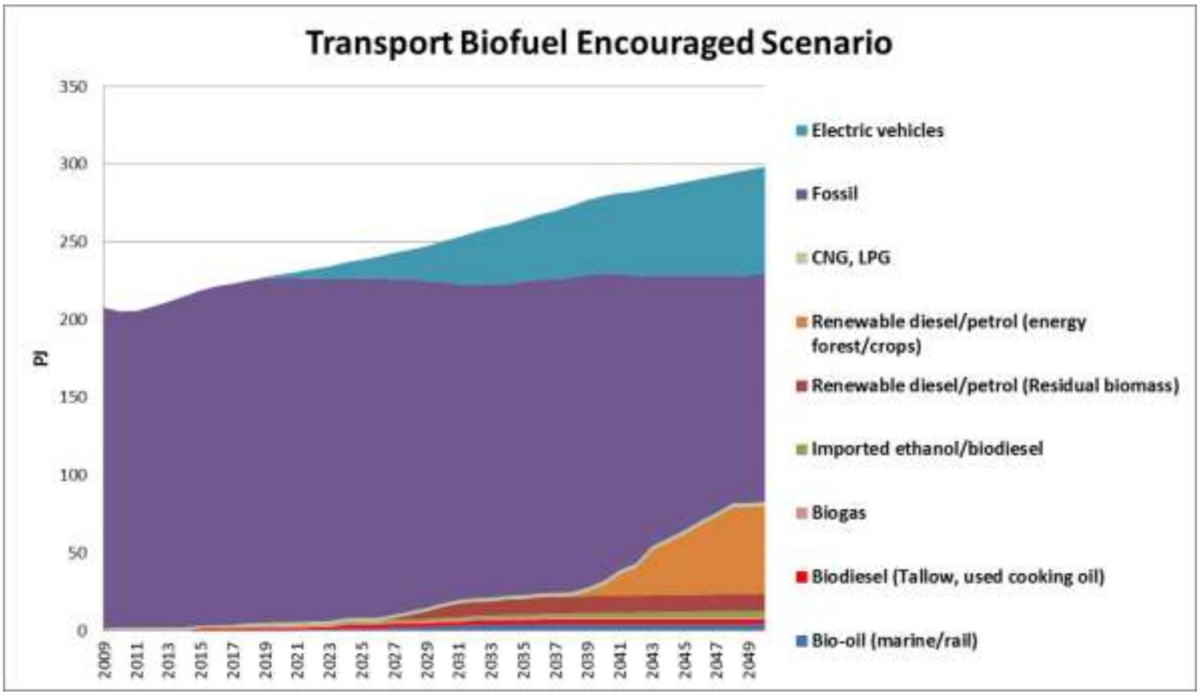

Figure 3: Encouraged scenario of annual transport biofuel production

12.3 Suggested complementary measures

The following complementary measures would encourage the production of liquid biofuels.

1. Government signals to local government and industry that it wants to encourage domestic mitigation to avoid the need for purchase of international units and emissions from export industries.

2. Government specifically support the reduction of GHG emissions in domestic industries, similar to that given to export and high growth industries. This would be supported by:
    a. Explicitly providing support to businesses engaged in GHG reduction transport activities;

b. Providing accelerated depreciation and/or suspensory loans for capital investments resulting in greenhouse gas emission reduction;
c. Government does an annual cost-benefit of forward offshore purchase of GHG obligations vs acquiring domestic mitigation through a capital fund which funds the public good component of transitioning low carbon transport fuels.

3. Introducing central and local government procurement policies so that renewable energy and efficient energy use options must be considered when making investment decisions and all additional benefits are included in a full life cycle analysis of options.

4. Government and Bioenergy Association agree transport targets to encourage production of transport biofuels

5. Government and industry through the Bioenergy Association develop a transport biofuel development programme based on the results of the Scion led New Zealand Biofuels Roadmap project.

6. Increase the 5% limit on biodiesel blending to 7%.

7. Government encourages additional domestic added value processing of wood with the consequence that greater volumes of high quality wood fibre are available for biomaterial and biofuel production.

8. Government R&D funding increases for:
   - Advanced liquid biofuels research having regard for the likely areas of application in NZ that will be economic over the next decade (eg targeting biofuels for industrial, marine and aviation applications, for strategic reserves and for their lower health related emissions)
   - High value bio-products where biofuels are a co-product

14. Emissions reduction from wood energy

Summary of greenhouse gas mitigation options and what would achieve greater uptake from the Bioenergy Association

13.1 Introduction

Opportunities in the period out to 2025 (and beyond) for switching from fossil fuels to biomass fuel for heat supply have been assessed by the Bioenergy Association. Furthermore, the contribution this could make to greenhouse gas mitigation as a primary driver has been assessed. Three scenarios were developed to identify what would have to occur to get greater levels of greenhouse gas mitigation. This information sheet summarises the options and proposes policy environments to achieve this.

