OCTOBER 2014

PREPARED FOR

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Nelson Air Emission Inventory – 2014

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EXECUTIVE SUMMARY

The main air contaminant of concern in Nelson is PM_{10}, particles in the air less than 10 microns in diameter. PM_{10} concentrations in Nelson have exceeded the National Environmental Standard (NES) of 50 µg/m^3 since monitoring commenced in 2001. The worst PM_{10} concentrations have been measured in Nelsons Airshed A which includes the Nelson South, Washington area. Management measures were introduced via an Air Plan which became operative in 2008. Since then PM_{10} concentrations have decreased significantly, particularly in the Airshed A area.

The purpose of this emission inventory is to evaluate emissions to air for 2014, the contribution of different sources to these emissions and to assess the extent of any change in PM_{10} emissions from anthropogenic sources over time. Sources included in the inventory are domestic heating, motor vehicles and industrial and commercial activities. 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: carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide and benzene.

A domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels and data were combined with census responses for heating methods to provide an indication of changes in heating across Nelson. The results show that electricity is the most common method of heating the main living area with 73% (Airshed A) to 88% (Airshed B2) of households electric heating methods. For these households heat pumps were the most common electric heating option (60% - 80% of households using heat pumps depending on airshed). Wood burners were used by 35% of households in AIrshed A, B1 and 2 and 32% of households in Airshed C. In 2006 the proportions were 38%, 35%, 34% and 37% respectively.

Domestic heating is the main source of anthropogenic PM_{10} emissions in all Airsheds in Nelson accounting for 55% (Airshed B1) to 94% of daily winter emissions. Motor vehicle emissions are minimal at around 2-6% of daily winter PM_{10} emissions. The industrial contribution to PM_{10} emissions was 41% in Airshed B1 (Tahunanui/ Airport) and 2-5% in the other airsheds. On an average winter's night, around 164 kilograms of PM_{10} are discharged from these sources in Airshed A, 159 kg in Airshed B1, 223 kg in Airshed B2 and 186 kg in Airshed C.

A comparison of PM_{10} emissions to previous inventories (after adjusting for differences in methodology) suggests a reduction in anthropogenic PM_{10} emissions of around 56% in Airshed A, 44% in Airshed B1, 39% in Airshed B2 and 46% in Airshed C since 2006. An evaluation of the reductions in PM_{10} concentrations will be carried out in a separate study.

1 INTRODUCTION

The main air contaminant of concern in Nelson is PM_{10}, particles in the air less than 10 microns in diameter. Concentrations of PM_{10} have exceeded the National Environmental Standard (NES) limit of 50 µg/m^3 in Nelson since monitoring commenced in 2001. The worst PM_{10} concentrations have been measured in the Nelson South/ Washington area. In 2001, 81 exceedences of 50 µg/m^3 were recorded and maximum concentrations were around 165 µg/m^3.

The NES for PM_{10} specifies a limit of 50 µg/m^3 for PM_{10}) which can only be exceeded on one occasion per year. The NES was introduced in 2004 (Ministry for Environment, 2004) and took effect from September 2005. Full compliance with the NES is not required in Nelson until September 2020 although concentrations must not exceed 50 µg/m^3 more than three times per year by September 2016.

Nelson City Council carried out scientific studies, including an emission inventory in 2001 and again in 2006 to identify the main sources of PM_{10} in Nelson. The Nelson area was separated into "Airsheds" to ensure that air quality was not over managed in areas that did not warrant it. Four "Airsheds" were identified. Management measures to reduce PM_{10} concentrations were identified and introduced via an Air Plan which became operative in 2008. The Plan included management measures mainly targeting domestic home heating as emission inventories (Wilton & Simpson, 2001) identified domestic burning as the main source of winter time breaches of the NES. The plan aimed to reduce PM_{10} concentrations in Nelson by 70%. The measures included in the Air Plan were:

i. A ban on outdoor rubbish burning from 2004

ii. Emission limits for new installations of solid fuel burners of 1.5 g/kg and an energy efficiency of 65% (when tested to NZS 4013).

iii. A ban on the use of open fires from January 2008.

iv. A ban on the installation of solid fuel burners in new dwellings or existing dwellings using other heating methods from November 2008.

v. Staged phase out of older burners from 2010, 2011 and 2013. The latter phase out date of wood burners installed between 2000 and 2003 was withdrawn following 2011 revisions to the NES.

