Reefton Air Emission Inventory – 2012

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Executive Summary

An emission inventory was carried out for Reefton to estimate emissions to air of air contaminants, in particular PM_{10}. The inventory estimates emissions to air from domestic heating, motor vehicle, industrial and commercial activities and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because the methodology to estimate emissions is less robust. A previous air emissions inventory for Reefton was carried out in 2005.

The inventory focuses on suspended particles (PM_{10}) the main contaminant of concern in urban areas of New Zealand but also makes estimates of emissions of carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide.

A domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels. In Reefton multi fuel burners are used by half of the households and are the most common heating method. In 2012 around 25% of households used electricity in their main living area and 13% used wood burners. This compares with 24% households using electricity in the 2005 air emission inventory and 19% using woodburners. Many householders use more than one method to heat the main living area of their home.

Domestic heating is the main source of PM_{10} emissions, accounting for 96% of the daily winter PM_{10} emissions. Other sources included industry (3%) and outdoor burning (1%). Motor vehicles contributed less than 1% of the daily winter PM_{10} emissions. On an average winter's night, around 122 kilograms of PM_{10} are discharged from these sources.

Results suggest emissions have decreased since 2005 as a result of changes in domestic home heating emissions. The magnitude of the decrease requires further confirmation but may be up to 44%.

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1 Introduction

Emission inventories are used by Governments and Local Government internationally to provide an estimate of the quantities of contaminants from anthropogenic sources that are emitted into the air and the relative contribution of sources to total emissions. The sources that are included in emissions inventories in New Zealand are generally the domestic heating, motor vehicle, industrial and commercial and outdoor burning sector. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust.

In New Zealand the main air contaminant of concern in urban areas of New Zealand is particles in the air less than 10 microns in diameter (PM_{10}). In Reefton concentrations of PM_{10} breach the National Environmental Standard for PM_{10} (50 µg m^{-3} – 24-hour average with one allowable exceedence per year). In 2012 the NES was breached on 27 occasions.

This report primarily focuses on emissions of particles (PM_{10}) from domestic heating, motor vehicles, industrial and commercial activities and outdoor burning. Other contaminants included in this emission inventory are carbon monoxide, nitrogen oxides, sulphur oxides volatile organic compounds and carbon dioxide.

A previous emission inventory for Reefton was carried out in 2005. The main methods of home heating in Reefton in 2005 were multi fuel burners (68%), electricity (24%) and wood burners (19%). Open fires were used by 11% of households. In 2005 domestic heating was found to emit around 272 kilograms per day of PM_{10} (average winters night) and contributed 93% of the anthropogenic PM_{10} emissions in the Reefton airhshed.

2 Inventory Design

This inventory focuses on emissions and sources of PM_{10}, although estimates of other key contaminants are also made. It is unlikely that concentrations of other key contaminants are likely to exceed national environmental standards (NES) in Reefton.

2.1 Selection of sources

Estimates of emissions from the domestic heating, motor vehicles, industry and outdoor burning sector are included in the emissions inventory. The report also discusses PM_{10} emissions from a number of other minor sources.

2.2 Selection of contaminants

The inventory included an assessment of emissions of suspended particles (PM_{10}), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC) and carbon dioxide (CO_2).

Emissions of PM_{10}, CO, SOx and NOx are included as these contaminants are in the NES because of their potential for adverse health impacts. Carbon dioxide has been typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. However, these data are now generally collected nationally and for a broader range of greenhouse gases. Estimates of CO_2 have been retained in the inventory but readers should be directed to national statistics (e.g., www.climatechange.govt.nz.) should detailed data on this source be required. Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. It is unlikely that ozone formation from emissions within Reefton would cause ozone problems. In this report, VOC emissions have been estimated for existing sources but data on emissions from VOC specific sources (e.g., spray painting) has not been included.

2.3 Selection of areas

The Reefton inventory study area is based on the 2005 inventory area which includes the census area unit for Reefton. This differs slightly to the Reefton airshed gazetted for air quality management purposes.

Figure 2.1 shows the inventory study area (includes all blue CAU areas) and the Reefton airshed area. The inventory study area comprises the majority of the airshed area and has been retained as the study area for 2012 to enable direct comparisons between the 2005 and 2012 emission inventories.

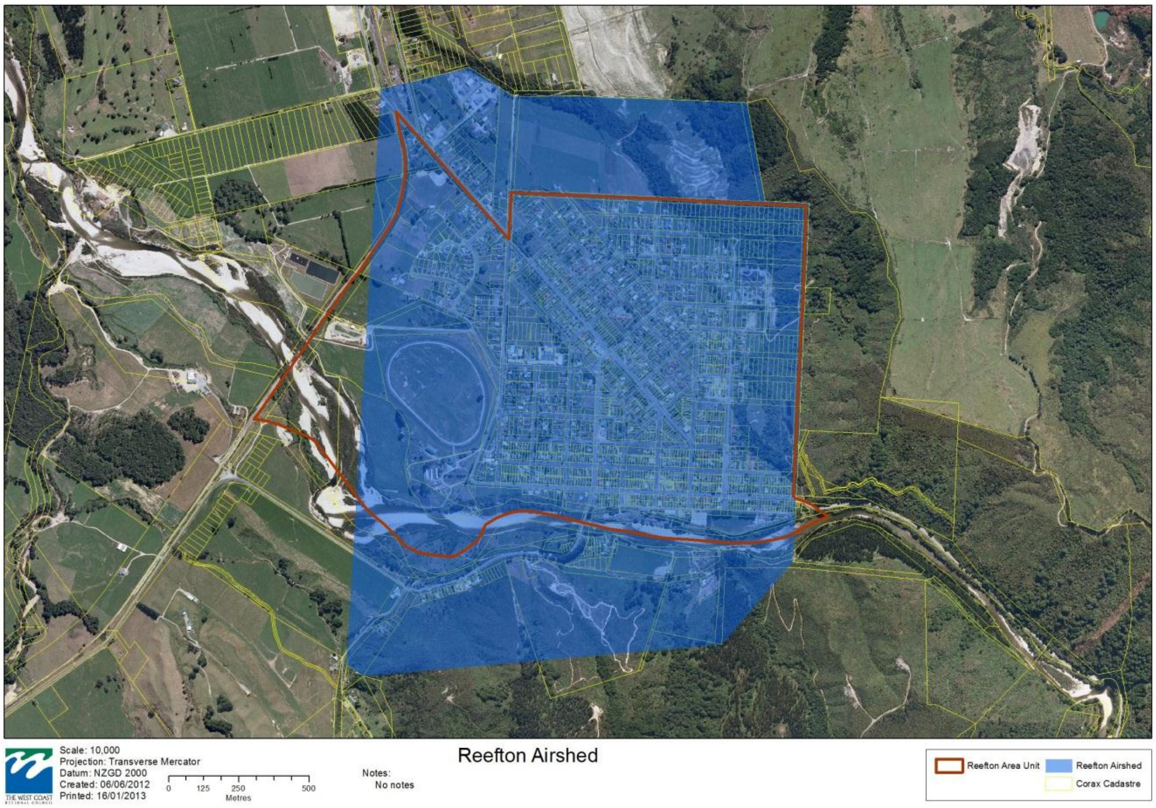

Figure 2.1: Reefton Airshed (source West Coast Regional Council).