The main barriers to greater uptake of the use of wood energy are the real and perceived cost, the availability of wood fuel compared to coal and natural gas, and inconsistent policy and price signals for externalities. The technology is proven and research on combustion is not required except on specific matters. The Bioenergy Association therefore recommends that the focus for growing the wood energy sector is on building the security of wood fuel supply with gradual growth in supply being driven by increasing demand from small and medium scale heat plant until sufficient supply capacity is available to address fuel security and cost issues for larger heat plant. This will enable the wood energy to grow in an orderly fashion and over time will allow the wood fuel supply market to meet the levels and reliability of supply required for large heat plant to convert from coal, and ultimately natural gas, to wood fuels.

There is potentially enough biomass available to meet much of the heat energy needs currently supplied by burning coal. However, the wood fuel supply market is currently under developed because the existing demand for wood fuel is low, but there are enough suppliers with commercial and technical capability to expand supply if demand for wood fuel increases consistently and in an orderly manner. The proposed policy measures are facilitative tools to get the market for wood fuel heat underway to further encourage growth in the fuel supply side. Once there is growth in wood fuel supply market then the demand side will become largely self-sustaining.

In this context, the co-firing of larger coal plant with wood is a useful transitional approach as the co-firing percentage can be varied based on supply, and gradually increased over time. This development of the local wood fuel supply market is a precursor for eventual replacement of the coal fueled plant with biomass fueled plant. However it should be noted that there are real technology limitations to the plant that can co-fire fuels and conversion efficiency is often degraded.

It is typically recognised that wood heat plants have higher initial capital costs and may incur additional costs with the purchase and handling of wood fuels compared to coal fired heat plants. Even so, wood energy can be the most economic option in many situations if total life cycle costs and other benefits are considered. Other significant non-energy benefits from switching from coal to wood fuel such as no requirement for mining, employment, regional growth, air quality etc. are all public good aspects, which suggests that there is a role for Government in assisting industry to transition from coal to locally sourced wood fuels.

Growth in the use of biomass as fuel would be significantly assisted by growth in the amount of added value processing of wood being undertaken in New Zealand. Export of unprocessed logs is not only a loss of opportunity for New Zealand based employment etc but it is an export of residue biomass that could be used as wood fuel within New Zealand. Biomass residues from wood processing make high grade wood fuel and is often close to where it can be used in heat plant. The policies related to the increased production of heat from biomass should be integrated with forestry and wood processing strategies as together they provide significant employment and regional economic growth opportunities.

This paper sets out what the Bioenergy Association's Wood Energy Interest Group believes is achievable and summarises the advocated strategy and policy options for using wood energy to contribute to the reduction of New Zealand's greenhouse gas emission and for meeting New Zealand's GHG emission targets.

13.2 Target areas

The work by Waikato University has shown that the heat used in the dairy and meat processing sectors are areas of priority with respect to reducing greenhouse gas emissions.