Significant reductions in PM_{10} concentrations have occurred in Nelson, particularly in the Nelson South Airshed A area. However, it is uncertain whether compliance with the NES will be achieved in all Airsheds within the current management regime. Updating of scientific studies including the emission inventory is required to evaluate the current state of air quality in Nelson.

The purpose of this emission inventory is to evaluate emissions to air for 2014, the contribution of different sources to these emissions and to assess the extent of any change in emissions over time. The sources that are included in emissions inventories in New Zealand are generally domestic heating, motor vehicle, industrial and commercial activities and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust. Outdoor burning is not included in the Nelson 2014 inventory as this activity is prohibited in Nelson.

The method used to estimate the contribution of natural sources to PM_{10} concentrations is referred to as source apportionment or receptor modelling. Ancelet, Davy, & Trompetter, (2013) carried out a source apportionment study for Nelson in 2006 - 2012 which suggests around 15%-20% of the daily winter PM_{10} concentrations on days when concentrations are elevated are from marine aerosol and soil. These sources are not included in the emission inventory assessment but will be included in any subsequent scientific studies which evaluate sources and the effectiveness of management options in improving PM_{10} concentrations should additional measures be required for Nelson.

2 INVENTORY DESIGN

This emission inventory focuses on PM_{10} emissions as PM_{10} 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).

No NES exists for benzo(a)pyrene (BaP). However, concentrations of this contaminant have been found to be high and in excess of ambient air quality guidelines in Christchurch. A strong correlation was found with PM_{10} concentrations, which in Christchurch occur as a result of emissions from domestic home heating, and BaP concentrations (McCauley, 2005). Estimates of BaP are included in the inventory as a contaminant of potential concern for sources for which emission factors are available. The other contaminant of concern in many urban areas of New Zealand including Nelson is arsenic (Ancelet et al., 2013). Arsenic is not included in the emission inventory as the main source is domestic burning of treated timber which is prohibited under the Air Plan.

2.1 Selection of sources

Estimates of emissions from the domestic heating, motor vehicles and industry are included in the emissions inventory. No outdoor burning emissions are estimated as this activity is prohibited in Nelson. 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), carbon dioxide (CO_2), benzene and benzo(a)pyrene (BaP). The latter contaminant has been included here because of the potential issues identified above.

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 Nelson 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

Nelson is located at the centre top of the South Island of New Zealand. It lies on the eastern shores of Tasman Bay and is bounded on the south by the Richmond Ranges. The topography is a largely hills and valleys although the central city area is largely flat as is much of the area to the east leading to the Waimea Plain. The town of Richmond in the Tasman Region also experiences poor air quality and is located close to the suburb of Stoke (Nelsons Airshed B2). The Tahanunui and airport area contains the main industrial area which includes primarily small scale industrial activities with respect to air discharges.

The census area units used in the emission inventory for Nelson are:

- Airshed A: Toi Toi, Broads, Kirks, Bronte, Grampians and part of Britannia Heights

- Airshed B1: Airport, Tahunanui and Tahuna Hills
- Airshed B2: Maitlands, Nayland, Saxton, Langbein, Isel Park, Ngawhatu and Enner Glynn
- Airshed C: Rest of Nelson - Enner Glynn, Tahuna Hills, part of Britannia Heights, The Brook, Atmore, Maitai, Clifton, The Wood, Trafalgar and Port Nelson

Figures 2.1 to 2.3 show the Airshed boundaries for the three Nelson Airsheds including the split of Airshed B into B1 (Tahunanui) and B2 (Stoke).