2.1 Temporal distribution

Data were collected based on daily data with some seasonal variations. Domestic heating data were collected based on average and worst-case wintertime scenarios and by month of the year. Motor vehicle data were collected for an average day as data sources do not contain seasonal variations in vehicle movements. Industrial data were collected by season as was outdoor burning data.

3 Domestic heating

3.1 Methodology

Domestic heating methods and fuel use used by households in Reefton was collected using a household survey carried out by Digipol during November 2012 (Appendix A). Table 3.1 shows the number of households based on 2006 census data for the inventory area, the estimated households for 2012, and survey details. The 2012 estimate of dwellings for Reefton was made by adjusting the 2006 occupied dwellings from the census by the proportional increase in population from 2006 (census) to 2011 based on an estimate of 980 supplied by Buller District Council. The 2005 inventory was also based on a total of 417 occupied dwellings.

Table 3.1: Summary household, area and survey data for the Reefton inventory area.

Households by census area unit 2006	Estimated households 2012	Sample size	Area (ha)	Sample error
402	417	200	201	5%

Home heating methods were classified as; electricity, open fires, wood burners 10 years or older (pre 2002), wood burners five to 10 years old (2003-2007), wood burners less than five years old (post 2007), pellet fires, multi fuel burners, gas burners and oil burners. The post 2007 wood burner category includes all wood burners meeting the NES design criteria and the 2003-2007 category includes a mix of NES compliant and non NES compliant wood burners.

Emission factors were applied to the results of the home heating survey to provide an estimate of emissions for each study area. The emission factors used to estimate emissions from domestic heating are shown in Table 3.2. The basis for these is detailed in Appendix B.

Table 3.2: Emission factors for domestic heating methods.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg	Benzene g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97
Open fire - coal	21	80	4	16.2	15	2600	0.00065
Pre 2002 burners	11	110	0.5	0.2	33	1600	0.97
2002-2006 burners	7	70	0.5	0.2	21	1600	0.97
Post 2007 burners	5	50	0.5	0.2	15	1600	0.97
Pellet burners	2	20	0.5	0.2	6	1600	0.97
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	0.97
Multi-fuel[1] – coal	21	80	1.2	16.2	15	2600	0.97
Oil	0.3	0.6	2.2	3.8	0.25	3200	0.00065
Gas	0.03	0.18	1.3	7.6E-09	0.2	2500	2.16E-05

[1] - includes potbelly, incinerator, coal range and any enclosed burner that is used to burn coal

The average weight for a log of wood is one of the assumptions required for this inventory to convert householder's estimates of fuel use in logs per evening to a mass measurement required for estimating emissions. Average log weights used for inventories in New Zealand have included 1.6 kilograms, 1.4 kilograms and 1.9 kilograms. The latter value is based on a survey of 219 households in Christchurch during 2002 and was the value used in the 2005 air emission inventory. A 2005 burner emission testing programme carried out in Tokoroa gave an average log weight of 1.3 kilograms. The sample size (pieces of wood weighed) for this study was 845. These were spread across only 12 households so it is uncertain how representative of the Tokoroa population a fuel weight of 1.3 kilograms per log might be. More recently a similar study was carried out in Nelson, Rotorua and Taumaranui. Results of fuel use from that study indicated an average fuel weight of 1.7 kilograms per log. A value of 1.6 kilograms is recommended for use in this inventory.

Emissions for each contaminant and for each time period and season were calculated based on the following equation:

Equation 3.1 **CE (g/day) = EF (g/kg) * FB (kg/day)**

Where:

CE = contaminant emission

EF = emission factor

FB = fuel burnt

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.6 kilograms.
- The average weight of a bucket of coal is 9 kilograms.

3.2 Home heating methods

Home heating methods and fuels used in Reefton during 2012 are shown in Table 3.3. Multi fuel burners were the main heating method, with 54% of households using this method to heat their main living area. The second most common method for home heating was electricity (26%) and wood burners 15%. Open fires and gas (mainly unflued) were each used by 5% of households in Reefton. Many households rely on more than one method of heating their main living area during the winter months and 18% of households did not use any heating methods in their main living areas.

The main coal used by residents was Giles Creek and was used by 48% of households that responded with a coal type. Other commonly used coals were Burkes Creek (13%), Heaphy (13%), Echo (10%), Reddale (10%) and Boatmans (5%). The weighted average sulphur content was 0.9%.

Around 3.6 tonnes of coal and 4.2 tonnes of wood is estimated to be burnt in Reefton on a typical winter's night.

Table 3.4 shows that most homes in Reefton have some sort of insulation with the majority having ceiling insulation, one third of houses having underfloor insulation and almost half of households having wall insulation.

Table 3.3: Home heating methods and fuels.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	26%	106		
Total Gas	5%	21	0.00	0%
Flued gas	1%	2		
Unflued gas	4%	19		
Oil	1%	4	0.03	0%
Open fire	5%	21		
Open fire – wood	5%	19	0.2	3%
Open fire – coal	4%	15	0.1	1%
Total Wood burner	15%	62	1.1	15%
Pre 2002 wood burner	5%	19	0.3	4%
2002-2006 wood burner	6%	25	0.5	6%
Post 2007 wood burner	5%	19	0.3	4%
Multi fuel burners	54%	225		
Multi fuel burners-wood	36%	150	2.8	36%
Multi fuel burners-coal	47%	198	3.5	45%
Wood fired stove	1%	4		
Total wood	56%	231	4.2	54%
Total coal	51%	212	3.6	46%
Total		417	8	100%

Table 3.4: Proportion of homes with insulation

Insulation type	HH	%
Ceiling	352	85%
Underfloor	135	33%
Wall	204	49%
Cylinder wrap	133	32%
Double glazing	79	19%
None	23	6%
Don't know	8	2%
Other	21	5%

3.3 Emissions from domestic heating

In Reefton a total of 117 kilograms of PM_{10} is emitted on an average winters' day from domestic home heating. Multifuel burners using coal are responsible for around 63% of this. Figure 3.1 shows the relative contributions of other heating methods.

