AUGUST 2017

PREPARED FOR

Marlborough District Council

PREPARED BY

Emily Wilton, Environet Ltd

www.environet.co.nz

Air Emission Inventory – Blenheim 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

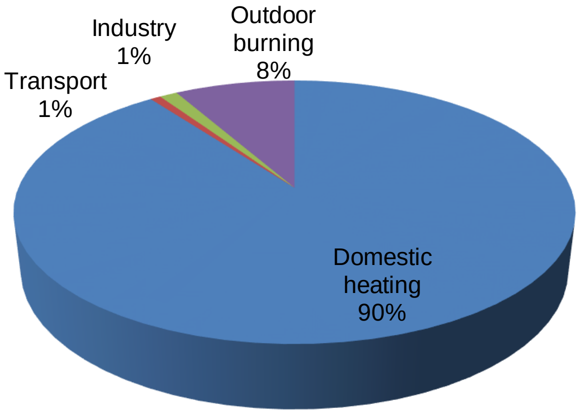
The main air contaminant of concern in Blenheim is PM_{10} (particles in the air less than 10 microns in diameter). The National Environmental Standard (NES) for PM_{10} is currently based on a 24-hour average and is set at 50 µg/m^3 with one allowable exceedance per year. A review of the NES for particulate is underway and a revised focus to annual average $PM_{2.5}$ concentrations is likely.

Blenheim is non-compliant with the current NES for PM_{10} with up to eight exceedences of 50 µg/m^3 recorded per year over the past ten years. From September 2016 Blenheim was required to comply with the NES meaning no more than one exceedance of 50 µg/m^3 per year. During 2017 the number of measured exceedences was 11, the highest number since the NES was introduced. Meteorological conditions typically play a major role in year to year variability in the magnitude of the concentrations and the number of exceedences.

The purpose of this assessment is to estimate the contribution of different sources to emissions to air and evaluate changes in PM_{10} emissions to air in Blenheim over time.

Sources included in the emission inventory are 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. While the evaluation focuses on PM_{10} other contaminants also evaluated include: $PM_{2.5}$ (particles in the air less than 2.5 microns) carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide.

Domestic heating was found to be the main source of daily winter PM_{10} emissions, accounting for 90% of the daily winter PM_{10}. The other main source is outdoor burning which contributes around 8%. On an average winter's night, around 658 kilograms of PM_{10} are discharged from all sources. This compares with around 716 kg/day in Blenheim in 2012 (after adjusting for revised 2012 population) indicating a reduction in PM_{10} emissions of around 8% may have occurred between 2012 and 2017.



1 INTRODUCTION

The main air contaminant of concern in most urban areas of New Zealand is PM_{10}, particles in the air less than 10 microns in diameter. National Environmental Standards (NES) set a limit for PM_{10} of 50 µg/m^3 (24-hour average) with one allowable exceedance per year.

Blenheim is non-compliant with the NES for PM_{10} with up to eight exceedences of 50 µg/m^3 recorded per year over the past ten years. From September 2016 Blenheim was required to comply with the NES meaning no more than one exceedance of 50 µg/m^3 per year. During 2017 the number of measured exceedences of the NES was 11, the highest number since the NES was introduced. Meteorological conditions typically play a major role in year to year variability in the magnitude of the concentrations and the number of exceedences. Air quality monitoring data for Blenheim suggests no significant reductions in PM_{10} concentrations measured at Redwoodtown since 2006.

The purpose of this emission inventory is to evaluate changes in emissions to air for Blenheim and the contribution of different sources to these emissions over time to evaluate the extent of any decrease in emissions. A previous assessment of emissions to air for Blenheim was carried out in 2012.

Sources included in the inventory are domestic heating, motor vehicle, industrial and commercial and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust. This report primarily focuses on emissions of particles (PM_{10}) from these sources. Other contaminants included in this emission inventory are $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter) carbon monoxide, nitrogen oxides, sulphur oxides volatile organic compounds and carbon dioxide.

2 INVENTORY DESIGN

This emission inventory focuses on particulate (PM_{10}) emissions as this, in conjunction with the finer size fraction has been identified as the main contaminant of concern in urban New Zealand. It is unlikely that concentrations of other contaminants are likely to exceed National Environmental Standards (NES).

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}), fine particles ($PM_{2.5}$) 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 NES contaminants because of their potential for adverse health impacts. $PM_{2.5}$ has been included in the inventory because this size fraction may have significance in terms of the current review of the NES. 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 Blenheim 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. It is likely that the inventory does not capture a number of sources of VOCs.

2.3 Selection of areas

The Blenheim inventory study area for 2017 is the inventory area defined by Census Area Units. Figure 2.1 shows that it is closely aligned to the airshed area that is gazetted by the Ministry for the Environment. This is the same area as used for the 2012 and 2005 emission inventories.

The census area units defining the inventory area are: Springlands, Whitney, Redwoodtown, Blenheim Central, Witherlea and Mayfield.

The industrial assessment excludes emissions from TimberLink and Musgroves, as these are located outside the Blenheim airshed and inventory area.

