BIOENERGY ASSOCIATION

Bioenergy: Facts and Figures

New Zealand

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Introduction

Bioenergy is energy derived from any renewable biomass (plant based) material which includes organic wastes, wood derived fuel materials, crops and algae. Bioenergy is used to produce heat, electricity and liquid fuels.

The use of bioenergy has been growing in New Zealand over the last 20 years with its most significant use being for domestic, commercial and industrial heat. The industrial heat is predominantly supplied to the wood processing sector.

Bioenergy: Facts and Figures 2016 provides a summary of the most up to date publicly available information related to the use of bio-based feedstocks for energy and its role in the New Zealand energy market. Limited information is currently available. However, it is envisaged that this complication will be the start of an ongoing process to collate and update statistical information on the use of bioenergy on a regular basis.

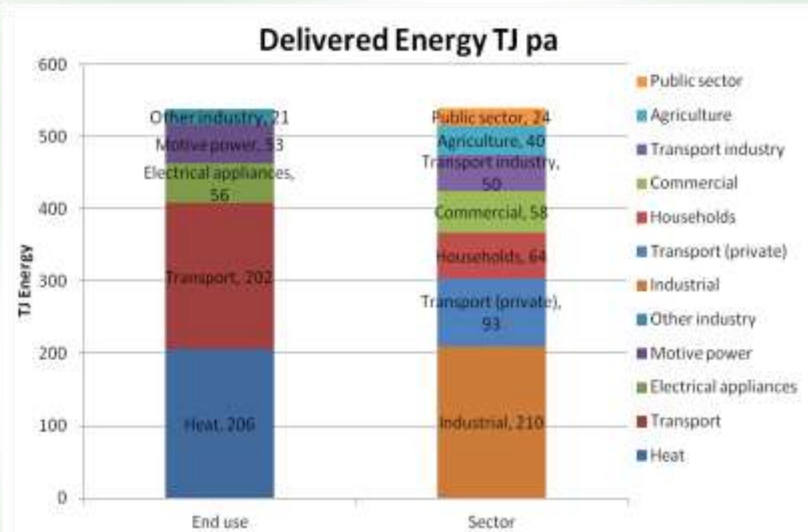
Bioenergy in New Zealand

Bioenergy in New Zealand accounts for around 10% of the total consumer energy supply. The benefits of bioenergy are:

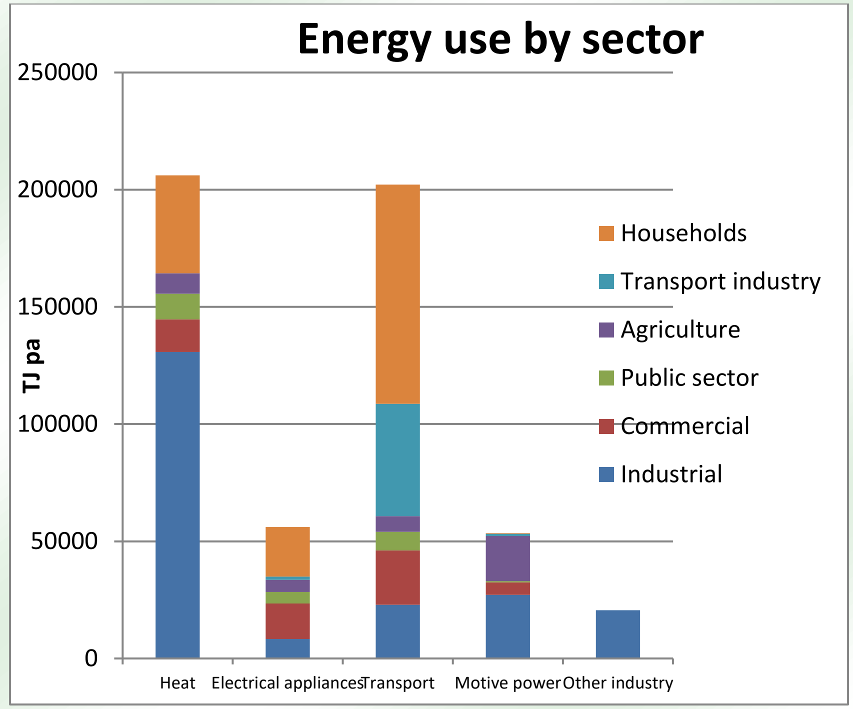
- Negligible net greenhouse gas emissions provided the fuels are from renewable biomass sources;
- Lower energy costs where the biomass feedstocks are from waste or residue streams;
- Opportunities for rural based job creation through developing supply chains;
- Biomass fuels can be stored and used when and where required;
- The production of biomass Integrates well with primary based sectors and rural land use; and
- Growing biomass for energy can also contribute to the mitigation of water quality issues and soil loss through alternative land use.

Energy in New Zealand

Industrial heat one of the major demands for energy and this sector is closely followed by the transport sector.