Tables 3.5 and 3.6 show the estimates of wintertime contaminant emissions for different heating methods under average and worst-case scenarios. Days when households may not be using specific home heating methods are accounted for in the "average" method shown in Table 3.6 and the worst-case scenario of all households burning on a given night is shown in Table 3.7. Under the latter scenario around 127 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night. On an average winter's night (June to August) just less than two thirds of domestic PM_{10} emissions come from the burning of coal, with just more than one third from the burning of wood.

Figures 3.2 and 3.3 and Table 3.7 show the monthly variation in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.8. Figure 3.5 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

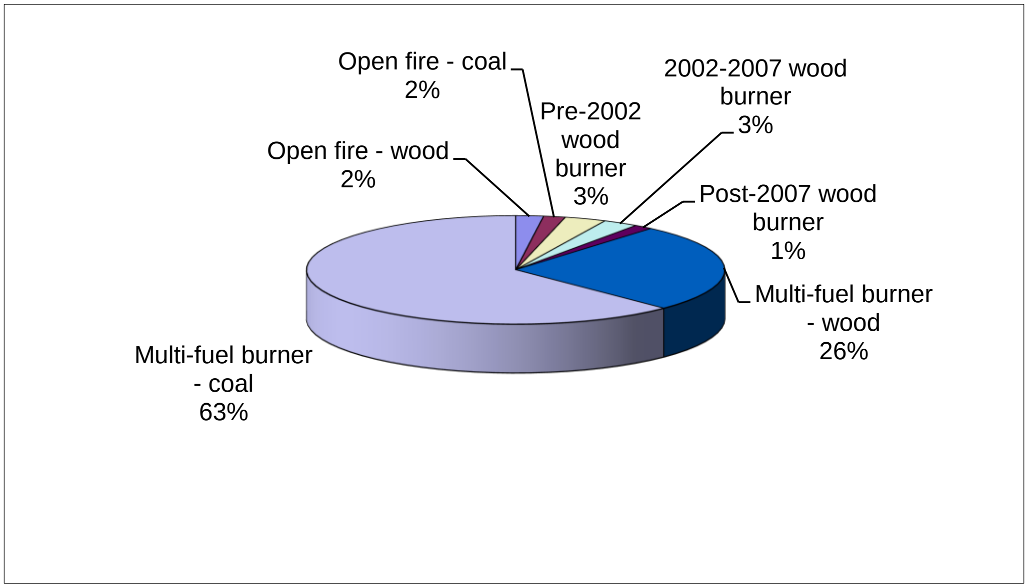

Figure 3.1: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Reefton.

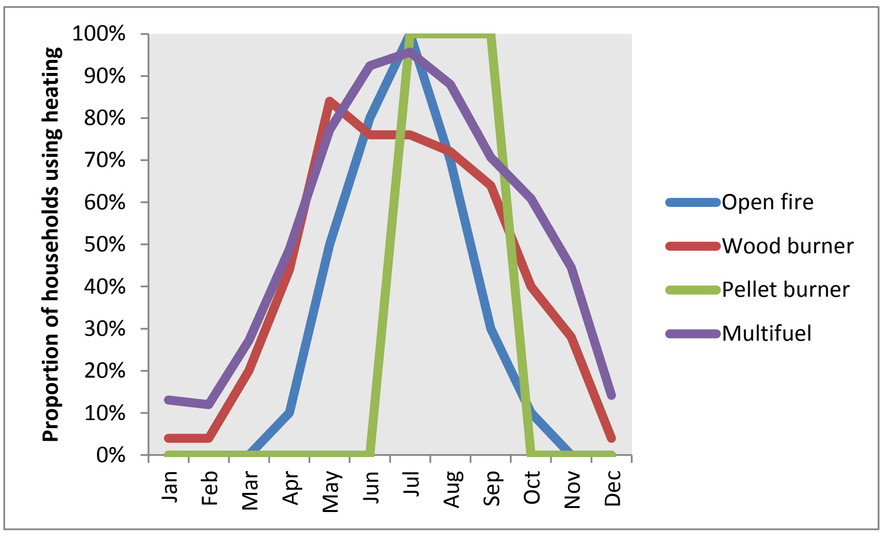

Figure 3.2: Monthly variations in appliance use in Reefton.

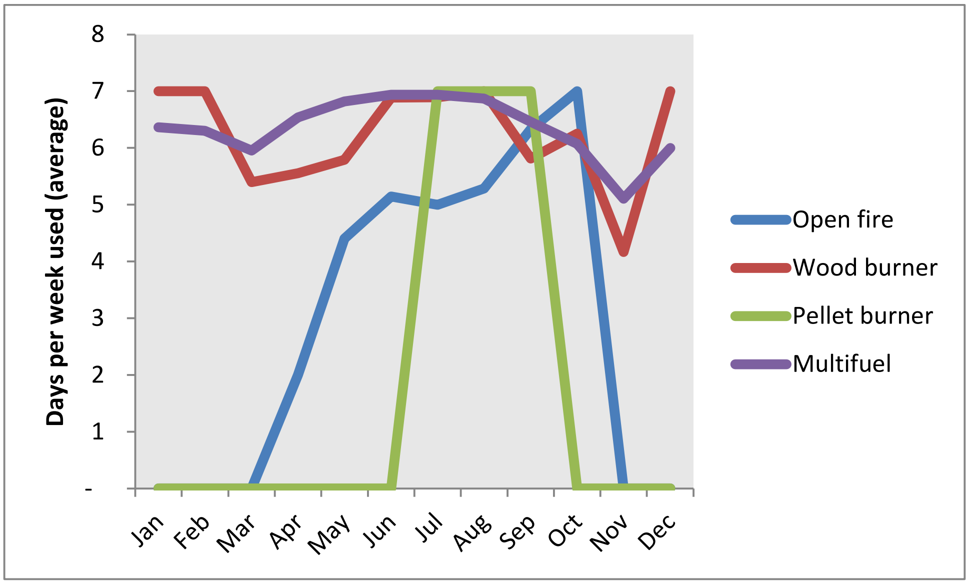

Figure 3.3: Average number of days per week appliances are used in Reefton.