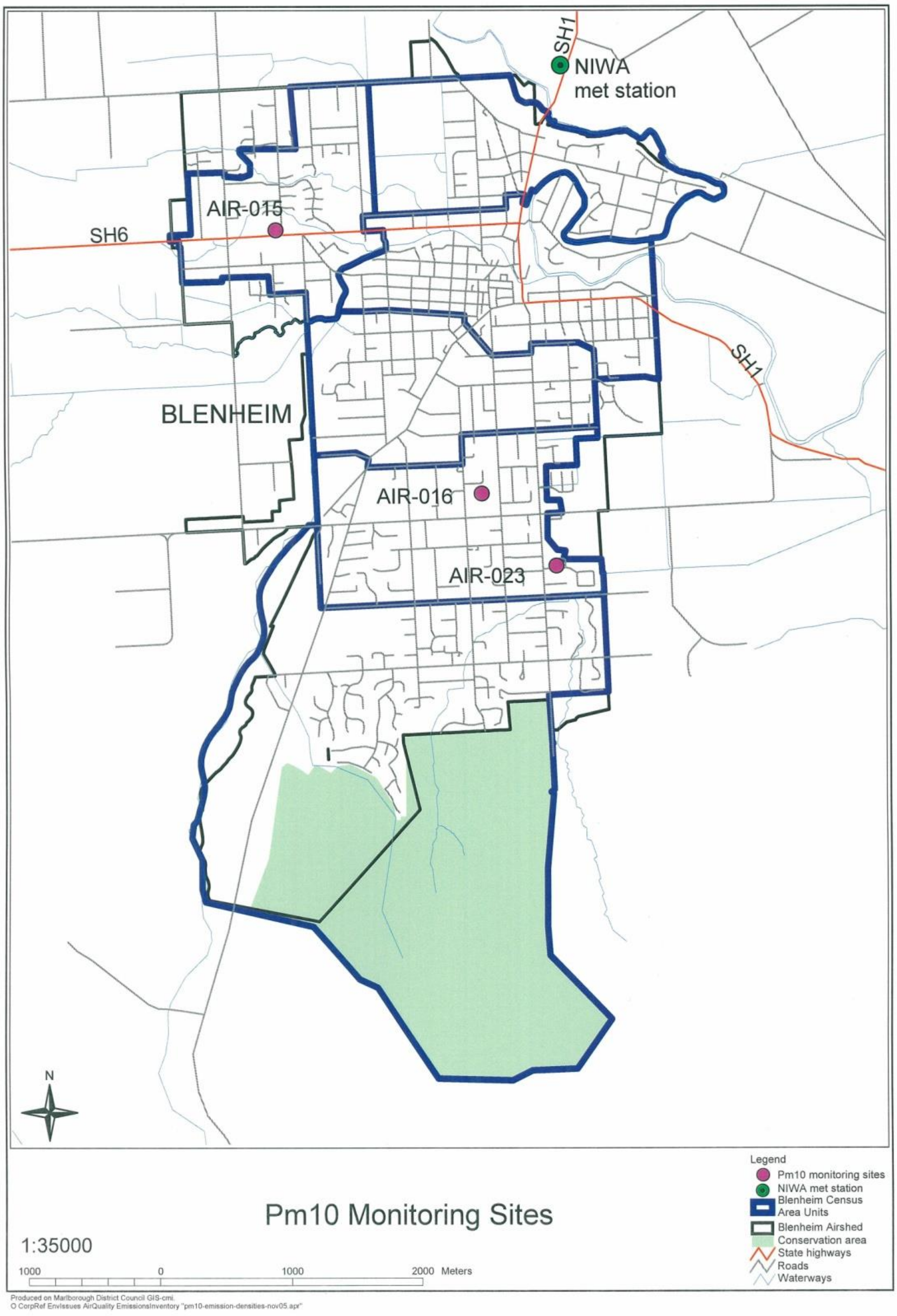


Figure 2.1: Blenheim Airshed and inventory area (source Marlborough District Council).

2.4 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 models do not contain seasonal variations in vehicle movements. Industrial data were collected by season as was outdoor burning data.

No differentiation was made for weekday and weekend sources. Collection of data for time periods of less than a data were not obtained for most data.

3 DOMESTIC HEATING

3.1 Methodology

Domestic heating methods and fuel used by households in Blenheim was collected using a household survey carried out by Versus during June 2017 (Appendix A). Table 3.1 shows the number of households based on 2013 census data and projected population increases for Blenheim.

Table 3.1: Summary household, area and survey data.

	Dwellings in inventory area	Sample size	Area (ha)	Sample error
Blenheim	10221	308	1930	5.5%

Home heating methods were classified as; electricity, open fires, wood burners, pellet fires, multi fuel burners, gas burners and oil burners. Wood burners were surveyed by age and these data were combined with information from the MDC consenting wood burner database and 2013 census information to establish total burner numbers and to classify the burners into pre 2006, 2006-2012 and post 2012 burners.

Emission factors were applied to these data 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	$PM_{2.5}$ g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg	BaP g/kg
Open fire - wood	7.5	7.5	55	1.2	0.2	30	1600	0.002
Open fire - coal	21	18	70	4	8	15	2600	2.70E-06
Pre 2006 burners	10	10	140	0.5	0.2	33	1600	0.003
Post 2006 burners	4.5	4.5	45	0.5	0.2	20	1600	0.003
Pellet burners	2	2	20	0.5	0.2	20	1600	0.003
Multi-fuel[1] - wood	10	10	140	0.5	0.2	20	1600	0.002
Multi-fuel[1] – coal	19	17	110	1.6	8	15	2600	2.70E-06
Oil	0.3	0.22	0.6	2.2	3.8	0.25	3200	
Gas	0.03	0.03	0.18	1.3	7.56E-09		2500	

[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. This was converted into average daily fuel consumption based on an average log weight of 1.6 kg per piece of wood and integrating seasonal and weekly usage rates. The value of 1.6 kg/log was selected as the mid-point of the range found from different New Zealand evaluations (Wilton & Bluett, 2012, Wilton, Smith, Dey, & Webley, 2006, Metcalfe, Sridhar, & Wickham, 2013). The log weight recommended for this work (1.6 kg/ piece) is the midpoint and average of the range of values.