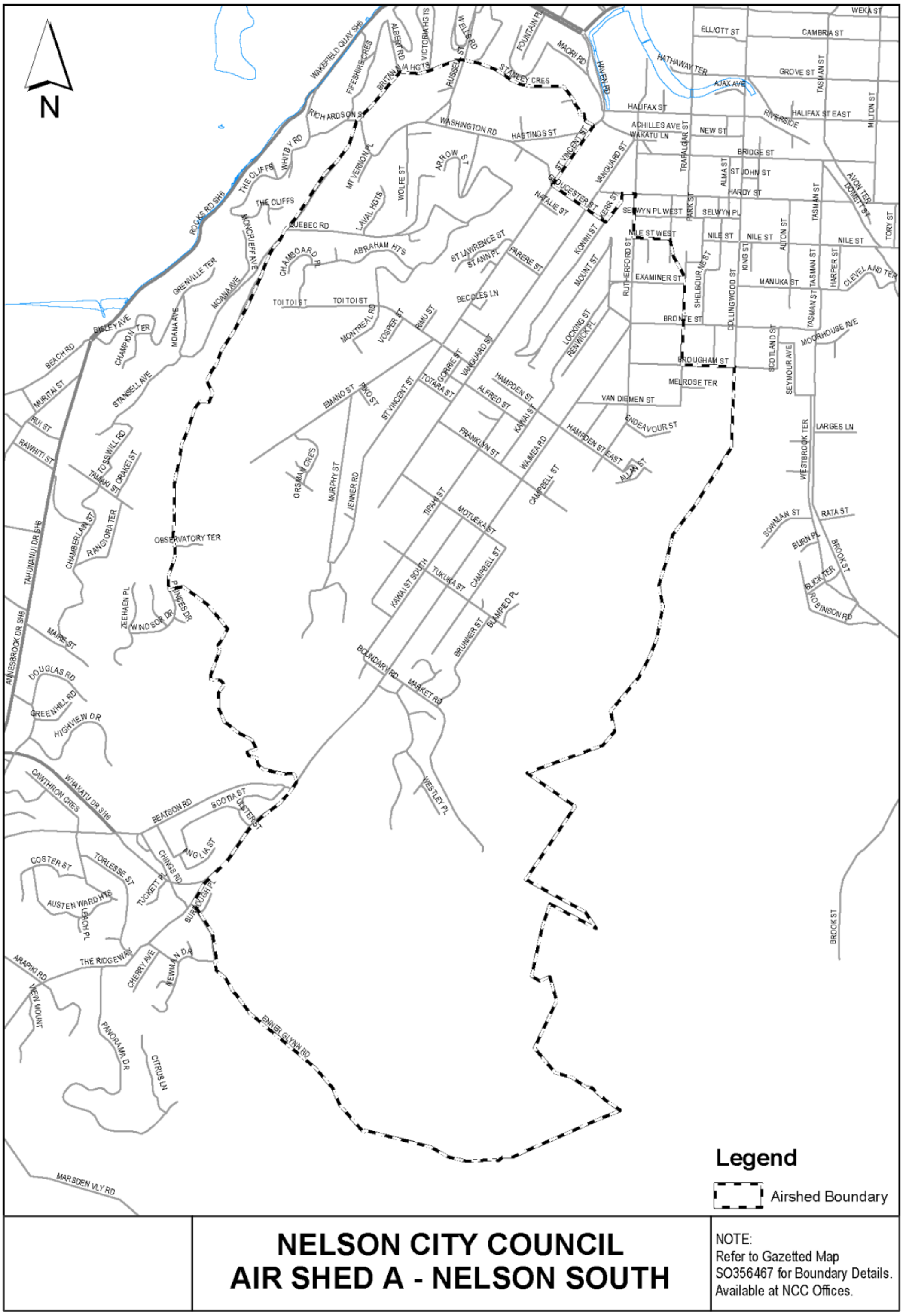

Figure 2-1: Area boundaries for Airshed A (source Nelson City Council).