Table 3.5: Reefton winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%
Open fire																				
Open fire - wood	0.2	3%	2	12	2%	25	124	3%	0	2	6%	0	0	0	7	37	4%	0	2	2%
Open fire - coal	0.1	1%	2	10	2%	7	37	1%	0	2	5%	2	8	2	1	7	1%	0	1	2%
Wood burner	1.1																			
Pre 2002wood burner	0.3	4%	4	19	3%	37	186	4%	0	1	2%	0	0	0	11	56	6%	1	3	3%
2002-2006 wood burner	0.5	6%	3	16	3%	32	158	4%	0	1	3%	0	0	0	10	47	5%	1	4	5%
Post 2007 wood burner	0.3	4%	2	8	1%	14	68	2%	0	1	2%	0	0	0	4	20	2%	1	3	3%
Wood fired stove	0.0	0%	0.0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0%	0	0	0%
Multi fuel burner																				
Multi fuel– wood	2.8	36%	31	153	26%	363	1805	41%	1	7	20%	1	3	1	109	541	56%	4	22	28%
Multi fuel – coal	3.5	45%	73	363	62%	417	2075	47%	4	21	60%	56	280	56	52	259	27%	9	45	56%
Gas	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0%	0	0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	1%	0	1	0	0	0	0%	0	1	1%
Total Wood	4.2	54%	42	208	36%	471	2342	53%	2	12	34%	1	4	1	141	703	73%	7	33	42%
Total Coal	3.6	46%	75	373	64%	425	2112	47%	5	23	65%	58	288	58	54	266	27%	9	46	58%
Total	8		117	581		895	4454		7	35		59	292	59	195	969		16	80	

Table 3.6: Reefton worst-case winter daily domestic heating emissions by appliance type.

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%
Open fire																				
Open fire - wood	0.3	4%	3	17	3%	35	174	4%	1	3	7%	0	0	0	10	52	5%	1	3	3%
Open fire - coal	0.1	2%	3	14	2%	10	52	1%	1	3	7%	2	11	2	2	10	1%	0	2	2%
Wood burner	1.5																			
Pre 2002wood burner	0.5	5%	5	25	4%	50	249	5%	0	1	3%	0	0	0	15	75	7%	1	4	4%
2002-2006 wood burner	0.6	7%	4	21	3%	42	211	4%	0	2	4%	0	1	0	13	63	6%	1	5	6%
Post 2007 wood burner	0.5	5%	2	11	2%	18	91	2%	0	1	3%	0	0	0	5	27	3%	1	4	4%
Wood fired stove	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0%	0	0	0%
Multi fuel burner																				
Multi fuel– wood	2.9	34%	32	161	25%	383	1903	39%	1	7	19%	1	3	1	115	571	53%	5	23	27%
Multi fuel – coal	3.7	43%	77	383	61%	440	2188	45%	4	22	57%	59	295	59	55	273	26%	10	47	54%
Gas	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0%	0	0	0%
Oil	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0%	0	0	0%
Total Wood	5	56%	47	236	37%	528	2628	54%	3	14	36%	1	5	1	158	788	74%	8	38	44%
Total Coal	4	44%	80	397	63%	450	2240	46%	5	24	64%	61	306	61	57	283	26%	10	49	56%
Total	9		127	632		979	4868		8	38		62	311	62	215	1072		18	88	

Table 3.7: Monthly variations in domestic heating appliance use.

	Percentage of houses using this method that use it during each month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gas	17%	17%	17%	33%	50%	67%	33%	50%	50%	50%	33%	17%
Open fire	0%	0%	0%	10%	50%	80%	100%	70%	30%	10%	0%	0%
Wood burner	4%	4%	20%	44%	84%	76%	76%	72%	64%	40%	28%	4%
Wood fired cooker	0%	0%	0%	0%	0%	0%	100%	100%	100%	0%	0%	0%
Multi fuel	13%	12%	27%	49%	77%	92%	96%	88%	71%	61%	45%	14%
Oil	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Average number of days per week house is heated (by those that actually use heat during that month)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gas	-	-	-	7	7	5	7	7	6	5	2	-
Open fire	-	-	-	2	4	5	5	5	6	7	-	-
Wood burner	7	7	5	6	6	7	7	7	6	6	4	7
Wood fired cooker	-	-	-	-	-	-	7	7	7	-	-	-
Multi fuel	6	6	6	7	7	7	7	7	6	6	5	6
Oil	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.8: Monthly variations in contaminant emissions from domestic heating.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day
January	8	63	0	4	14	1
February	7	57	0	3	13	1
March	16	129	1	7	29	2
April	32	259	2	15	59	4
May	92	710	5	46	155	13
June	112	863	7	56	188	15
July	117	895	7	59	195	16
August	106	814	6	53	177	15
September	48	381	3	22	87	7
October	37	298	2	17	68	5
November	22	177	1	10	40	3
December	8	64	0	4	14	1
Total (kg/year)	18528	144156	1070	9071	31812	2544

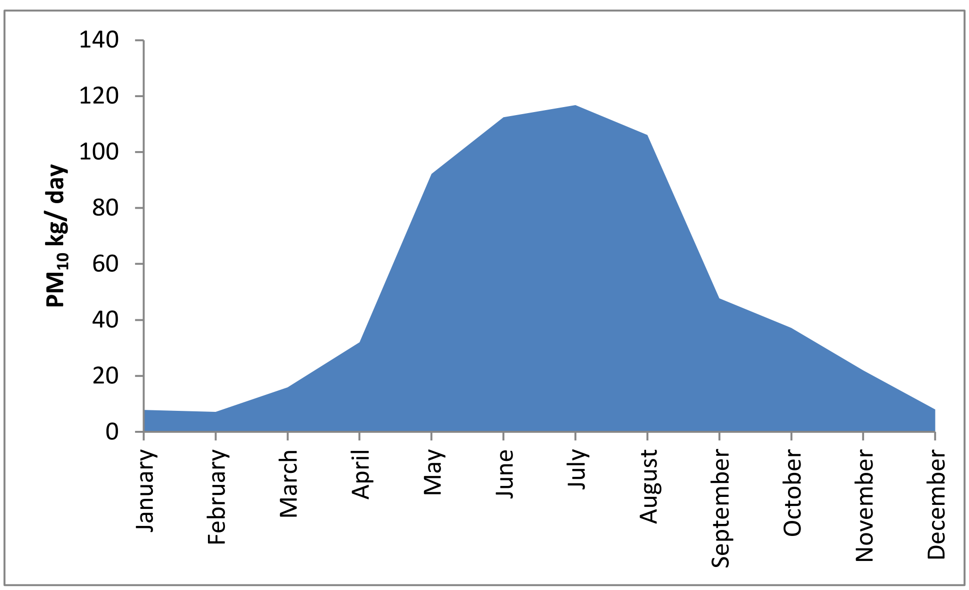

Figure 3.4: Monthly variations in PM_{10} emissions from domestic heating as a proportion of annual emissions.