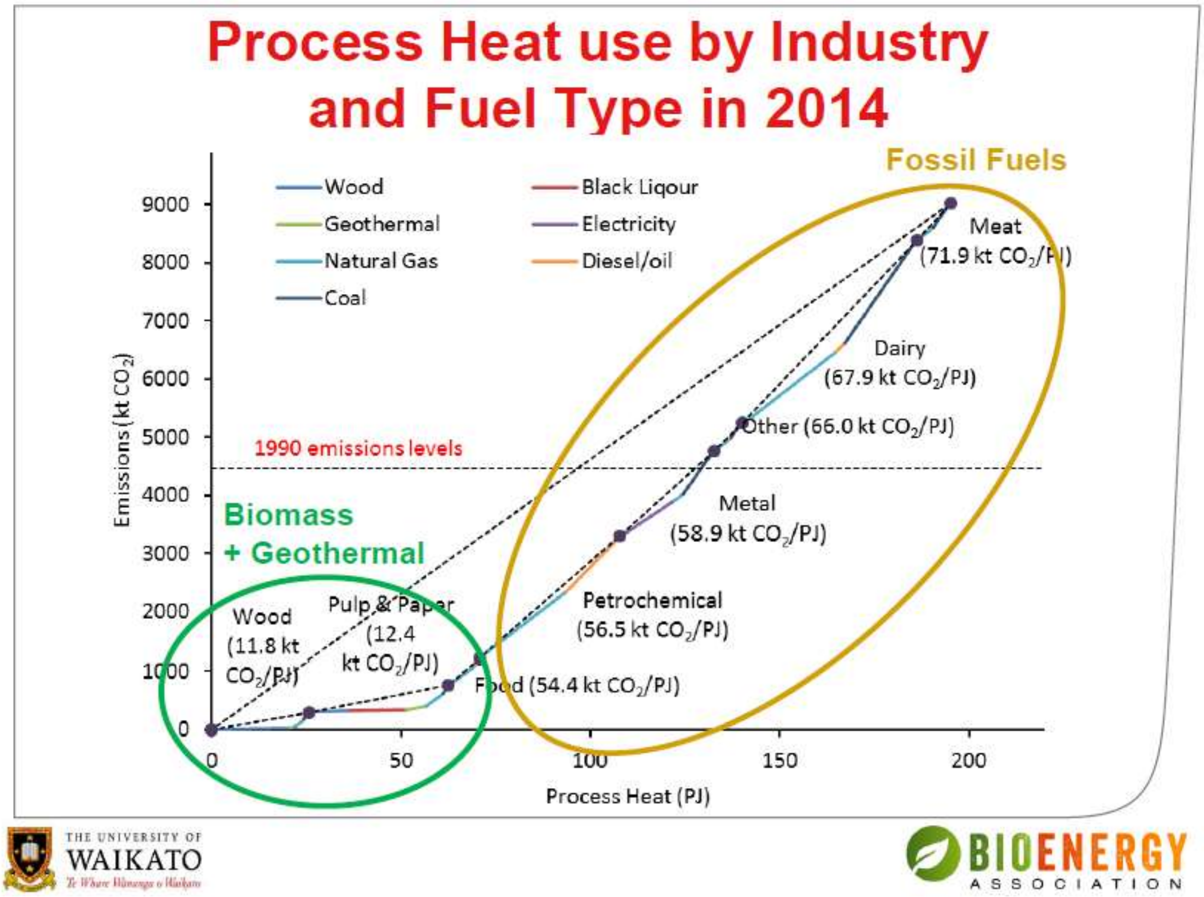

Figure 1: Greenhouse gas emissions intensity per sector

The ‘other’ sector which includes government owned facilities such as hospital, schools, prisons and community swimming pools is a component of the heat market where government can provide leadership and install effective plant as demonstration facilities. These are also facilities where the lifecycle economic benefits for Government will be substantial.

‘Other’ sector owned facilities are also ideal for assisting to create economies of scale adequate to provide incentive for wood fuel suppliers to scale up their operations. For example, growth in wood fuel supply will grow confidence in the dairy processing sector, which tends to have large sized heat plant, that the wood fuel suppliers can meet their large demand for wood fuel and that can be reliably delivered and consistently meet the relevant fuel specification.

13.3 Scenarios for Wood Energy Expansion

Scenarios assumed by the Bioenergy Association for growth in the production and utilization of wood energy to reduce greenhouse gas emissions are:

Scenario 1: Business as usual (BAU)

Conditions:

- Based on existing policies and market conditions. No policy changes.
- Uses existing technologies and an extension of current trends.
- No ‘maybes’. Only realistic activities based on existing sector participant’s activities.
- Assumes that the current ETS 1 for 2 policy is deleted and changes to ETS administration.

- Wood fuel heat plants continue to replace existing coal heat plants at the rate very similar to current installation rates.

Scenario 2: Encouraged Growth

Conditions:

- Government signals that it wants to encourage domestic mitigation so as to reduce the need to purchase international greenhouse gas reduction units.
- Carbon is priced at \$25/tonne CO_2-e (by 2016 - 2020) and is increasing at an agreed and consistent rate of 2.5% per year.
- Other differences from BAU:
    - Limited number of complementary measures pursued and implemented.
    - Central Government introduces policies to change Government procurement so that renewable energy and efficient energy use options must be considered when making investment decisions for heat plant and all additional benefits are included in a full life cycle analysis of options.
    - Government requires evaluation of heat plant capital investment options to be on a total life cycle value instead of a least capital cost basis.
    - Government's project appraisal models a projected higher CO_2 cost than the private sector may be-exposed to under the ETS, in line with MBIE's "Medium" scenario of \$25-50/tonne CO_2. This approach/modeling is justifiable as it will be demonstrating that the Government is taking clear long term decisions that reflect the likely real price of carbon over the full life of the assets.
    - Local councils are required to introduce similar central Government procurement policies for their own purchasing of heat plant. This will ensure that there is consistency across all regulatory agencies.
    - Government adopts a collaborative growth strategy with the wood energy sector based on reducing GHG emissions by using biomass instead of coal.
- Government procurement relies on the ETS as a surrogate for externalities – i.e. the new policies are complementary measures that significantly lift the use of renewable energy for GHG emission reduction.
- Medium to small sized plants are the initial focus for changing to wood fuels so as to grow the wood fuel supply market – but this changes with time to allow a shift to conversions for larger plants.
- Co-firing with coal is accepted as a transition pathway as a means of growing the wood fuel supply market.
- Wood fuel supply market growth is assisted by education and accreditation packages. (No constraint on fuel availability if the focus is on small/medium sized plants and given that around potentially 20-30PJ of available wood fuel has been identified nationwide over the next 20 – 25 years).
- New wood fueled plant is recognized as being more efficient than existing coal fired plant and operators opt for heat storage systems to achieve energy efficiency.
- Air quality standards and regional policies are improved and these policies and standard are not barriers to the use of wood fueled plant in any region throughout New Zealand.