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.

3.2 Home heating methods in Blenheim

The most popular form of heating the main living area of homes in Blenheim is electricity with around 76% of surveyed households using that method. Wood burners are the next most common method. Open fires and multi fuel burners are only used by a very small proportion of households and none of the households surveyed reported using coal. Table 3.3 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 86 tonnes of wood is burnt per typical winter's night in Blenheim. In 2012 the amount of wood used on average per night was around 70 tonnes[1] and around 1.5 tonnes of coal was used per night.

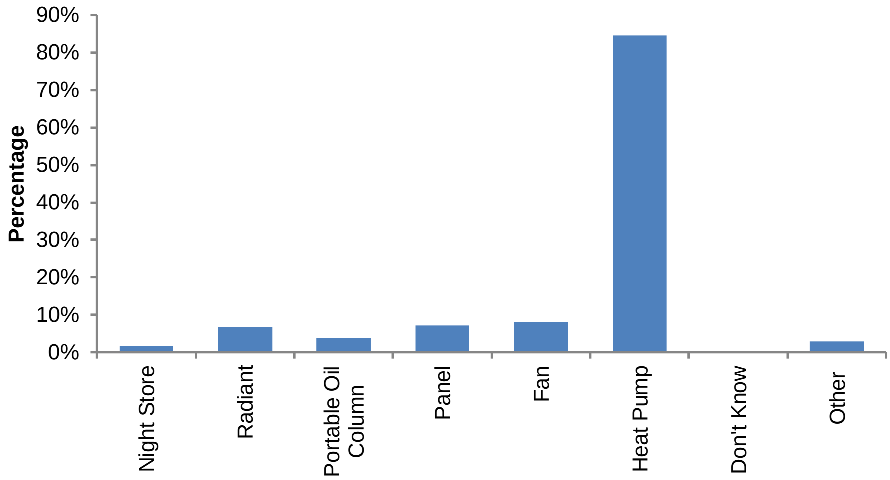


Figure 3.1: Electric heating options for Blenheim households (main living area).

Table 3.3: Home heating methods and fuels.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	76%	7,765		
Total Gas	7%	763		
Flued gas	3%	343		
Unflued gas	4%	420		
Oil	0%	33		
Open fire	1%	66		
Open fire - wood	1%	66	0.3	0%
Open fire - coal	0%	0	0.0	0%
Total Woodburner	43%	4,422	85.0	99%
Pre 2006 wood burner	18%	1,882	36.2	42%
2006-2011 wood burner	12%	1,223	23.5	27%
Post-2011 wood burner	13%	1,316	25.3	29%
Multi-fuel burners	0.3%	33		
Multi-fuel burners-wood	0.3%	33	0.7	1%
Multi-fuel burners-coal	0%	0	0.0	0%
Pellet burners	1%	133		0%
Total wood	44%	4,521	86	100%
Total coal	0%	0	0	0%
Total		10,221	86	100%

3.3 Emissions from domestic heating.

Around 591 kilograms of PM_{10} is discharged on a typical winter's day from domestic home heating in Blenheim. This assumes that all households with burners installed post September 2005 are compliant with models approved as NES compliant burners. These burners have do not allow a reduced oxygen supply to the firebox limiting the ability to shut the burner down to enable an overnight burn.

Figure 3.2 shows that the majority (61%) of the PM_{10} emissions are from pre-2006 wood burners. The NES design criteria for wood burners was mandatory for new installations on properties less than 2 hectares from September 2005. Wood burners installed during the years 2006 to 2011 contribute to 18% of domestic heating PM_{10} emissions and burners less than five years old contribute 19%. Open fires and multi fuel burners contribute around 1% each.

Tables 3.4 and 3.5 show the estimates of emissions for different heating methods under average and worst-case scenarios respectively. Days when households may not be using specific home heating methods are accounted for in the daily winter average emissions[2]. Under the worst-case scenario that all households are using a burner on any given night around 649 kilograms of PM_{10} is likely to be emitted.

The seasonal variation in contaminant emissions is shown in Table 3.6. Figure 3.3 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

[2] Total fuel use per day is adjusted by the average number of days per week wood burners are used (e.g.,6/7) and the proportion of wood burners that are used during July (e.g.,95%).

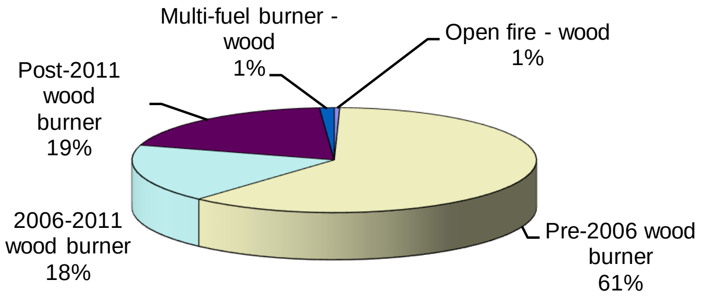


Figure 3.2: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating.