4 Motor vehicles

Motor vehicle emissions to air include tailpipe emissions (all contaminants) and particulate emissions occurring as a result of the wear of brakes and tyres. Assessing emissions from motor vehicles involves collecting data on vehicle kilometres travelled (VKT) and the application of emission factors to these data.

Historically the emission factors used for motor vehicle emissions assessments in New Zealand were taken from the New Zealand Traffic Emission Rates (NZTER) database using local vehicle fleet profiles derived from motor vehicle registrations. The NZTER database was developed by the Ministry of Transport (MOT) based on measured emissions rates from actual vehicle emissions tests on New Zealand vehicles under various road and traffic conditions. However, assumptions underpinning the model were not documented. As a result, the Auckland Regional Council developed the Vehicle Emission Prediction Model (VEPM 5.0). Emissions factors for PM_{10}, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 5.0.

Emission factors for SOx were estimated for diesel vehicles based on the sulphur content of the fuel (0.01%) and the assumption of 100% conversion to SOx. Total VKT for diesel vehicles were estimated based on the proportion of diesels in the vehicle fleet. Table 4.1 details the emission factors used to estimate motor vehicle emissions for 2012 for Reefton.

Table 4.1: Emission factors for 2012 for Reefton

	g/VKT	Source
CO	5.50	VFEM 5.0
CO_2	265	VFEM 5.0
VOC	0.35	VFEM 5.0
NOx	0.75	VFEM 5.0
PM_{10}	0.046	VFEM 5.0
PM_{10} Brake and Tyre	0.0010	VFEM 5.0
SOx	0.004	Order of magnitude estimate only based on S content of diesel

Estimates of VKT were obtained from the Ministry of Transport by CAU for the year ending 2010 (Badger, 2012, pers comm). These are based on modelling and overestimate VKTs relative to vehicle registration information for 2010 (MOT, 2012) by around 8%. To align the model estimates to the vehicle registration data VKTs were adjusted downwards by 8%.

Table 4.2 shows the estimated number of VKTs for Reefton for 2010 which are considered the best available information from which to estimate 2012 motor vehicle emissions. Time of day estimates were based on the time of day breakdown from the Havelock North - 2005 vehicle data because there was not any time of day data available for Reefton

Table 4.2: VKT by time of day for Reefton

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Blenheim	6956	1702	2636	2275	344

Emissions for each time period were calculated by multiplying the emission factor by the VKT for that time period.

Emissions (g) = Emission Rate (g/VKT) * VKT (A-B)

4.1 Motor vehicle emissions

Less than one kilogram per day of PM_{10} is estimated to occur from motor vehicle emissions in Reefton. Other contaminant emissions from motor vehicles in Reefton include around 38 kilograms of CO and five kilograms of NOx (Table 4.3). In comparison, in Christchurch, where CO concentrations occasionally exceed ambient air quality guidelines during winter months, motor vehicles emit around 109 tonnes of CO within the main urban area.

Table 4.3: Summary of daily motor vehicle emissions in Reefton.

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Reefton	201	0.3	2	38	190	5	26	0.01	0.07
		VOC		CO_2					
	Hectares	kg	g/ha	t	kg/ha				
Reefton	201	2	12	2	9				

5 Industrial and Commercial

5.1 Methodology

An evaluation of potential discharges to air from industrial and commercial sources in Reefton was undertaken to identify activities that discharge PM_{10}. The West Coast Regional Council staff provided information on discharges to air from industrial and commercial activities in the Reefton airshed. The selection of industries for inclusion in this inventory was based on potential for PM_{10} emissions.

As site specific emissions data were not available, emissions were estimated using activity data and emission factor information, as indicated in Equation 5.2. Activity data from industry includes information such as the quantities of fuel used, or in the case of non-combustion activities, materials used or produced. Activity data was collected from local industry by West Coast Regional Council staff.

Equation 5.2 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

The emission factors used to estimate the quantity of emissions discharged are shown in Table 5.1. The coal fired boiler emission factors for PM_{10} are based on New Zealand specific emission factors as described in Wilton et. al. 2007. An average sulphur content of 1% was assumed for industrial coal burning.

Fugitive dust emissions from industrial and commercial activities were not included in the inventory assessment because of difficulties in quantifying the emissions.

Table 5.1: Emission factors for industrial discharges.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg
Underfeed stokers	2.0	5.5	4.8	13.5	0.1	2400

5.2 Industrial and commercial emissions

Discharges from six industrial and commercial activities were included in the assessment. These were all coal fired boilers and assumed to be underfeed stokers owing to the low heat output ratings. Around four kilograms of PM_{10} are discharged to air from industrial and commercial activities in Reefton on an average winters' day.

Table 5.2: Summary of industrial emissions (daily winter) in Reefton

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Reefton	201	4	18	10	50	9	43	33	164
		VOC		CO_2					
	Hectares	**kg**	**g/ha**	**t**	**kg/ha**				
Reefton	201	0	1	4	22				

6 Outdoor burning

Outdoor burning of green wastes or household material can contribute to PM_{10} concentrations and also discharge other contaminants to air. In some urban areas of New Zealand outdoor burning is prohibited because of the adverse health and nuisance effects associated with these emissions. Outdoor burning includes any burning in a drum, incinerator or open air on residential properties in the study area.

The West Coast Regional Air Quality Plan currently permits outdoor burning of vegetative matter. This plan is currently under review as are rules relating to outdoor burning.

6.1 Methodology

Emissions from outdoor burning in Reefton were estimated for the winter months based on data collected during the 2012 domestic home heating survey. The survey showed 13% of households burnt rubbish in the outdoors during the winter. Typically there would be 2-3 fires burnt per day during winter.

Emissions were calculated based on the assumption of an average weight of material per burn of 27 kilograms and using the emission factors in Table 6.1. This was based on an estimated fire size of $0.36m^3$ and 75 kg/m^3.

Estimates of PM_{10} and other emissions for each area are detailed in sections 6.2 to 6.4. It should be noted, however, that there are a number of uncertainties relating to the calculations. In particular it is assumed that burning is carried out evenly throughout the winter, whereas in reality it is highly probable that a disproportionate amount of burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

Table 6.1: Outdoor burning emission factors (AP42, 2002).

	PM_{10} g/kg	**CO g/kg**	**NOx g/kg**	**SOx g/kg**	**VOC g/kg**	**CO_2 g/kg**	**Benzene g/kg**
Outdoor burning	8	42	3	0.5	4	1470	0.97

In Reefton around one kilogram of PM_{10} from outdoor burning could be expected per day during the winter months on average from outdoor burning.

Table 6.2: Outdoor burning emission estimates for Reefton.