Scenario 3: Accelerated Growth

Conditions:

- Government seriously considers and adopts some complementary measures to the ETS.
- Carbon is priced at $50/tonne CO_2-e (2016 - 2020) and it is increasing at an agreed and consistent rate of 5.0% each year.
- Other differences from scenario 2:
    - The Government's project appraisal models for the replacement of fossil fueled energy plant use a projected CO_2 cost, in line with MBIE's "High" scenario of $100/tonne.
    - Low cost policies are introduced to address barriers specific across sectors and within a sector.
    - Government sets targets for the heat market to achieve specific reductions in GHG emissions.
    - Government does an annual cost-benefit of forward offshore purchase of GHG obligations compared to acquiring domestic mitigation through a capital fund which funds the public good component of transitioning to wood fuel.
    - Policies are introduced allowing for accelerated depreciation on capital expenditure and the introduction of suspensory loans to reduce the effect of current capital cost barriers.
    - The Government continues with capital grant schemes as part of regional development programmes similar to Southland's Wood Energy Programme.
- Government encourages additional domestic added value processing of wood with the consequence that greater volumes of high quality wood fuel become available.

13.4 GHG Reduction Benefits of Using Wood Fuel for Heat

A. Reduction in GHG emissions

Modeling the potential to replace fossil fuelled heat plants with wood fueled heat plants shows under the 'Business as Usual' scenario (Scenario 1) that GHG emissions (Kt CO_2-e) from heat plant will reduce by only 4%. Whereas if the complementary measures as proposed by the Bioenergy Association are adopted then GHG emissions from heat plant can be reduced by as much as 42% for Scenario 2 and up to 61% under Scenario 3 conditions. This is a reduction from 6.4 million tonnes CO_2-e to 3.7 Mt CO_2-e for scenario 2 and down to 2.5 Mt CO_2-e for scenario 3. Such emission reductions are a significant component of the total GHG emissions for New Zealand which are 56.7 Mt CO_2-e (net emissions for 2014). Energy gross emissions are around 32 Mt CO_2-e, so the proposed GHG emissions savings arising from wood fuel substitution for fossil fuels are potentially a substantial contribution to what is required to meet the Paris Agreement targets.

The figures below show the change in both energy (PJ) and GHG emissions (Kt CO_2-e) that are achievable by adopting the complementary measures as proposed by the Bioenergy Association.

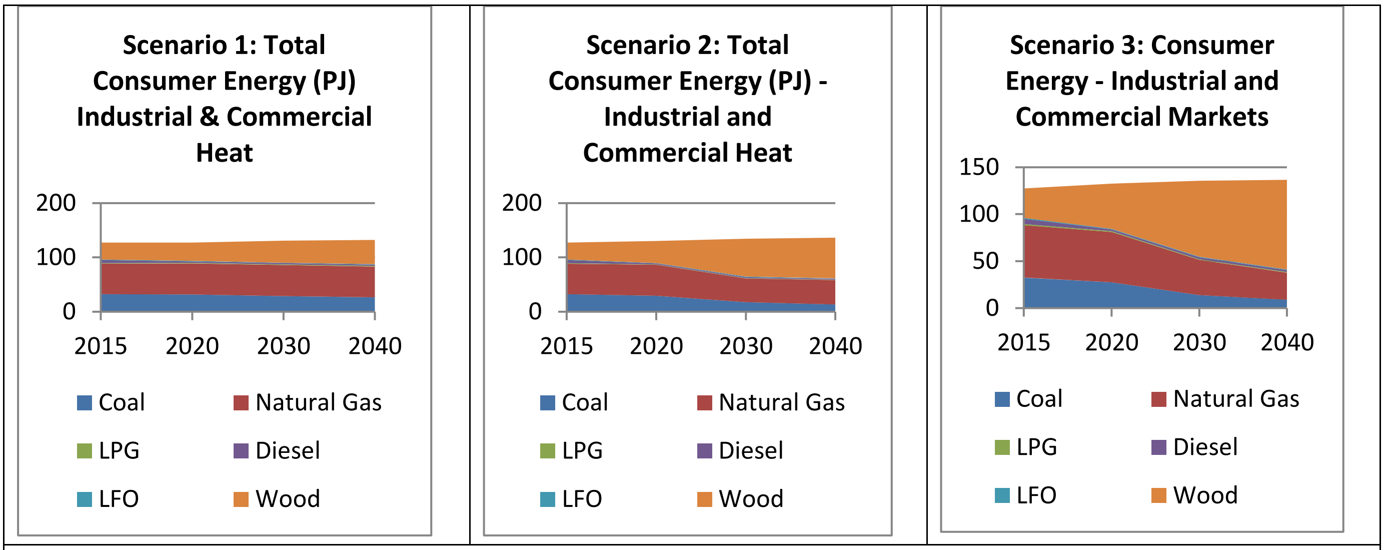

Figure 2: Heat energy production (PJ) – (Note figures exclude electricity and geothermal)