Table 3.4: Blenheim winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	0.3	0%	3	1	0%	19	10	0%	0	0	1%	0	0	0%	10	5	0%	1	0	0%	3	1	0%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood burner	85.0																						
Pre 2006 wood burner	36.2	42%	362	187	61%	5063	2623	69%	18	9	42%	7	4	42%	1193	618	54%	58	30	42%	362	187	61%
2006-2011 wood burner	23.5	27%	106	55	18%	1058	548	14%	12	6	27%	5	2	27%	470	244	21%	38	19	27%	106	55	18%
Post 2011 wood burner	25.3	29%	114	59	19%	1138	590	15%	13	7	29%	5	3	29%	506	262	23%	40	21	29%	114	59	19%
Pellet Burner	0.0	0%	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	0.7	1%	7	4	1%	98	51	1%	0	0	1%	0	0	1%	14	7	1%	1	1	1%	7	4	1%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Gas	0.0	0%	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	0%	0	0	0%
Total Wood	86.0	100%	591	306	100%	7376	3822	100%	43	22	100%	17	9	100%	2194	1137	100%	138	71	100%	591	306	100%
Total Coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total	86		591	306		7376	3822		43	22		17	9		2194	1137		138	71		591	306	

Table 3.5: Blenheim winter daily domestic heating emissions by appliance type (worst case).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	0.8	1%	6	3	1%	44	23	1%	1	0	2%	0	0	1%	24	12	1%	1	1	1%	6	3	1%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood burner	92.9																						
Pre 2006 wood burner	39.5	42%	395	205	61%	5537	2869	69%	20	10	41%	8	4	42%	1305	676	54%	63	33	42%	395	205	61%
2006-2011wood burner	25.7	27%	116	60	18%	1157	600	14%	13	7	27%	5	3	27%	514	266	21%	41	21	27%	116	60	18%
Post 2011 wood burner	27.7	29%	124	65	19%	1245	645	15%	14	7	29%	6	3	29%	553	287	23%	44	23	29%	124	65	19%
Pellet Burner	0.0	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	0.7	1%	7	4	1%	98	51	1%	0	0	1%	0	0	1%	14	7	1%	1	1	1%	7	4	1%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Gas	0.0	0%	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	0%	0	0	0%
Total Wood	94	100%	649	336	100%	8080	4187	100%	48	25	100%	19	10	100%	2411	1249	100%	151	78	100%	649	336	100%
Total Coal	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total	94		649	336		8080	4187		48	25		19	10		2411	1249		151	78		649	336	

Table 3.6: Monthly variations in contaminant emissions from domestic heating in Blenheim.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	$PM_{2.5}$ kg/day
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	6	70	0	0	21	1	6
April	40	498	3	1	151	9	40
May	369	4609	27	11	1368	86	369
June	583	7275	43	17	2167	136	583
July	591	7376	43	17	2194	138	591
August	532	6645	39	15	1972	124	532
September	127	1581	9	4	473	30	127
October	26	322	2	1	96	6	26
November	6	70	0	0	21	1	6
December	2	28	0	0	8	1	2
Total (kg/year)	69971	873242	5126	2037	259774	16295	69971

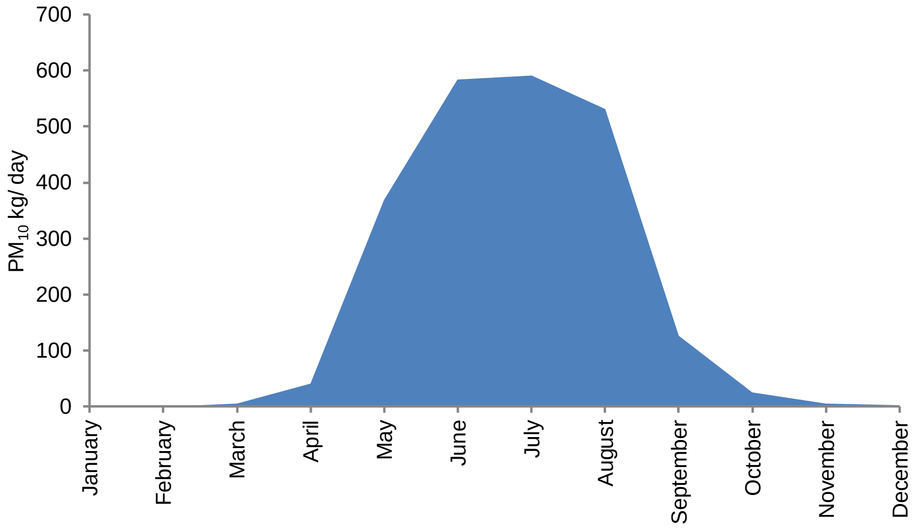


Figure 3.3: Monthly variations in PM_{10} emissions from domestic heating.

4 MOTOR VEHICLES

4.1 Methodology

Motor vehicle emissions to air include tailpipe emissions of a range of 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.