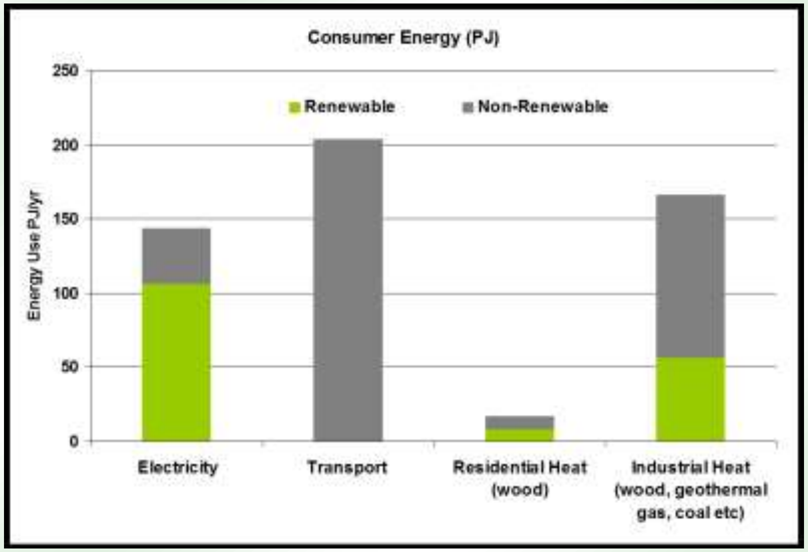
Delivered energy by end use Source: EECA (Unpublished)



Heat use by sector Source: EECA (unpublished)

Renewable Energy in New Zealand

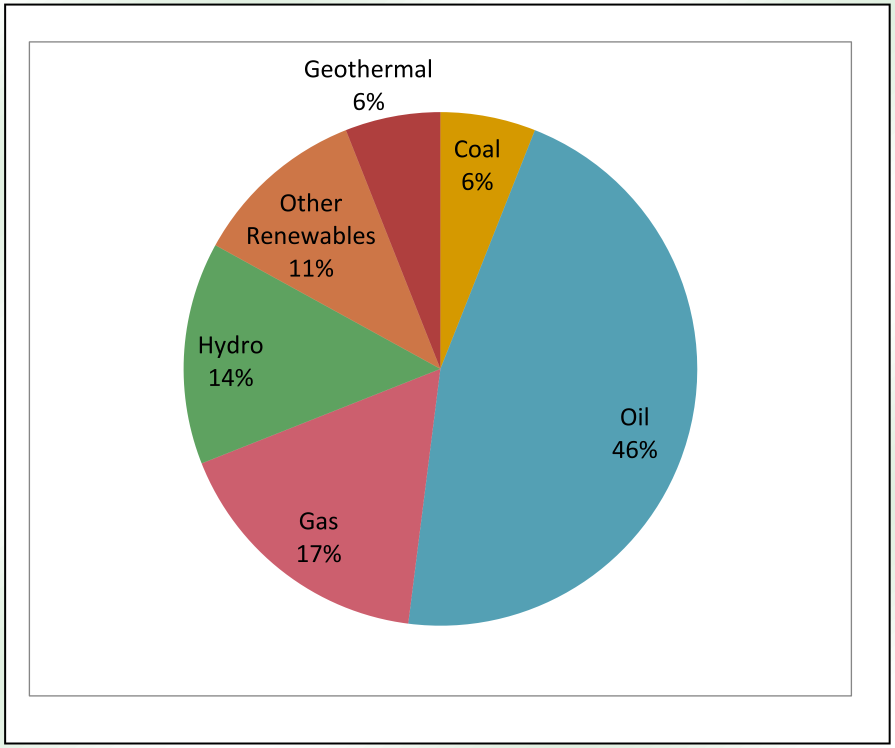
Renewable energy in New Zealand is 31% of total consumer energy supply.



Share of renewable and non-renewable energy consumption

Source: EECA

Biomass sources are 7%.:Biofuels and biogas are < 1%.



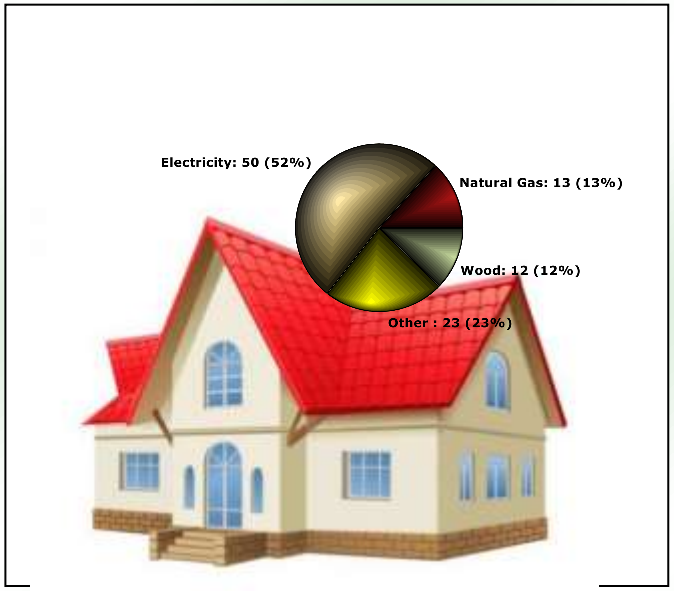
Consumer energy supply in New Zealand and the contribution from renewable sources.(2)

- Most of the consumer energy soured from biomass is used for heat.
- Renewable heat is 70 PJ.
- Wood fuel derived consumer energy makes up 20% of the total heat market and 55% of the total renewable heat market.
- New Zealand has the fourth highest renewable energy supply globally behind Norway, Iceland and Brazil.

- Electricity generation from hydro and geothermal is the main contributor to New Zealand's renewable energy supply.