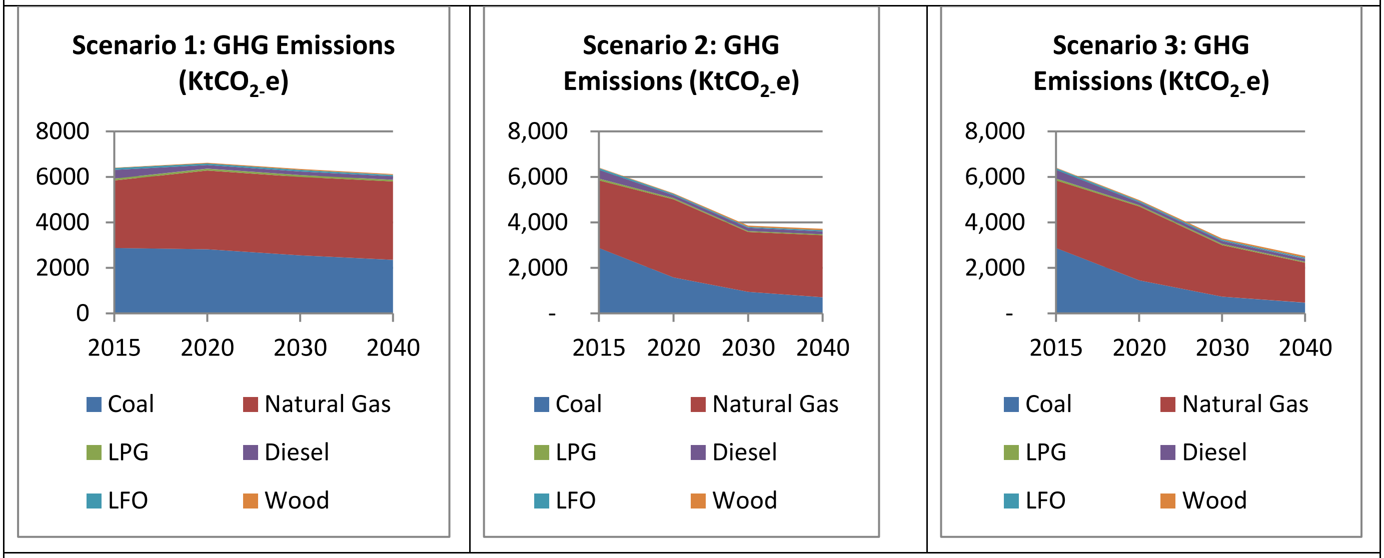

Figure 3: Greenhouse Gas Emissions ($MtCO_2$ eq)

Table 1 shows the estimated number of heat plant which are assumed to move from fossil fuel to biomass fuel in the periods to 2040. As the focus in the earlier periods is on the small to medium sized heat plant such as schools, community facilities and rest-homes etc this number of changes is considered realistic and achievable within the current sector capabilities.

Table 1. Increase in the number of wood fueled heat plants over the years 2016 - 2040 and the percentage change in GHG emissions over the same period.

Scenario		2016 - 2020	2021 - 2030	2031 - 2040
Business as Usual	No. of plants	28	100	130
	% GHG change	-3	4	3
Encouraged Growth: Scenario 2	No. of plants	141	342	174
	% GHG change	18	27	4
Accelerated Growth: Scenario 3	No. of plants	281	366	176
	% GHG change	22	34	23

These assumptions are based on the experience from recent hospital and local government investment projects which shows that if central and local Government adopts procurement policies that require evaluation of heat plant options on a total value, instead of a least cost basis, there will be a higher uptake of wood fueled plant. This in turn will build the wood fuel supply market which will have a positive effect on the transition of other commercial entities to also convert to wood. This in part will be due to cost efficiencies in the wood fuel supply market.

The introduction of financial incentives (such as an accelerated depreciation policy) in scenario 3 would speed up the adoption of wood plant by larger private sector users of heat such as for dairying, meat and potentially wood processing sectors.

Conversion to wood fueled heat plant will have a significant effect on GHG emission reduction.

B. Overview of wider benefits

When biomass is used as a heating fuel, the displacement of fossil based fuels means that the carbon burden from using these fossil fuels is reduced.