Emission factors for motor vehicles are determined using the Vehicle Emission Prediction Model (VEPM 5.1) developed by Auckland Council. Emission factors for PM_{10}, $PM_{2.5}$, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 5.1. Default settings were used for all variables except for the temperature data and the vehicle fleet profile which was based on Marlborough vehicle registration data for 2016 (Table 4.1). Temperature data were based on a 2016 winter average temperature for Blenheim of 9 degrees. Resulting emission factors are shown in Table 4.2.

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.

The number of vehicle kilometres travelled (VKT) for the airshed was estimated using the New Zealand Transport Authority VKT data for 2013 available at the census area unit level and adjusted downwards based on changes for the region from 2013- 2016[3]. The latter information suggests an 18% decrease in VKT within the Region over this period. No CAU data for VKT were available for more recent years. The impact of changes in VKT along SH1 as a result of the road closure between Kaikoura and Blenheim in 2016 was not accounted for. Table 4.3 estimates the VKT by time of day based on road network model time of day distribution for a similar sized urban area (Taupo).

Table 4.1: Vehicle registrations for the year ending June 2016.

Blenheim	Petrol	Diesel	LPG	Other	Total
Cars	28,260	3,911	7	5	32,183
LCV	1	2,297	0	3	2,301
Bus	0	0			0
HCV		1,116			1,116
Miscellaneous	720	1588	12	2	2,322
Motorcycle	2,163				2,163
Total	31144	8912	19	10	40,085

Table 4.2: Emission factors for Blenheim vehicle fleet (2016).

	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	PM_{10} g/VKT	PM brake & tyre g/VKT	Benzene g/VKT
Blenheim	3.55	225	0.23	0.41	0.019	0.01	0.01

[3] http://www.transport.govt.nz/ourwork/tmif/transport-volume/tv001/

Table 4.3: VKT by time of day for Blenheim.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Blenheim	164567	31909	67856	54914	9889

Emissions for each time period were calculated by multiplying the appropriate average emission factor by the VKT for that time period and level of service.

Emissions (g) = Emission Rate (g/VKT) * VKT

4.2 Motor vehicle emissions

Just under 5 kilograms per day of PM_{10} are estimated to be emitted from motor vehicles daily in Blenheim. The analysis found that around 34% of the PM_{10} from motor vehicles is estimated to occur as a result of the wearing of brakes and tyres. Table 4.4 shows the daily estimates of emissions in Blenheim.

Table 4.4: Summary of daily motor vehicle emissions

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Blenheim	1930	4.7	2.5	584	302	67	35	0.3	0.2
		VOC		CO_2		Benzene		$PM_{2.5}$	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Blenheim	1930	39	20	37	19	2.2	1	5.0	2.6

5 INDUSTRIAL AND COMMERCIAL

5.1 Methodology

Information on activities discharging to air in Blenheim were provided by the Marlborough District Council. Several the activities with current air discharge consents were determined to no longer be in operation in 2012 when the industrial emissions were last assessed. In addition, several industries had changed from the more polluting coal fuel to diesel. Emissions from gas and some diesel boilers were not included in the inventory as the PM_{10} emissions from them are negligible for small to medium size boilers.

The selection of industries for inclusion in this inventory was based on potential for PM_{10} emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily VOCs were not included in the assessment.

For most industries included in the assessment, site specific emissions data was available from the resource consent application. Emissions were estimated based on equation 5.1.

Equation 5.1 Emissions (kg/day) = Emission rate (kg/hr) x hrs per day (hrs)

Where site specific emissions data were not available (for example for contaminants other than PM_{10}), 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 using data contained on resource consent applications or by direct contact with industry.

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. Other emission factors are from the USEPA AP42 database[4].

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	$PM_{2.5}$ g/kg
Coal underfeed	2	5.5	4.8	18 x S*	0.1	2400	1.2
Diesel boiler	0.3	0.67	3.2	0.1	0.2	3194	0.2
Pellet boiler	0.8	6.8	0.8	0.0	0.1	1069	0.7
Crematorium	0.04		0.1				

* where S is the sulphur content of the fuel

[4] http://www.epa.gov/ttn/chief/ap42/index.html

5.2 Industrial and commercial emissions

Table 5.2 shows the estimated emissions to air from industrial and commercial activities in Blenheim. Around eight kilograms is estimated to be discharged to air per winter's day. The assessment excludes a couple of the larger emitters in the area as these are located outside of the Blenheim Airshed. The main source of industrial PM_{10} emissions within the study area is the hospital boiler. Emissions from this source remain relatively unchanged since 2012.

Table 5.2: Summary of industrial emissions (daily winter).

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Blenheim	1930	8	4	22	11	21	11	40	21
		VOC		CO_2		$PM_{2.5}$			
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha		
Blenheim	1930	0	0	11	6	4.9	2.5		

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 notified Marlborough Plan prohibits outdoor burning in Blenheim during the winter months. The plan is not yet operative. However, because outdoor burning is prohibited in a notified plan a resource consent would be required for outdoor rubbish burning until such time as the plan became operative.

6.1 Methodology

Outdoor burning emissions for Blenheim were estimated for the winter months based on data collected during the 2017 domestic home heating survey. The survey showed 5% of households in Blenheim burnt rubbish in the outdoors during the winter.

Emissions were calculated based on the assumption of an average weight of material per burn of 159 kilograms per cubic metre of material[5] and using the emission factors in Table 6.1 with an average fire size of 1.9 m3 (size based on survey responses). The assumption of material density is higher than for previous inventories.