	PM_{10} **kg/ day**	**CO** **kg/ day**	**NOx** **kg/ day**	**SOx** **kg/ day**	**VOC** **kg/ day**	**CO_2** **t/ day**
Summer (Dec-Feb)	1.0	3.4	0.2	0.0	0.4	0.1
Autumn (Mar-May)	1.0	3.4	0.2	0.0	0.3	0.1
Winter (June-Aug)	0.9	3.0	0.2	0.0	0.3	0.1
Spring (Sept-Nov)	0.9	3.0	0.2	0.0	0.3	0.1

7 Other sources of emissions

This inventory includes all likely major sources of PM_{10} within the inventory area that can be adequately estimated using inventory techniques. Other sources of emissions not included in the inventory that may contribute to measured PM_{10} concentrations at some times during the year include dusts (a portion of which occur in the PM_{10} size fraction) and to a much lesser extent sea spray.

Lawn mowers, leaf blowers and chainsaws can also contribute small amounts of particulate. These are not typically included in emission inventory studies owing to the relatively small contribution, particularly in areas where solid fuel burning is a common method of home heating. Based on data for other areas, PM_{10} emissions from lawn mowing in all areas are likely to be much less than one kilogram per day[1].

[1] Pacific Air and Environment (1999) indicates around 0.07 grams of PM_{10} are emitted per household per day for the Wellington Region.

8 Total emissions

Around 122 kilograms of PM_{10} is discharged to air on an average winter's day over Reefton. Figure 8.1 shows that domestic home heating is the main source of these emissions contributing 96% of the daily wintertime emissions. Outdoor burning contributes 1%, industry 3% and transport less than 1% of the 2012 winter time PM_{10} emissions.

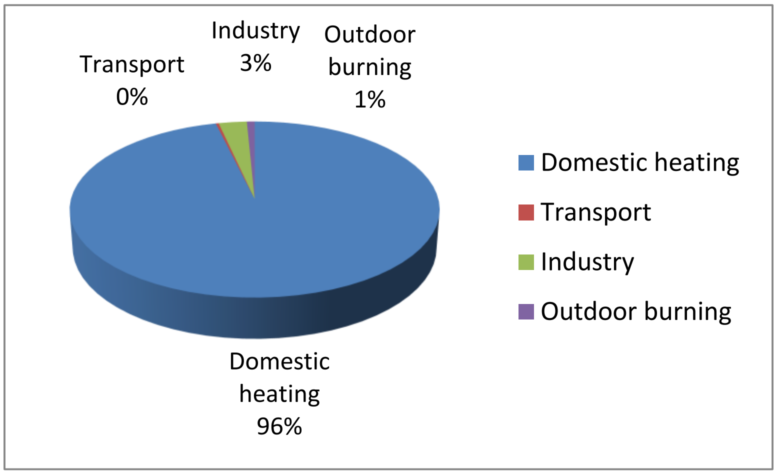

Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions in Reefton.

Domestic home heating is also the main source of winter time CO, SO_2, VOCs and CO_2 in Reefton. (Figure 8.2).

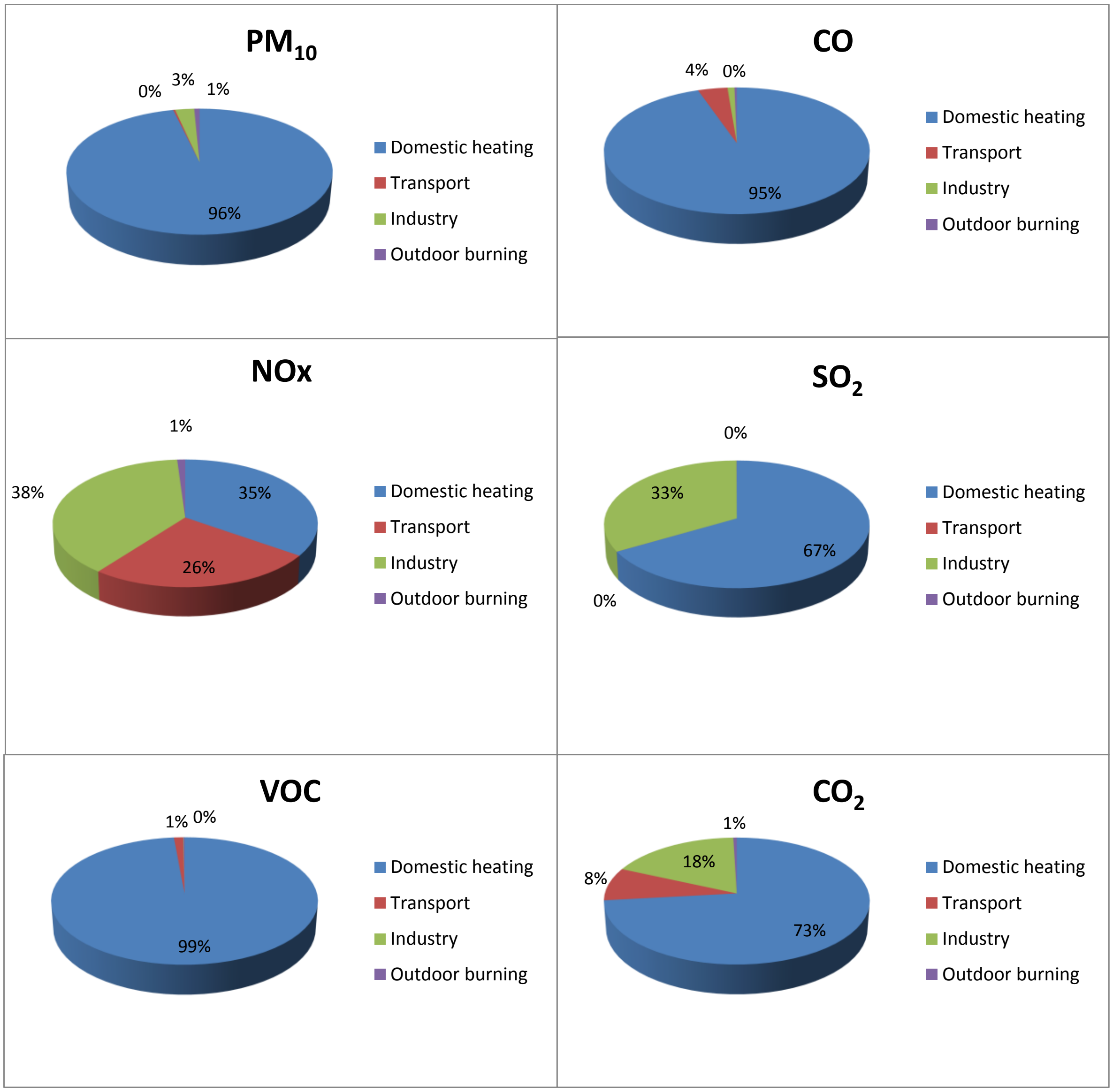

Figure 8.2: Relative contribution of sources to contaminant emissions in Reefton.