The size of the wood energy market

Total NZ Boiler Capacity	5778 MW
Wood-Fired Boilers in the Wood Processing Sector	1,232 MW (21%) of the NZ total
Total Wood Fired Boilers outside Wood Processing Sector	187MW
Total Coal Fired Heat Plant Capacity	1470 MW

Wood fuel is well used in the Wood Processing Sector (WPS) but is used in only 187MW of 4356 MW outside the WPS (just 4%). So there is 4,356 MW switching potential and sufficient woody biomass from logging and other woody or fibrous residues to potentially contribute up to around 30 PJ of energy out to 2040.

Government related service sectors (prisons, Councils, defence facilities, education, hospitals research institutes and universities) currently have around 58% of the total number of heat plants representing about 7% of total heat energy demand. However, currently only around 7% of these are using wood fuels. Similarly 283 of the ~500 coal heat plants nationwide are operated by Government related organisations, although they tend to be small compared to industrial plants. This indicates that there are opportunities for the Government to demonstrate leadership in GHG emission reduction by adopting a wood fueled heat plant procurement scheme, but that there are also big gains for commerce and industry.

Around ~30 PJ of current coal fueled energy demand could be replaced by biomass. The resulting job creation would be at least 3,200 -7800 permanent jobs per year due to the development of the woody residue fuel supply chain and new heat plant installation and maintenance when considering the conditions for Scenario 3.

The additional benefits arising from the proposed GHG reduction measures are significant:

- **Multiple national and local benefits – and not just the supply of energy:**
  - National and regional economic growth (new factories, local jobs, etc);
  - Business growth and financial resilience (cost effective renewable energy);
  - Environmental: reduced emissions to air, waste reduction, and improved water quality arising from land use change (e.g.pasture to forest and other crops);
  - Clean, green, low carbon economy supporting 'green' products in international markets.

- **Additional value for forest & land owners:**
  - 10-15% of forestry fibre can be wasted (so a major opportunity, especially for Iwi as emerging forest owners).
- **Economic growth from world leading fibre-growing conditions:**
  - Enhanced opportunities for bio-oil, bio-chemicals, bio-plastics etc ("Bio-materials");
  - The possible development of bioenergy centres where wood fuels, bio-oil, biogas and liquid fuel systems are integrated and supplying multiple services and benefits.
  - Co-products with traditional farming contributing extra revenue streams for farmers.
- **However market failure means most benefits are not currently being realised:**
  - A "Rational Choice" for a company is not the same as a rational choice for New Zealand;
  - Energy users don't care about non-cost benefits (jobs, energy diversity etc);
  - Selling logs to Asia minimises economic benefits, and exports employment opportunities;
  - Increased added value processing of wood within New Zealand produces economic value for NZ through the creation of jobs and higher value export products, plus high quality wood fuel for heat.

13.4 Barriers

The fact that the primary benefits of transition from using fossil fuels to using renewable fuels to produce heat energy is a public good makes it difficult for private sector heat plant owners to justify making the change. However, industry has shown by recent decisions to move from using fossil fuels to using biomass fuel that the private benefits can often in niche applications justify the shift.

Trading in wood fuel is new and limited outside the WPS, so the wood fuel supply sector is still in its infancy. Until recently heat plant owners using wood fuel have generally been able to supply the fuel from their own wood processing operations. However, with the entry of heat plant owners who have to purchase wood fuel then further market development is required which will involve developing standards, contracting best practice and market pricing knowledge.

For many owners of existing fossil fueled heat plant the opportunity to switch from fossil fuel to wood fuel is limited as unless the plant has reached the end of its economic life and they are installing new plant they may make energy efficiency changes to the plant but not replace it with wood fueled equipment. The programme to eventually have no coal fueled heat plant has to thus be spread over many years – hence the scenarios go out to 2050. Bioenergy Association recommends that in order to gain public good benefits of climate change and use of renewable energy that Government should have a policy of encouraging that no new coal fueled heat plant be built.

Access to capital for investment in new heat plant is a significant barrier. Policies to assist this will lift investment.

13.5 Proposed complementary measures

Government has established the Emissions Trading Scheme to assist with realigning the costs of high carbon fuels to low carbon fuels. However, to meet the Paris greenhouse gas emission reduction targets without any other initiatives it is likely to require New Zealand to purchase international greenhouse gas reduction units. Bioenergy Association analysis shows that because of the high value of the public good benefits of switching from use of fossil fuels to biomass fuels for heating it may be more cost effective for the Government to introduce some light handed and relatively simple complementary measures to assist Crown agencies and business to switch. This leadership would encourage development of the wood fuel supply market which would then provide encouragement for private sector heat facility owners to also switch to wood fuels.

Under the “Encouraged Growth scenario (scenario 2) the following complementary measures would encourage transition from coal to wood fuel and thus achieve significant GHG reductions from public sector, and industrial heat applications.