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

[5] Based on the average of low and medium densities for garden vegetation from (Victorian EPA, 2016)

6.2 Outdoor burning emissions

Table 6.2 shows that around 54 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Blenheim. The greater prevalence of burning during the winter months is unusual as typically burning frequency is higher during spring and autumn.

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 on days more suitable for burning. 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. Outdoor burning emissions include a higher degree of uncertainty relative to domestic heating, motor vehicles and industry owing to uncertainties in the distribution of burning and potential variabilities in material density.

Table 6.2: Outdoor burning emission estimates.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	$PM_{2.5}$ kg/day
Summer (Dec-Feb)	13	45	3	1	5	2	13
Autumn (Mar-May)	15	52	4	1	5	2	14
Winter (June-Aug)	54	183	13	2	19	6	51
Spring (Sept-Nov)	21	69	5	1	7	2	19

7 OTHER SOURCES OF EMISSIONS

This inventory includes all likely major sources of PM_{10} 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 of the year include dusts (a portion of which occur in the PM_{10} size fraction) and sea spray. These sources are not typically included because the methodology used to estimate the emissions is less robust.

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 less than one kilogram per day[6].

[6] 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 658 kilograms of PM_{10} is discharged to air in Blenheim on an average winter's day. This compares with an estimated 679 kilograms per day for 2012 indicating a reduction in emissions of less than 5% since 2012.

Figure 8.1 shows that domestic home heating is the main source of PM_{10} emissions contributing 90% of the daily wintertime emissions. Outdoor burning contributes 8%, and industry and transport each 1% of the total wintertime PM_{10} emissions.

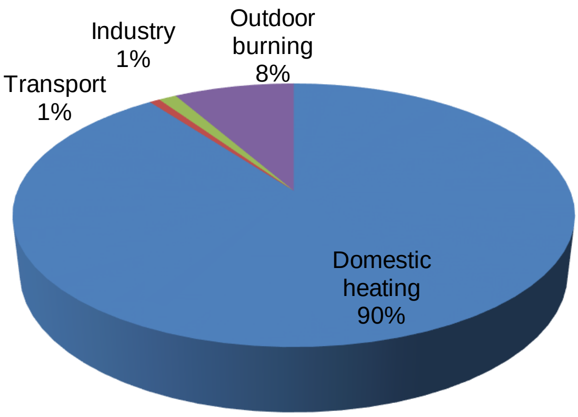


Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions.

Changes in estimated PM_{10} emissions in Blenheim from 2005 to 2017 is illustrated in Figure 8.2. This shows a reduction in emissions of around 21% was anticipated between 2005 and 2012 (after adjusting for population differences[7]) with a further 8% reduction anticipated for the period 2012 – 2017.

[7] The 2012 emission inventory assumed a population for Blenheim inventory area of 9397 based on 2006 census data and Statistics New Zealand population projections for Blenheim of 0.4% per year. The 2013 census indicated a usually resident population for the area of 9939 (6% higher).

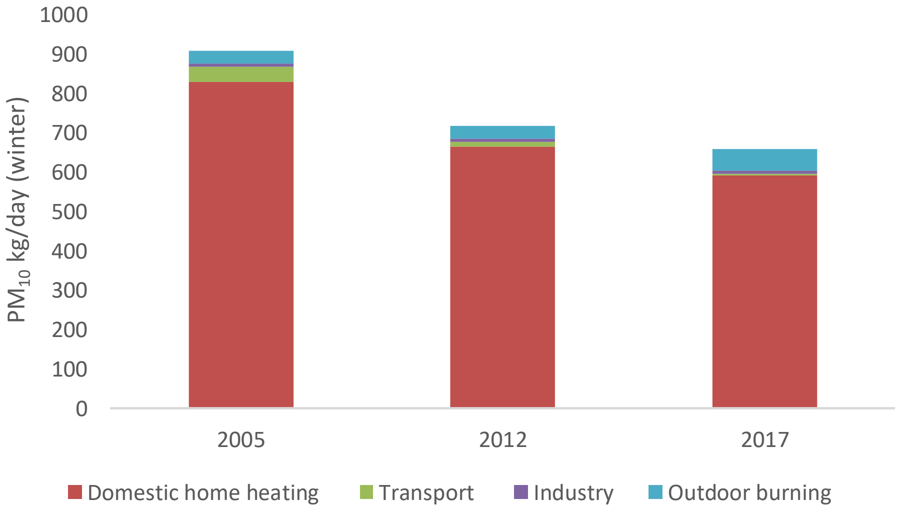


Figure 8.2: Comparison of estimated changes in daily winter PM_{10} emissions from 2012 to 2017.