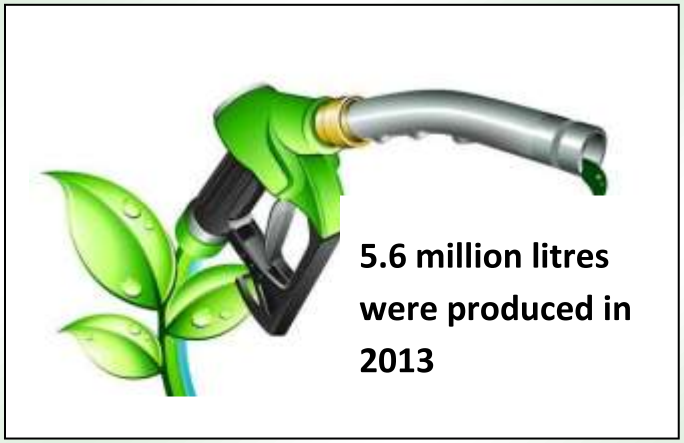
Use of Wood for Domestic Heating

Wood is a significant fuel used for domestic heating and is used for around 12% of the total heating requirements (space and hot water heating). Space and hot water heating makes up around 65% of the total energy supplied to households. Around 50% of houses have solid wood burning devices.



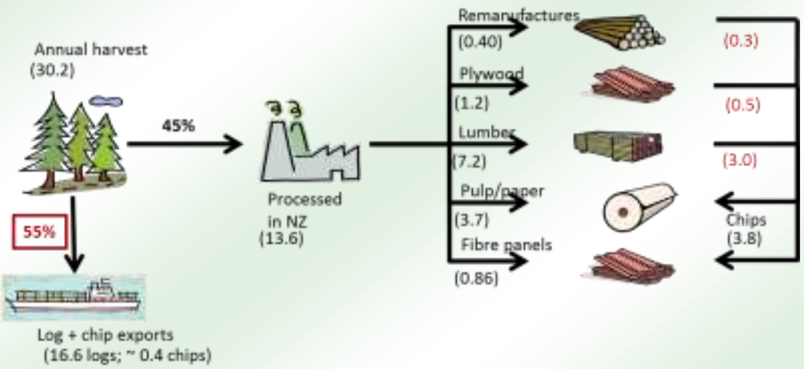
Energy use for domestic heating and the contribution from wood derived fuels. [2]

Biofuel Production & Use



- Total oil based fuels used in New Zealand in 2013 was 248 PJ [3].
- Biofuel production in 2013 decreased to the lowest level since 2007.
- Bio-ethanol production makes up 95% of biofuel.
- The total biofuel consumption was 6.5 million litres.
- New Zealand imported 1.3 million litres of biofuel mainly sourced from sugar cane.
- 5.2 million litres of bio-ethanol are produced by the fermentation of whey and cheese by-products.
- A 10% blend of petrol reduces greenhouse gas emissions by 5 – 6.5% compared to regular petrol.

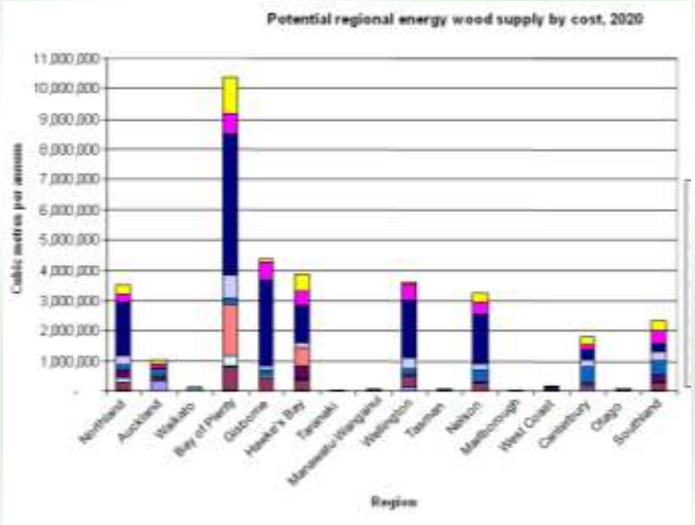
Fibre flows for wood processing in New Zealand



Wood flow by use. Source, Wood Processors and Manufacturers Association

Potential regional energy wood supply by cost, 2020

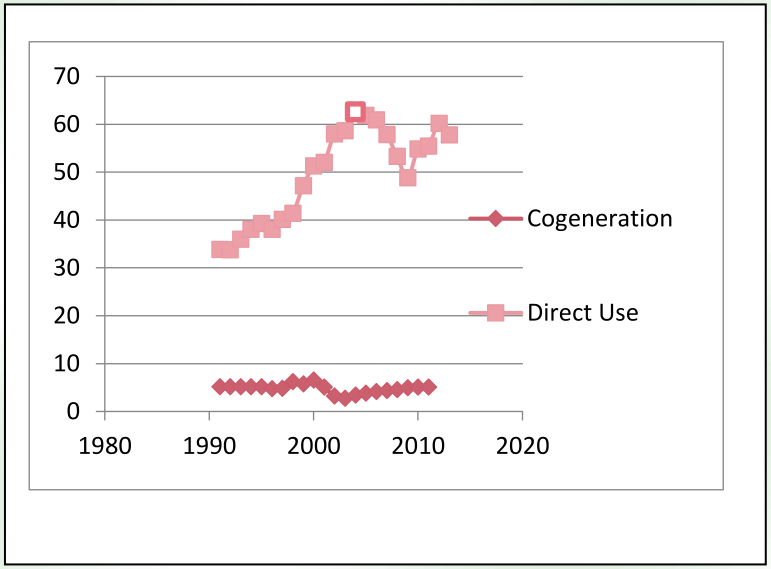
The regions with the greatest quantities of residues available are Northland, Bay of Plenty, Gisborne, Hawke's Bay, Wellington Nelson and Southland.