Table 8.1 shows daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) and Table 8.2 shows seasonal variations in PM_{10} emissions. Domestic home heating is also the dominant source of PM_{10} emissions during the summer months although the contribution decreases from around 96% to around 70%.

Table 8.1: Daily contaminant emissions from all sources (winter average).

	PM_{10}		CO		NOx		SOx	
	kg	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Domestic home heating	117	581	895	4454	7	35	59	292
Transport	0.3	2	38	190	5	26	0	0
Industry	3	16	9	45	8	39	29	146
Outdoor burning	1	4	3	15	0	1	0	0
Total	121	603	946	4704	20	100	88	439

	VOC		CO_2			
	kg	**g/ha**	**t**	**g/ha**		
Domestic home heating	195	969	16	80		
Transport	2	12	2	9		
Industry	0	0	4	19		
Outdoor burning	0	2	0	1		
Total	198	983	22	109		

Table 8.2: Monthly variations in daily PM_{10} emissions.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	8	71%	1	9%	2	17%	0	3%	11
February	7	68%	1	10%	2	19%	0	3%	11
March	16	79%	1	5%	3	14%	0	2%	20
April	32	88%	1	3%	3	8%	0	1%	36
May	92	96%	1	1%	3	3%	0	0%	96
June	112	96%	1	1%	4	3%	0	0%	117
July	117	96%	1	1%	4	3%	0	0%	122
August	106	96%	1	1%	4	3%	0	0%	111
September	48	92%	1	2%	3	6%	0	1%	52
October	37	90%	1	2%	3	7%	0	1%	41
November	22	84%	1	3%	3	11%	0	1%	26
December	8	72%	1	9%	2	16%	0	3%	11
Total kg year	18529		349		1036		119		20034

9 Comparison to 2005

Table 9.1 compares reported heating methods in 2012 to those from 2005. Results suggest a decrease in the proportion of households using wood burners, gas, open fires and multi fuel burners although differences in all except multi fuel burners are within the margin of error of the two surveys.

Table 9.1: Home heating methods and fuels in 2005 and 2012.

	2012 heating methods		2005 heating methods	
	%	HH		
Electricity	26%	106	24%	98
Total Gas	5%	21	13%	56
Flued gas	1%	2	1%	3
Unflued gas	4%	19	13%	52
Oil	1%	4	1%	5
Open fire	5%	21	11%	45
Open fire – wood	5%	19	10%	40
Open fire – coal	4%	15	7%	29
Total Wood burner	15%	62	19%	80
Older wood burners	5%	19	10%	40
Mid aged wood burner	6%	25	5%	23
Newer wood burner	5%	19	4%	17
Multi fuel burners	54%	225	68%	282
Multi fuel burners-wood	36%	150	68%	282
Multi fuel burners-coal	47%	198	60%	250
Pellet burners	1%	4	0%	-
Total wood	56%	231	96%	401
Total coal	51%	212	67%	279
Total		417		417

The 2005 inventory estimated around 272 kilograms per day (kg/day) of PM_{10} from domestic home heating. If these data are adjusted for changes in emission factors the 2005 estimate would be 208 kg/day. As the 2012 estimates for domestic heating are around 117 kg/day a 44% reduction in PM_{10} emissions appears to have occurred in Reefton since 2005. Additional questions included in the 2012 survey to ascertain changes in heating methods since the 2005 survey supports a small reduction in the use of multi fuel burners (around 1%). However, a further 25% of respondents who had not changed heating methods had not resided in Reefton since 2005 and changes to heating methods may have occurred prior to their arrival. The survey suggests that around 6% of households had removed open fires since 2006 and replaced them with multi fuel burners, wood burners or heat pumps. It is feasible that emissions have decreased in Reefton since 2005 and that this reduction could be in the order of 44%. Concentrations of PM_{10} measured in 2011 were lower than previous years and could be indicative of a decrease. Further evaluations of the impact of year to year variations in meteorological conditions is required to ascertain whether the low concentrations observed in 2011 were in response to a decrease in emissions or occurred as a result of unusual meteorological conditions.

Particulate emissions from motor vehicles are also estimated to have decreased since 2005 as a result of improvements in vehicle technology. These differences will be minimal however, owing to the very small contribution of motor vehicles to PM_{10} concentrations. Industrial emissions are unlikely to have changed significantly since 2005.

Although the 2005 inventory shows around 14 kg/day of PM_{10} from outdoor burning compared with just one kg/day in 2012 it is uncertain whether any change has occurred as no surveying of outdoor burning in Reefton took place in 2005.

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Appendix A: Home Heating Questionnaire

1. Good morning / afternoon/evening - Is this a home or business number?(- West Coast Regional District Council

May I please speak to an adult in your household who knows about your home heating systems? We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use to heat your main living area during a typical year. The survey will take about 5 minutes. Is it a good time to talk to you now?

Have you changed your heating method whilst living in Reefton at any time during the last 7 years?
If yes – have you changed from

What have you changed to:

Have you changed any other heating method whilst living in Reefton at any time during the last 7 years?
If yes – have you changed from

What have you changed to:

Have you changed any other heating method whilst living in Reefton at any time during the last 7 years?
If yes – have you changed from

What have you changed to:

If no Have you lived in Reefton for the past 7 years.

2. (a) Do you use any type of electrical heating in your MAIN living area during a typical year?

(b) What type of electrical heating do you use? Would it be...

- ☐ Night Store
- ☐ Radiant
- ☐ Portable Oil Column
- ☐ Panel
- ☐ Fan
- ☐ Heat Pump
- ☐ Don't Know/Refused
- ☐ Other (specify)

(c). Do you use any other heating system in your main living area in a typical year? *(If yes then question 3 otherwise Q9)*

3. (a) Do you use any type of gas heating in your MAIN living area during a typical year? *(If No then question 4)*

(b) Is it flued or unflued gas heating? If necessary: (A flued gas heating appliance will have an external vent or chimney)

(c) Which months of the year do you use your gas burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How many days per week would you use your gas burner during

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(e) Do you use mains or bottled gas for home heating?

(f) What size gas bottle do you use?

(f.2) How many times in a winter would you refill your x kg gas bottle? Interviewer: Winter is defined as May to August inclusive.

4. (a) Do you use a log burner in your MAIN living area during a typical year? (This is a fully enclosed burner but does not include multi fuel burner i.e., those that burn coal) *(If No then question 5)*

(b) Which months of the year do you use your log burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your log burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your log burner?