7. **Government and Bioenergy Association agree targets for switching to the use of biomass for coal by 2020, 2030**.
   - The objective is to encourage the use of biomass fuel for production of heat from all new heat plant and reduce the amount of coal used for heat production in existing facilities.
   - Government signals to local government and industry that it encourages the use of biomass as fuel
   - Government adopts a collaborative growth strategy with the wood energy sector based on reducing GHG emissions by using biomass to substitute for coal in the short term and other fossil fuels further out.
   - The Bioenergy Association and Government agree specific targets for the use of biomass as fuel in public sector facilities, food processing, and wood processing sectors by 2020 and2030 and for all heat plant by 2040.
   - EECA and Bioenergy Association, under a Collaboration Agreement, agree on a strategy and action plan including: target regions and sectors; promotion; education and information programme; value proposition information; collection and dissemination of demonstration project information.
   - MBIE to extend the existing mechanism for the collection of data relating to the use for biomass for heat and to provide annual reporting on biomass use for heating by region.
   - EECA continue with capital support schemes as part of regional development programmes similar to the Wood Energy South in the Waikato and Otago regions.
   - Government to review the present use of the landfill Waste Disposal Levy and the criteria for grant allocations from the Waste Minimisation Fund, so as to include use of biomass waste as a fuel for heat plant.
   - Working closely with EECA and MBIE, establish a case study to quantify all the "public good" benefits arising from the shift from fossil fuels to wood fuels (including enhanced land management, waste reduction, employment opportunities, enhance catchment management and reduced air emissions[18].
   - The Bioenergy Association will assist to achieve the targets by:
     - Establishing a working group with EECA to develop a work programme for switching in each target sector and region.
     - Preparation and promotion of the value of using accredited wood fuel suppliers and registered wood energy advisers.
     - Collating and publishing useful information from any demonstration facilities into a Technical Guide.
     - Collating technical information from case studies and making it available widely to heat users.

[18] Air emissions can be reduced by using modern heat plant and substituting for small scale domestic style wood burners.

    - Hosting regional meetings to assist heat users and their advisers to be up-to date with switching opportunities and practises.

8. **Central Government introduces procurement policies so that waste to energy or other renewable energy options must be considered when making capital investment decisions and all costs and benefits are included in a full life cycle analysis of options and reasons provided for not adopting a renewable energy solution.**
    - Central Government introduces policies to change Government procurement policies so that renewable energy and efficient energy use options must be considered when making investment decisions and all additional benefits are included in a full life cycle analysis of options.
    - EECA and the Bioenergy Association develop Technical Guide:
        - Methods for evaluation of options for supply of heat.
    - Government's project appraisal model uses a CO_2 cost profile assumption published by EECA from time to time. This profile takes account of assumed movement over time as a result of the ETS (This approach/modelling will also demonstrate that the Government is taking clear long term decisions that reflect the likely real price of carbon over the life of fossil fueled-plant i.e. 20 years plus).
    - Local councils be required to introduce procurement policies similar to those adopted by central Government.

9. **EECA extends the repayment period for Crown Loans**
    - Extend the period of Crown Loans for biomass energy facilities beyond the current 5 years to better reflect the economic lifecycle costs and 'public good' benefits of a heat facility.

Under the Accelerated Growth Scenario (scenario 3) the following complementary measures would encourage transition from coal to wood fuel and provide significant further GHG reductions from public sector and industrial heat applications.

i. **The complementary measures in Encourage Growth Scenario (scenario 2), but with a higher projected price of carbon for heat plant modelling for all Government facilities.**

ii. **Government introduces policies to allow for accelerated depreciation of renewable energy, waste to energy and energy efficiency capital investments.**
    - Renewable energy and energy efficiency equipment is more capital intensive but often has lower on-going operating costs than alternatives.
    - Access to capital is a major barrier to investment in renewable energy and energy efficiency solutions. Allowance of accelerated depreciation is fiscally neutral to Government except for timing. However accelerated depreciation can provide a significant assistance to plant investors.

iii. **Government establishes a GHG Reduction Fund to provide suspensory or low interest loans or similar for renewable energy and energy efficiency capital investments.**
    - Many renewable energy projects may be potentially financially attractive but access to capital is a major barrier. Having provision for suspensory loans which are paid back out of operating profits once the project is operational can assist potential projects get underway.
    - Suspensory loans from central government, or restructured rates schemes at city council level could assist the uptake of this low emission technology.