Key to above graph

Use of Wood Fuel

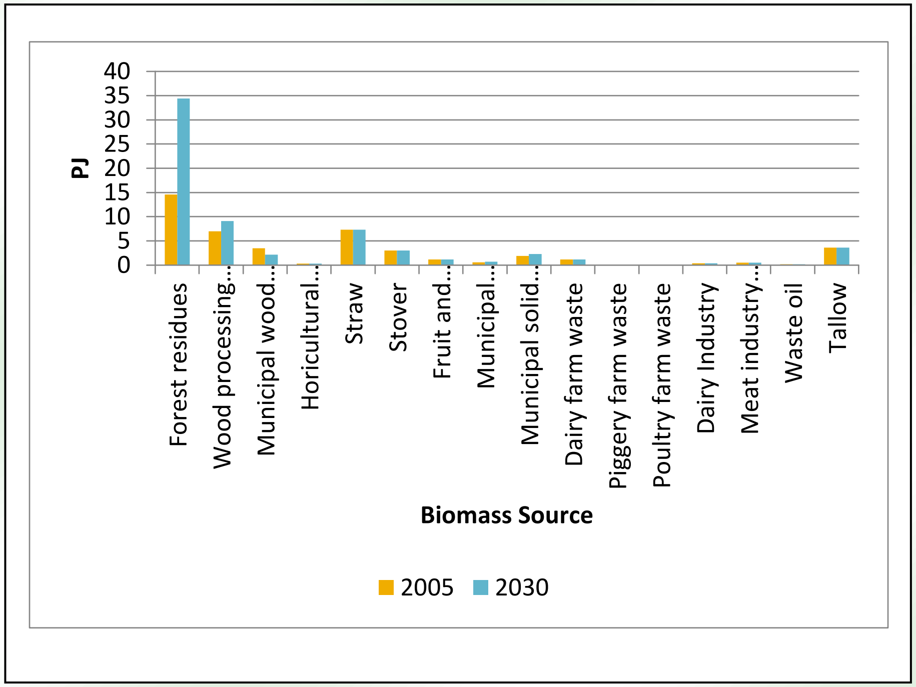
Over the last 25 years, the use of wood as a source of energy has increased by 70% compared to 1990 levels.



Use of wood as a fuel (PJs) 1990 to 2013 [5]

Potential for Bioenergy Production

If all available wastes and wood residue sources were to be used for bioenergy production then the potential increase in bioenergy would be around 45.5 PJ. By 2030 this would grow to an additional 66.5 PJ.

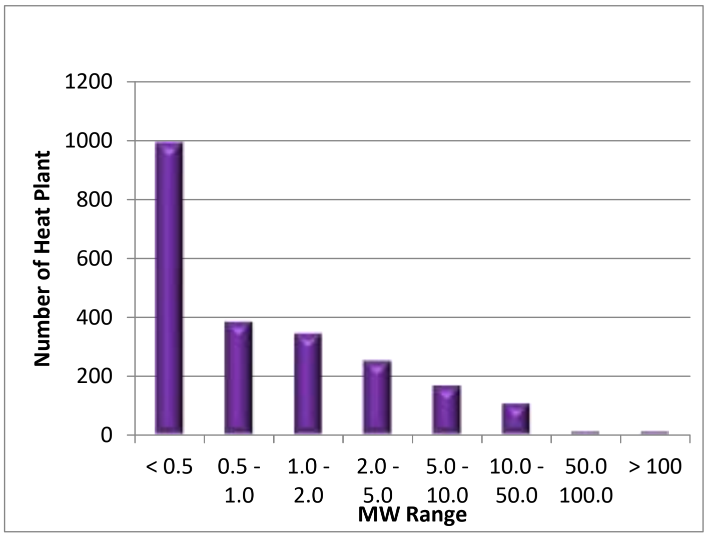


Potential biomass feedstocks available for energy [4].

Forest residues are the greatest contributor to this potential increase in wood fuels, increasing from an additional 14.6 PJ in 2005 to 34.4 PJ by 2030 [(4)].

New Zealand Heat Plant Overview

- The total heat plant capacity in New Zealand is 6800 MW.
- There are 2260 heat plants in New Zealand.