(e) In a typical year, how many pieces of wood do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.

(f) ask only If they used their log burner during non winter months How many pieces of wood do you use per day during the other months? Interviewers note : winter is defined as May to August inclusive.

(g) In a typical year, how much wood would you use per year on your log burner? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks, one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

(h) Do you buy wood for your log burner, or do you receive it free of charge?

(i) What proportion would be bought?

5. (a) Do you use an enclosed burner which burns coal as well as wood – i.e., a multi fuel burner in your MAIN living area during a typical year? (This includes incinerators, pot belly stoves, McKay space heaters etc but does not include open fires.) *(If No then question 6)*

(b) Which months of the year do you use your multi fuel burner?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June

☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your multi fuel burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your multi fuel burner?

(e) What type of multi fuel burner is it?

(f) In a typical year, how much wood do you use on your multi fuel burner per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as May to August inclusive

(g) ask only If they used their multi fuel burner during non winter months How much wood do you use per day during the other months?

(h) In a typical year, how much wood would you use per year on your multi fuel burner?_____ (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with

(i) Do you use coal on your multi fuel burner?

What type of coal do you use, is it
Boatmans
Burkes Creek
Echo
Giles Creek
Heaphy
Island Block
Reddale
Spring creek
Strongman
Terrace
Don't Know
other (Specify)

(j) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day) Interviewer: Winter is defined as May to August inclusive .

(k) Ask only If they used their multi fuel burner during non winter months How much coal do you use per day during the other months?

(l) Do you buy wood for your multi fuel burner, or do you receive it free of charge?

(m) What proportion would be bought?

6. (a) Do you use an open fire (includes a visor fireplace which is one enclosed on three sides but open to the front) in your MAIN living area during a typical year? *(If No then question 7)*

(b) Which months of the year do you use your open fire

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June

☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your open fire during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) Do you use wood on your open fire?

(e) On a typical year, how much wood do you use per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as may to August inclusive

(f) Ask only If they used their open fire during non winter months How much wood do you use per day during the other months?

(g) In a typical year, how much wood would you use per year on your open fire? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

(h) Do you use coal on your open fire?

What type of coal do you use, is it
Boatmans
Burkes Creek
Echo
Giles Creek
Heaphy
Island Block
Reddale
Spring creek
Strongman
Terrace
Don't Know
other (Specify)

(i) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day)____ Interviewer: Winter is defined as may to August inclusive

(j) Ask only If they used their open fire during non winter months How much coal do you use per day during the other months?

(k) Do you buy wood for your open fire, or do you receive it free of charge?

(l) What proportion would be bought?

7. (a) Do you use a pellet burner in your MAIN living area during a typical year? *(If No then question 8)*

(b) Which months of the year do you use your pellet burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your pellet burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your pellet burner?

(e) What make and model is your pellet burner? First, can you tell me the make?

(e) and what model is your pellet burner?

(f) In a typical year, how many kilograms of pellets do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.

(g) Ask only If they used their pellet burner during non winter months How many kgs of pellets do you use per day during the other months? Interviewers note : winter is defined as May to August inclusive.

(h) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?

8. (a) Do you use any other heating system in your MAIN living area during a typical year? *(If No then question 9)*

(b) What type of heating system do you use (if they respond with diesel or oil burner go to question c otherwise go to Q8)

(c) Which months of the year do you use your oil burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How many days per week would you use your diesel/oil burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(e) How much oil do you use per year ?

9. Does you home have insulation?

- ☐ Ceiling
- ☐ Under floor
- ☐ Wall
- ☐ Cylinder wrap
- ☐ Double glazing
- ☐ None
- ☐ Don't know
- ☐ Other

DEMOGRAPHICS We would like to ask some questions about you now, just to make sure we have a cross-section of people for the survey. We keep this information strictly confidential.

D1. Would you mind telling me in what decade/year you were born ?

D2. Which of the following describes you and your household situation?

- ☐ Single person below 40 living alone
- ☐ Single person 40 or older living alone
- ☐ Young couple without children
- ☐ Family with oldest child who is school age or younger
- ☐ Family with an adult child still at home
- ☐ Couple without children at home
- ☐ Flatting together
- ☐ Boarder

D3 With which ethnic group do you most closely relate?

Interviewer: tick gender.

D4 How many people live at your address?

D5 Do you own your home or rent it?

D6 Approximately how old is your home?

D7 How many bedrooms does your home have?

Thank you for your time today. Your answers will be very helpful. In case you missed it, my name is ---------- from DigiPoll in Hamilton. Have a nice day/evening.

Appendix B: Emission factors for domestic heating.

Emission factors for wood burners were based largely on the review of New Zealand emission rates carried out for the Christchurch 1999 emission inventory with adaptations made for different burner age categories and with adjustments made to account for more recent real life testing of pre 1994 and NES compliant wood burners (Wilton & Smith, 2006; Smith, et. al., 2008).

The Christchurch 1999 review resulted in revised factors for open fires burning wood and the burning of coal on open fires and multi fuel burners. The open fire wood emission factor was reduced from 15 g/kg (used in previous inventories) to 10 g/kg. This was based on a combination of overseas literature, in particular the studies by Stern (1992) and Dasch (1982), and the results of a limited number of tests carried out in New Zealand. The New Zealand tests were carried out by Applied Research and gave emission rates of around 7 g/kg.

An emission factor of 21 g/kg was selected for coal burning on an open fire and in a multi fuel burner and was based on the average of the tests carried out in New Zealand, weighted for the more predominant use of bituminous coals, based on the 80% to 20% figures quoted by Hennessy (1999).

The older wood burner emission rates were based on testing of older wood burners “in situ” in Tokoroa during 2005 as detailed in Wilton and Smith, 2006. The burner age category for the latter testing is older (pre 1994) than the category included here (pre 1999). As a result emission factors previously used for pre 1994 burners were adjusted downwards based on the assumption that one third of the burners in this category would be between 1994 and 1999. Previously an emission factor for PM_{10} of 7 g/kg was used for 1994 to 1999 burners. Post 2004 emission factors were based on an emission factor of 3 g/kg based on the results of Smith et. al., 2008. The average of the emission factor for NES compliant burners and older burners of 6 g/kg PM_{10} was used for burners in the age category 1999 to 2004.

The gas and oil PM_{10} emission factors were based on testing in New Zealand (Scott, 2004).

Domestic heating emission factors for CO, NOx, SOx and CO_2 were also based on the Christchurch 1999 emission factor revisions with adjustments made for relationships with PM_{10} where appropriate.