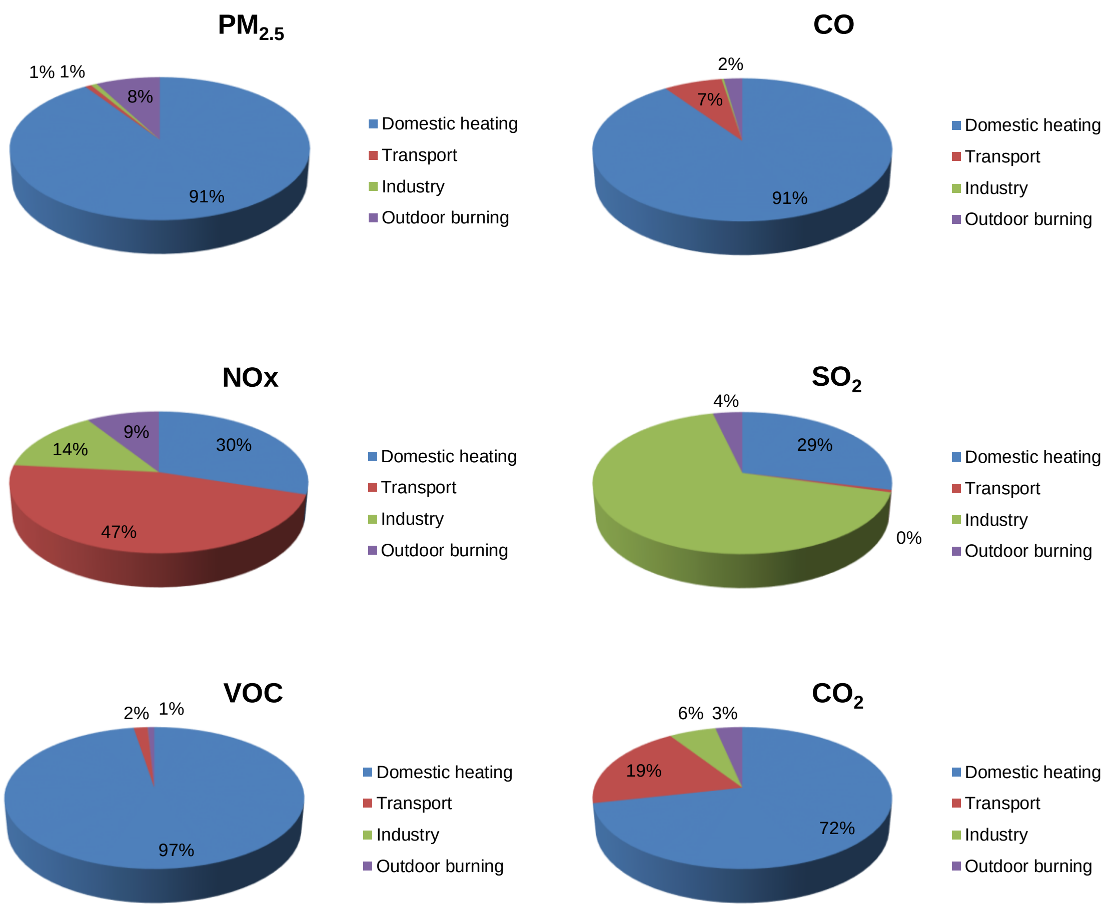


Figure 8.3: Relative contribution of sources to daily winter contaminant emissions.

Domestic home heating is also the main source of daily winter $PM_{2.5}$, CO, VOCs and CO_2, motor vehicles are the main source of daily winter NOx and industry the main source of SOx (Figure 8.3).

Table 8.1 shows seasonal variations in PM_{10} emissions. Although domestic home heating is the dominant source of PM_{10} emissions during the winter months, during the summer, outdoor burning is the main source of PM_{10} emissions. Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.2.

Table 8.1: 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	0	0%	13	60%	4	19%	5	21%	22
February	0	0%	13	59%	5	20%	5	21%	23
March	6	18%	15	50%	5	16%	5	15%	31
April	40	61%	15	23%	5	8%	5	7%	66
May	369	94%	15	4%	5	1%	5	1%	395
June	583	90%	54	8%	8	1%	5	1%	651
July	591	90%	54	8%	8	1%	5	1%	658
August	532	89%	54	9%	8	1%	5	1%	599
September	127	80%	21	13%	6	4%	5	3%	158
October	26	46%	21	36%	5	9%	5	8%	56
November	6	15%	21	57%	5	15%	5	13%	36
December	2	9%	13	55%	4	17%	5	19%	25
Total kg year	69971		9507		2126		1726		

Table 8.2: 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	591	306	7376	3822	43	22	17	9
Transport	5	2	584	302	67	35	0	0
Industry	8	4	22	11	21	11	40	21
Outdoor burning	54	28	183	95	13	7	2	1
Total	658	341	8164	4230	144	75	60	31
	VOC		CO_2		$PM_{2.5}$			
	kg	g/ha	tonnes	kg/ha	kg	g/ha		
Domestic home heating	2194	1137	138	71	591	306		
Transport	39	20	37	19	5	3		
Industry	0	0	11	6	5	3		
Outdoor burning	19	10	6	3	51	26		
Total	2251	1167	192	100	652	338		

REFERENCES

Bluett, J., Smith, J., Wilton, E., & Mallet, T. (2009). Real world emission testing of domestic wood burners. Presented at the 19th International Clean Air and Environment Conference, Perth.

Metcalfe, J., Sridhar, S., & Wickham, L. (2013). Domestic fire emissions 2012: options for meeting the national environmental standard for PM10. Auckland Council technical report, TR 2013/022.

Smith, J., Bluett, J., Wilton, E., & Mallet, T. (2009). In home testing of particulate emissions from NES compliant woodburners: Nelson, Rotorua and Taumaranui 2007. NIWA report number CHC2008-092.

Smith, J., & Wilton, E. (2006). Air Emission Inventory - Matamata, Putaruru and Waihi 2006.

Smithson, J. (2011). *Inventory of emissions to air in Christchurch 2009*. Environment Canterbury Report R11/17.