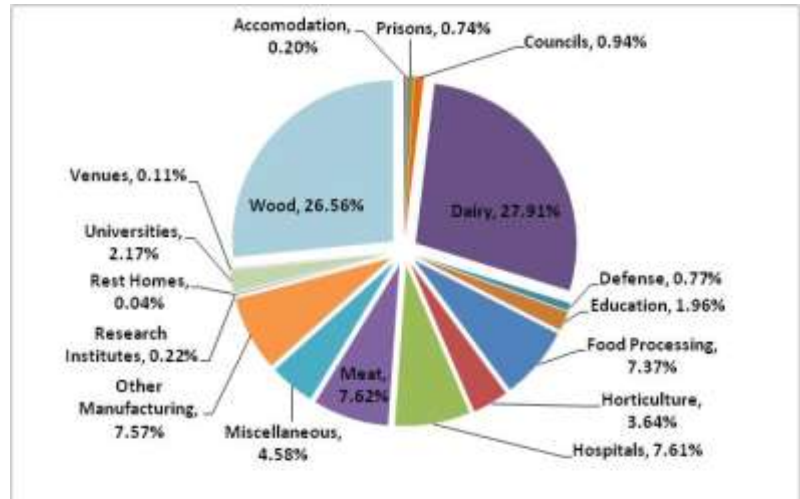


Number of heat plants and size range [(1)]

- Most heat plants are <0.5 MW with most of these being used at schools, universities and prisons.

- The dairy sector has 64 heat plants that are greater than 10 MW. This represents 52% of all heat plants >10 MW.
- The wood processing sector has 179 heat plants and 29 of these plants are > 10 MW.

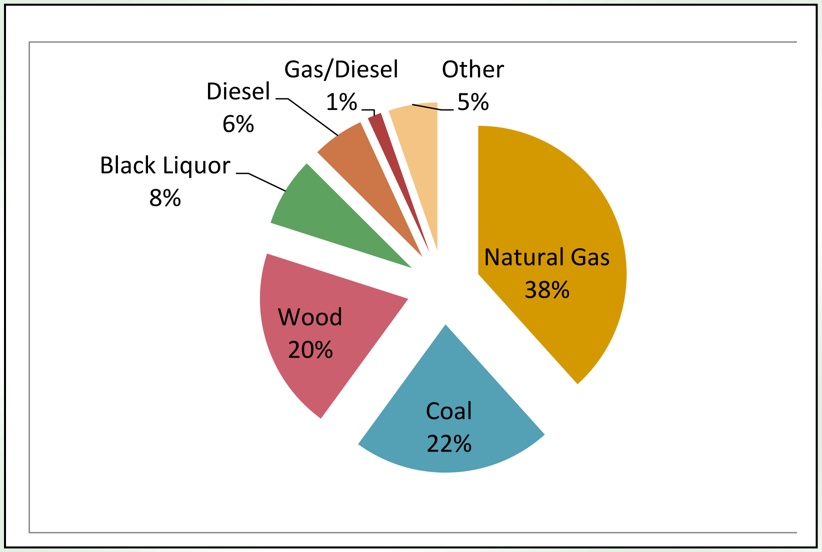
The two largest sectors using heat plant are the wood processing and dairy sectors.



Percentage of the total heat used by the various sectors [(1)].

Wood Fuel for the Industrial and Commercial Heat Sector

Wood fuel is used for 20% of the total commercial and industrial heat market (by MW capacity).



Percentage of MW by fuel type [1].

Natural gas is the largest fuel type category used for heating (by capacity MW – 38%)

Installed Capacity of Heat Plant (MW) by Sector and Fuel Type

Sector	Coal	Natural Gas	LPG	Diesel	LFO	Wood	Total (MW)
Accommodation	2.78	1.428	3.75	9	1.6	1	19.558
Prisons	0	30.03	9.915	4.25	0	0.6	44.795
Councils	4.45	12.7995	0.1	9.885	0	1.885	29.1195
Dairy	547	1343.51	1.3	28.68	5	0	1925.49
Defence	14.06	12.07	0	2.34	0	0	28.47
Education	44.1	42.2	0	12.13	0	7.5	105.93
Food Processing	211.3513	265.34	6.88	40.96	9.23	9.7	543.4613
Horticulture	102.92	99.78	2.3	0	7.05	4	216.05
Hospitals	112.75	109.35	7.47	84.45	0.1	3	317.12
Meat	242.83	155.25	12.45	25.09	11.2	8.5	455.32
Miscellaneous	11.45	60.419	5.2	10.759	6.3	5.25	99.378
Other Manufacturing	46.2	66.88	1.1	14.9	0	142.9	271.98
Research Institutes	0	9.93	0	0	0	1.13	11.06
Rest Homes	0.3	0.998	0.2	0.4	0.1	0.3	2.298
Universities	36.05	70.527	0.75	2.05	4.6	1.3	115.277
Venues	0	6.857	0	0	0	0	6.857
Wood	93.85	245.4	8	4.6	0	1232.94	1584.79
Total	1470.091	2532.769	59.415	249.494	45.18	1420.005	5776.954

MW heat capacity for the different sectors by fuel type. Adapted from the Heat Plant Data Base 2014.

Wood Fuelled Heat Plants Compared to Fossil Fuelled Plant by Sector

Sector	Coal	Natural Gas	LPG	Diesel	LFO	Wood	Total
Accommodation	3	2	4	8	2	1	20
Prisons	0	188	125	23	0	6	342
Councils	13	60	1	30	0	9	113
Dairy	27	103	5	9	1	0	145
Defence	3	6	0	2	0	0	11
Education	215	171	0	37	0	64	487
Food Processing	19	85	5	21	4	4	138
Horticulture	53	28	1	0	8	1	91
Hospitals	42	116	10	24	1	2	195
Meat	57	88	8	18	6	2	179
Miscellaneous	7	40	6	20	5	6	84
Other Manufacturing	13	18	1	5	0	4	41
Research Institutes	0	21	0	0	0	3	24
Rest Homes	3	11	2	4	1	3	24
Universities	10	100	1	4	2	2	119
Venues	0	12	0	0	0	0	12
Wood	25	40	1	4	0	118	188
	490	1089	170	209	30	225	2213

Number of heat plants for each sector by fuel type

Assuming that the government related sectors comprise of the following:

- Prisons
- Councils
- Defense
- Education
- Hospitals
- Research Institutes
- Universities

The percentage of heat plants in the Government related sectors is 58%. Only 7% of the heat plants operated by the Government related sectors are wood fuelled. Of the total number of heat plants only 10% are currently wood fuelled.