- Government does an annual cost-benefit of forward offshore purchase of GHG obligations versus acquiring domestic mitigation through a capital fund which funds the public good component of transitioning from coal to wood fuel.
- There may be a role for a GHG Reduction or a Clean Energy Fund, similar to that in Australia, to make money available to private sector projects to complement the Crown loans available through EECA for renewable investment projects.
- A GHG Reduction Fund should be established to make loans, similar to Crown Loans, available to private sector projects.
    - Australia has such a fund in the Clean Energy Finance Corporation (CEFC) whose role is to overcome market impediments and help accelerate Australia towards the transformation to a low carbon economy, minimise its ultimate cost and create positive adjustment for the economy, including through new forms of clean technology business, new jobs, development of new or expansion of existing businesses and development of new technological know-how. However, the NZ version of such a fund would need to be scaled to a smaller NZ project size.
    - The CEFC places priority on its investments generating economic, social and environmental benefits, including building capacity and capability within the renewable energy sector, demonstrating applications and financing for new technologies, development of new or existing businesses and the development of new technologies and know-how. CEFC investments to date are demonstrating the potential to expand Australia's manufacturing capability and create new industry and employment opportunities across the country, particularly in regional areas.
    - The CEFC's portfolio of contracted investments is expected to earn an average return of approximately 6.1 percent. While New Zealand's lower population density may not produce such attractive returns, their participation in the market provides liquidity to ensure efficient pricing. CEFC's lower cost of funds, flexible structuring and capacity to match the term of the financing to the life of the assets has allowed them to de-risk transactions so that private financiers become involved.

iv. Support for domestic added value processing of wood

- Assist the forestry and wood products sector realise efficiency gains, therefore value. Government encourages additional domestic added value processing of wood with the consequence that greater volumes of high quality wood fuel become available.

13.6 Assumptions

The assumptions for the wood energy GHG reduction scenarios are:

Note these assumptions are reflected in the number of existing plants that are currently fossil fueled and which are converted to wood derived fuels.

Business as Usual: Scenario 1
• Over the period 2016 - 2040 around 10 fossil fuelled heat plants are substituted with wood fueled heat plants annually. This would result in 258 additional wood fueled plants being installed. This is a small rise in the number of plants currently being developed each year.
• Expansion in the total consumer energy for the industrial and commercial heat sector increases for natural gas and wood by 2% over the 24 year period.

Encouraged Growth: Scenario 2	Accelerated Growth: Scenario 3
• Wood fuels includes all form of fuels derived from wood and herbaceous materials and may include wood residues, torrefied wood, miscanthus, bio-oil, pellets and producer gas. Wood residues and other fibrous materials are expected to be the main fuel supplies.	• As for Scenario 2
• A total of 657 heat plant conversions from fossil fuels to wood occur over the period 2016 - 2040. This equivalent to 27 heat plant conversions per year for 24 years.	• A total of 823 heat plant conversions from fossil fuels to wood occur over the period 2016 – 2040. Note these tend to be bigger plants after 2020 in the dairy, meat and wood sectors. This is equivalent to 34 heat plant conversions for 24 years.
• Coal plants tend to be substituted first	• Coal plants tend to be substituted first
• Coal co-firing is being used at appropriate sites	• As for scenario 2
• All sectors are encouraged to switch to wood fuels - but there is an emphasis on the Government facilities which tend to have smaller capacity heat plants.	• The dairy, education, meat and wood sectors are the main sectors to take advantage of the depreciation regime for the period 2020 – 2040. Larger plants are able to come online due to improved security of wood fuel supply.
• Emission factors for GHG emissions of different fuels derived from Ministry of the Environment voluntary reporting guidelines	• The emission factors as for scenario 2.
• That the heat plant providers are not constrained in the supply of heat plant (i.e. there is spare capacity in the heat plant delivery and installation supply chain). Wood fuel can be supplied effectively where it is required.	• As for scenario 2.
• By initially focusing on the small plants and developing the wood fuel market (where wood fuels can be delivered more cost effectively) then this encourages an increase in the larger non Government related boilers to be converted to wood fuel.	
• The conversion to wood fueled heat plant reduces after 2030 because the 'easy' to convert plants are reduced.	
• Electricity and geothermal heat were not included in this analysis.	

13.7 Key Points

- Public support statements from Government/Ministers will encourage new thinking by forest and wood products sector, and investors.
- The switch from fossil fuels to use of wood fuel provides significant public benefits with regard to climate change and transitioning to a low carbon future.
- Adoption of policies for government and local body procurement of wood fueled heat plant would:
    - Move government agency decision making from short term least capital cost focus to lifecycle analysis resulting in fit for purpose decision making;
    - Provide economies of scale for the wood fuel supply market to grow;
    - Demonstrate that the Government is serious about addressing climate change;
    - Provide demonstration to private sector heat plant owners of the ease and low risk of switching from coal to wood fuel.
- The efficiency of the wood fuel supply market would be improved by;
    - Increased demand for wood fuel from a greater number of heat plant owners;
    - Bioenergy Association and EECA collaborating to quantify the economic, environmental and social benefits of wood fuels compared to fossil fuels through full life cycle assessments;

    - Increased domestic processing from the forestry and wood products sectors which will increase the availability of wood residues and quality of wood fuel supplies.
- Greater assistance provided by the establishment of funding mechanisms to support the transition to renewable energy:
    - Accelerated depreciation;
    - Reinstate, and ideally boost, the EECA wood energy programme and apply this to other regions;
    - Establish a "Green Fund" to leverage private capital.