Stern, C. H., Jaasma, D. R., Shelton, J. W., & Satterfield, G. (1992). Parametric Study of Fireplace Particulate Matter and Carbon Monoxide Emissions. *Journal of the Air & Waste Management Association*, *42*(6), 777–783. http://doi.org/10.1080/10473289.1992.10467029

Victorian EPA. (2016). Waste Materials Density Data. Victorian EPA. Retrieved from http://www.epa.vic.gov.au/business-and-industry/lower-your-impact/~/media/Files/bus/EREP/docs/wastematerials-densities-data.pdf

Wilton, E. (2014). Nelson Air Emission Inventory - 2014. Nelson City Council Technical Report.

Wilton, E. (2016). *Air quality monitoring report for Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge, Morrinsville and Te Awamutu-Kihikihi - 2015*. Environment Waikato Report 2016-5.

Wilton, E., & Bluett, J. (2012). Factors influencing particulate emissions from NES compliant woodburners in Nelson, Rotorua and Taumarunui 2007. NIWA Client Report 2012- 013.

Wilton, E., Smith, J., Dey, K., & Webley, W. (2006). Real life testing of woodburner emissions. *Clean Air and Environmental Quality*, *40*(4), 43–47.

APPENDIX A: HOME HEATING QUESTIONNAIRE

1. I'm _________from and I am calling from Versus Research on behalf Marlborough 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 5-7 minutes depending on your answers. Is it a good time to talk to you now?

Before we start can I please confirm that you live in Blenheim?

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)

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)During the winter, what times of the day do you typically use your log burner

(f) Approximately what time during the evening would you put your last load of wood on the fire?

(g) 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.

(h) 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.

(i) 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)

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

(k) What proportion would be bought?

l) If you placed your hand on your burner first thing in the morning (e.g., 6am-7am) after having used it the night before would it be?

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?

(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?

(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 were based on the review of New Zealand emission rates carried out by Wilton et al., (2015) for the Ministry for the Environments air quality indicators programme. This review evaluated emission factors used by different agencies in New Zealand and where relevant compared these to overseas emission factors and information. Preference was given to New Zealand based data where available including real life testing of pre 1994 and NES compliant wood burners (Wilton & Smith, 2006; Smith, et. al., 2008) and burners meeting the NES design criteria for wood burners (Bluett, Smith, Wilton, & Mallet, 2009; Smith, Bluett, Wilton, & Mallet, 2009).

The PM_{10} open fire emission factor was reduced in the review relative to previous factors. Some very limited New Zealand testing was done on open fires during the late 1990s. Two tests gave emissions of around 7.2 and 7.6 g/kg which at the time was a lot lower than the proposed AP42 emission factors (http://www.rumford.com/ap42firepl.pdf) for open fires and the factors used in New Zealand at the time (15 g/kg). An evaluation of emission factors for the 1999 Christchurch emission inventory revised the open fire emission factor down from 15 g/kg to 10 g/kg based on the testing of Stern, Jaasma, Shelton, & Satterfield, (1992) in conjunction with the results observed for New Zealand (as reported in Wilton, 2014). The proposed AP42 emission factors (11.1 g/kg dry) now suggest that the open fire emission factor may be lower still and closer to the result of the limited testing carried out in New Zealand. Consequently a factor of 7.5 g/kg for PM_{10} (wet weight) is proposed to be used for open fires in New Zealand based on the likelihood of the Stern et al., (1992) data being dry weight (indicating a lower emission factor), the data supporting a proposed revised AP 42 factor and the results of the New Zealand testing being around this value. It is proposed that other contaminant emissions for open fires be based on the proposed AP42 emission factors adjusted for wet weight.

The emission factor for wood use on a multi fuel burner was also reduced from 13 g/kg (used in down to the same value as the pre 2004 wood burner emission factor (10 g/kg). The basis for this was that there was no evidence to suggest that multi fuel burners burning wood will produce more emissions than an older wood burner burning wood.

Emission factors for coal use on a multi fuel burner are based on limited data, mostly local testing. Smithson, (2011) combines these data with some further local testing to give a lower emission factor for coal use on multi fuel burners. While these additional data have not been viewed, and it uncertain whether bituminous and subbituminous coals are considered, the value used by Smithson has been selected. The Smithson, (2011) values for coal burning on a multi fuel burner have also been used for PM_{10}, CO and NOx as it is our view that many of the more polluting older coal burner (such as the Juno) will have been replaced over time with more modern coal burners.

No revision to the coal open fire particulate emission factor was proposed as two evaluations (Smithson, (2011) and Wilton 2002) resulted in the same emission factor using different studies. Emissions of sulphur oxides will vary depending on the sulphur content of the fuel, which will vary by location. A value of 8 g/kg is proposed for SOx based on an assumed average sulphur content of 0.5 g/kg and relationships described in AP42 for handfed coal fired boilers (15.5 x sulphur content).

An emission factor of 0.5 g/kg was proposed for NOx from wood burners based on the AP42 data because the non-catalytic burner measurements were below the detection limit but the catalytic converter estimates (and conventional burner estimates) weren't. This value is half of the catalytic burner NOx estimate.

A ratio of 14 x PM_{10} values was used for CO emission estimates as per the AP42 emissions table for wood stoves. This is selected without reference to any New Zealand data owing to the latter not being in any publically available form.