Sector	Number of Coal Plants
Prisons	0
Councils	13
Defence	3
Education	215
Hospitals	42
Research Institutes	0
Universities	10
Total	283

Number of coal fired plants potential available to be converted to wood fuels.

The government related sectors currently operate around 13% of coal fuelled plants in New Zealand.

Fuel	2015	Kt CO2 eq
Coal	32.5	2,877.7
Natural Gas	55.9	2,968.9
LPG	1.3	79.5
Diesel	5.5	386.8
LFO	1.0	72.6
Wood	31.3	25.1
Total	127.5	6,410.6

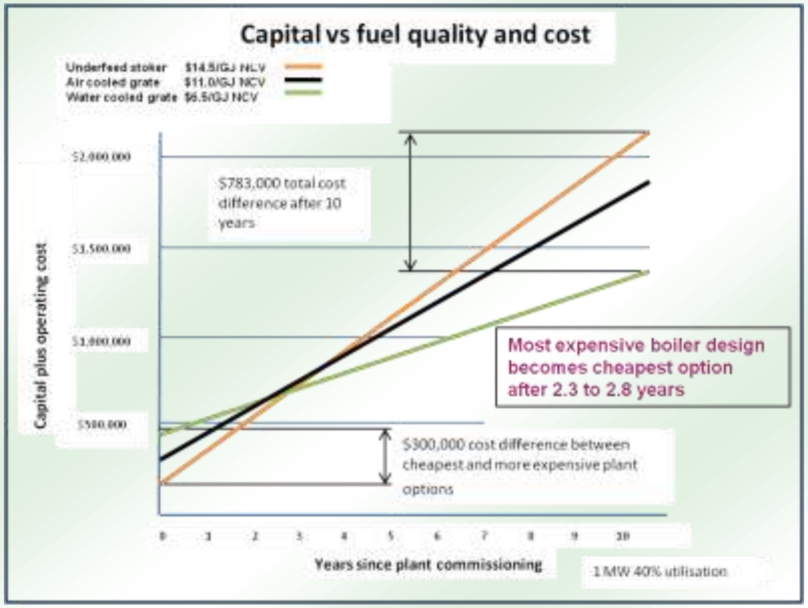
Greenhouse gas emission from fuel used for commercial and industrial related heat (2015).

	ktCO2eq	
	2015	2020
Coal	2877.7	1576.1
Natural Gas	2968.9	3436.8
LPG	79.5	48.82
Diesel	386.8	132.6
LFO	72.6	50.6
Wood	25.1	32.4
	6410.6	5277.32

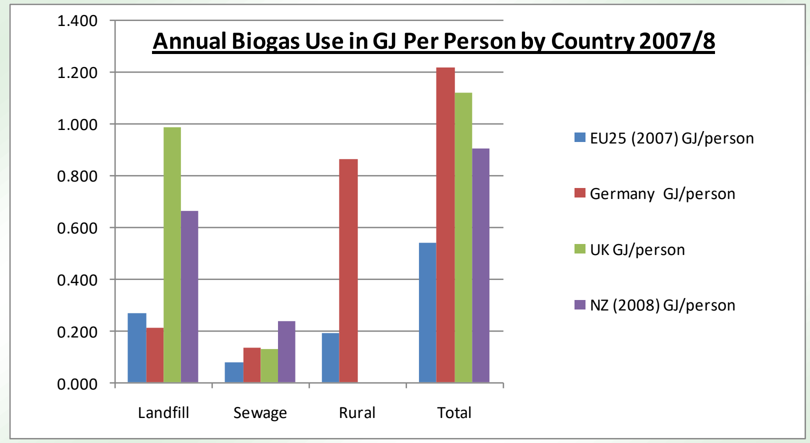
Greenhouse gas emissions reductions to 2020 through replacing fossil fuels with wood fuels for commercial and industrial heat. This reduction assumes the "Encouraged Growth Scenario". Note this scenario is from the Bioenergy Association Information Sheet 32.

The "Encouraged Growth Scenario would potentially reduce greenhouse gas emissions by 18% by 2020 from the commercial and industrial heat sectors.

Relative cost of purchasing and operating a wood fueled heat plant



Use of Biogas In different countries



Annual biogas use in GJ /person by Country (year 2007/2007)

Methane reduction by biogas technologies

The waste sector produces mainly methane emissions (96.4%). 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 waste water treatment facilities and emissions from the waste sector contributed 5,054 kt CO2-e or 6.2% of NZ's total greenhouse gas emissions.

Source	2013 emissions[1] (kt CO2-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.

Composition of waste to municipal landfills in 2013.

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

There are[2] 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.
- 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 CO2-e of emissions from the waste sector (8.9%).

Domestic and commercial wastewater contributed 254.5kt CO2-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.

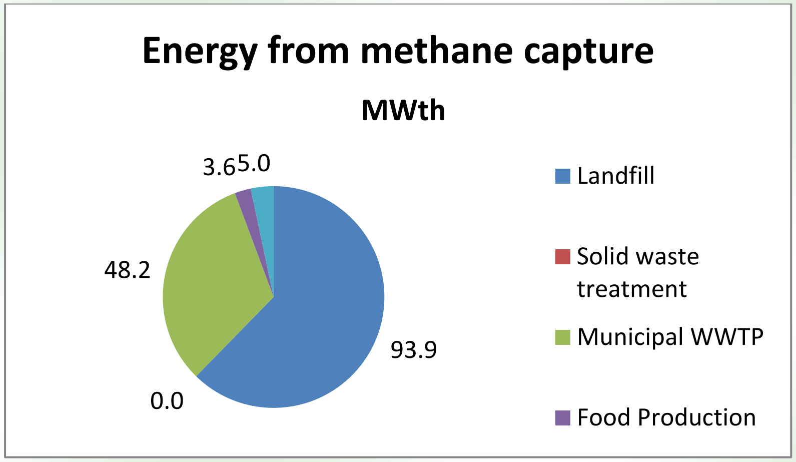
Industrial waste water contributed 196.1kt CO2-e (43.5%) emissions from wastewater facilities. The major source of industrial

[1] Net emissions after methane recovery. In 2013 1354.25 kt CO2-e methane was recovered.

[2] As at 31 December 2012. Source New Zealand's Greenhouse Gas inventory 1990-2013, Ministry for the Environment.

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 serving 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.



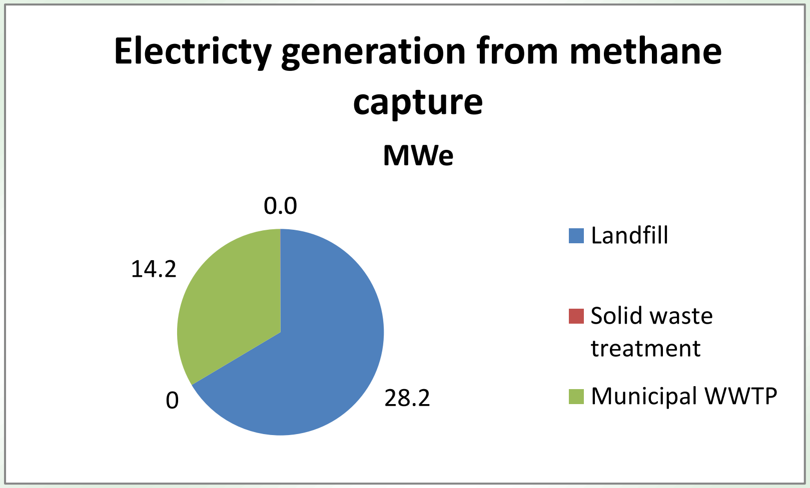
Energy from methane capture

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[3].

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



Electricity generation form methane capture

[3] Ledgard and Brier 2004

Wood Fuel Characteristics

Energy Content of various forms of biomass.

Section: Appendix A

Heat Content Ranges for Various Biomass Fuels (dry weight basis[a]) with English and Metric Units

Fuel type & source	English			Metric[b]			
		Higher Heating Value		Higher Heating Value		Lower Heating Value	
	Btu/lb[c]	Btu/lb	MBtu/ton	kJ/kg	MJ/kg	kJ/kg	MJ/kg
Agricultural Residues							
Corn stalks/stover (1,2,6)	7,487	7,587 - 7,967	15.2 - 15.9	*17,636 - 18,519*	*17.6 - 18.5*	16,849 - 17,690	16.8 - 18.1
Sugarcane bagasse (1,2,6)	7,031	7,450 - 8,349	14.9 - 16.7	*17,317 - 19,407*	*17.3 - 19.4*	17,713 - 17,860	17.7 - 17.9
Wheat straw (1,2,6)		*6,964 - 8,148*	13.9 - 16.3	16,188 - 18,940	16.1 - 18.9	15,082 - 17,659	15.1 - 17.7
Hulls, shells, prunings (2,3)		6,811 - 8,838	13.6 - 17.7	*15,831 - 20,543*	*15.8 - 20.5*		
Fruit pits (2-3)		8,950 - 10,000	17.9 - 20.0				
Herbaceous Crops	7,791						
Miscanthus (6)				18,100 - 19,580	18.1 - 19.6	17,818 - 18,097	17.8 - 18.1
switchgrass (1,3,6)		7,754 - 8,233	15.5 - 16.5	*18,024 - 19,137*	*18.0 - 19.1*	16,767 - 17,294	16.8 - 18.6
Other grasses (6)				18,185 - 18,570	18.2 - 18.6	16,909 - 17,348	16.9 - 17.3
Bamboo (6)				19,000 - 19,750	19.0 - 19.8		
Woody Crops	8,852						
Black locust (1,6)		8,409 - 8,582	16.8 - 17.2	*19,546 - 19,948*	*19.5 - 19.9*	18,464	18.5
Eucalyptus (1,2,6)		*8,174* - 8,432	16.3 - 16.9	19,000 - *19,599*	*19.0 - 19.6*	17,963	18.0
Hybrid poplar (1,3,6)		*8,183* - 8,491	*16.4* - 17.0	19,022 - *19,737*	*19.0 - 19.7*	17,700	17.7
Willow (2,3,6)		7,983 - 8,497	16.0 - 17.0	18,556 - 19,750	18.6 - 19.7	16,734 - 18,419	16.7 - 18.4
Forest Residues	7,082						
Hardwood wood (2,6)		8,017 - 8,920	16.0 - 17.5	*18,635 - 20,734*	*18.6 - 20.7*		
Softwood wood (1,2,3,4,5,6)		8,000 - 9,120	16.0 - 18.24	*18,595 - 21,119*	*18.6 - 21.1*	17,514 - 20,768	17.5 - 20.8
Urban Residues							
MSW (2,6)		5,644 - 8,542	11.2 - 17.0	*13,119 - 19,855*	*13.1 - 19.9*	11,990 - 18,561	12.0 - 18.6
RDF (2,6)		*6,683 - 8,563*	*13.4 - 17.1*	15,535 - 19,904	15.5 - 19.9	14,274 - 18,609	14.3 - 18.6
Newspaper (2,6)		8,477 - 9,550	17 - 19.1	*19,704 - 22,199*	19.7 - 22.2	18,389 - 20,702	18.4 - 20.7
Corrugated paper (2,6)		7,428 -7,939	14.9 - 15.9	17,265 - 18,453	17.3 - 18.5	17,012	
Waxed cartons (2)		11,727 - 11,736	23.5 - 23.5	*27,258 - 27,280*	*27.3*	25,261	

Sources:

1 http://www1.eere.energy.gov/biomass/feedstock_databases.html
2 Jenkins, B., *Properties of Biomass*, Appendix to *Biomass Energy Fundamentals*, EPRI Report TR-102107, January, 1993.
3 Jenkins, B., Baxter, L., Miles, T. Jr., and Miles, T., *Combustion Properties of Biomass*, Fuel Processing Technology 54, pg. 17-46, 1998.
4 Tillman, David, *Wood as an Energy Resource*, Academic Press, New York, 1978
5 Bushnell, D., *Biomass Fuel Characterization: Testing and Evaluating the Combustion Characteristics of Selected Biomass Fuels*, BPA report, 1989
6 http://www.ecn.nl/phyllis
Original references are provided in the Phyllis database for biomass and waste of the Energy Research Centre of the Netherlands.

[a] This table attempts to capture the variation in reported heat content values (on a dry weight basis) in the US and European literature based on values in the Phyllis database, the US DOE/EERE feedstock database, and selected literature sources. Table A.3 of this document provides information on heat contents of materials "as received" with varying moisture contents.

[b] Metric values include both HHV and LHV since Europeans normally report the LHV (or net calorific values) of biomass fuels.

[c] HHV assumed by GREET model given in Table A.1 of this document

Relationship between moisture content and energy content

Moisture con	Wood Net CV	Wood Net CV	Miscanthus N	Wheat straw	Hardwood de	Softwood de	Hardwood en	Softwood en	Hardwood ch	Softwood ch	Hardwood lo	Softwood log	Hardwood ch
Wet basis	Net CV	Realizable e	Net CV	Net CV	Density	Density	Energy densi	Energy densi	Energy densi	Energy densi	Energy densi	Energy densi	Bulk density
%	GJ/t	GJ/t	GJ/t	GJ/t	kg/m3	kg/m3	GJ/m3	GJ/m3	GJ/m3	GJ/m3	GJ/m3	GJ/m3	kg/m3
0%	19.0	19.0	18.0	17.0	580	410	11.0	7.8	4.1	2.9	7.4	5.2	215
5%	17.9	17.9	17.0	16.0	597	422	10.7	7.6	4.0	2.8	7.2	5.1	221
10%	16.9	16.8	16.0	15.1	615	435	10.4	7.3	3.8	2.7	7.0	4.9	228
15%	15.8	15.8	14.9	14.1	634	448	10.0	7.1	3.7	2.6	6.7	4.7	235
20%	14.7	14.7	13.9	13.1	654	462	9.6	6.8	3.6	2.5	6.5	4.6	242
25%	13.6	13.6	12.9	12.1	684	484	9.3	6.6	3.5	2.4	6.3	4.4	253
30%	12.6	12.5	11.9	11.2	733	518	9.2	6.5	3.4	2.4	6.2	4.4	272
35%	11.5	11.4	10.8	10.2	790	558	9.1	6.4	3.4	2.4	6.1	4.3	292
40%	10.4	10.4	9.8	9.2	856	605	8.9	6.3	3.3	2.3	6.0	4.2	317
45%	9.4	9.3	8.8	8.3	933	660	8.7	6.2	3.2	2.3	5.9	4.1	346
50%	8.3	8.2	7.8	7.3	1027	726	8.5	6.0	3.1	2.2	5.7	4.0	380
55%	7.2	7.1	6.8	6.3	1141	806	8.2	5.8	3.0	2.2	5.5	3.9	422
60%	6.1	6.0	5.7	5.3	1283	907	7.9	5.6	2.9	2.1	5.3	3.7	475
65%	5.1	5.0	4.7	4.4	1467	1037	7.4	5.2	2.7	1.9	5.0	3.5	543
8%	17.3	17.3			608	429	10.5	7.4					
12%	16.4	16.4			622	440	10.2	7.2					
27%	13.2	13.2			703	497	9.3	6.6					
62%	5.71	5.6			1351	955							

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