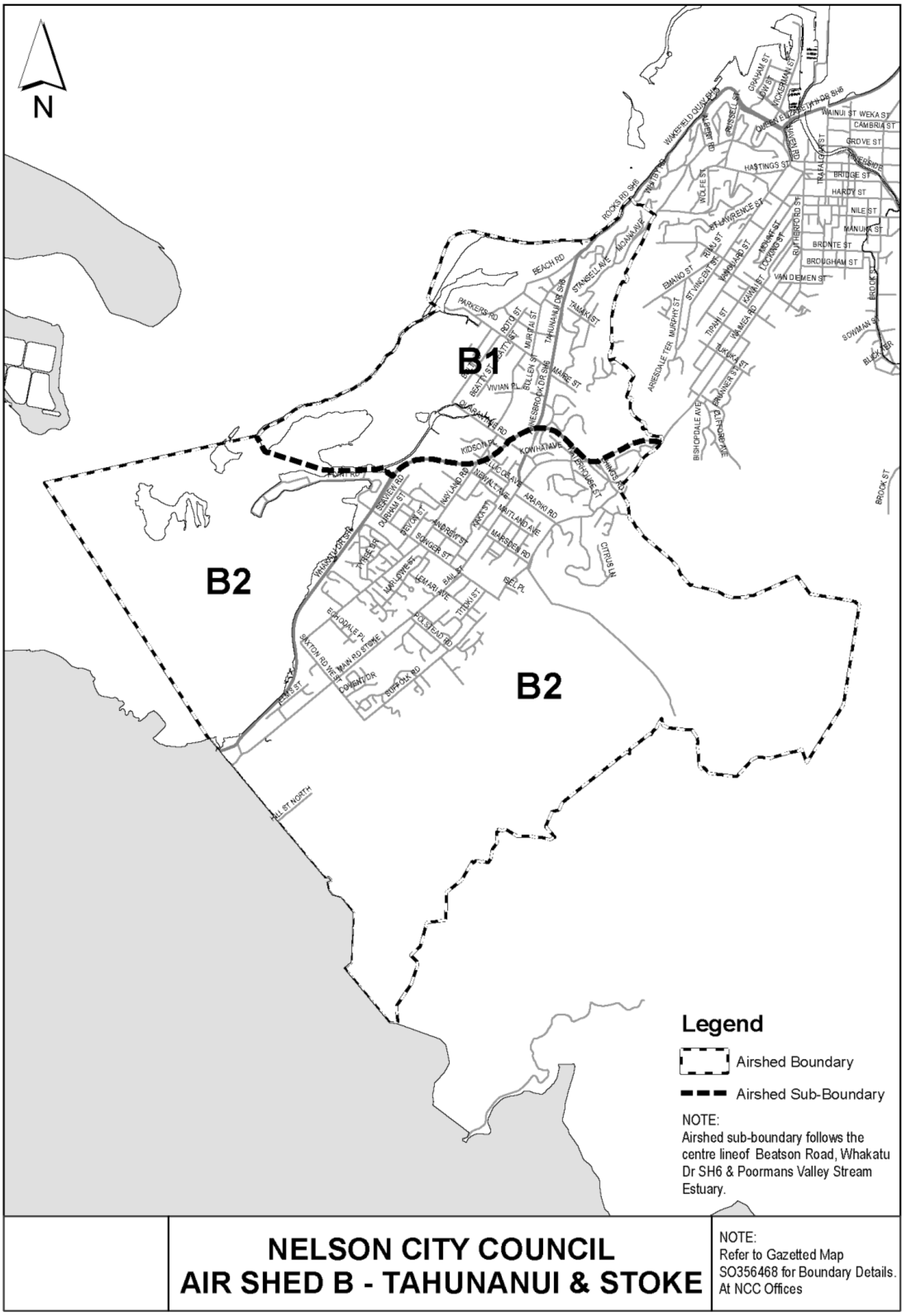

Figure 2-2: Area boundaries for Airshed B (source Nelson City Council).

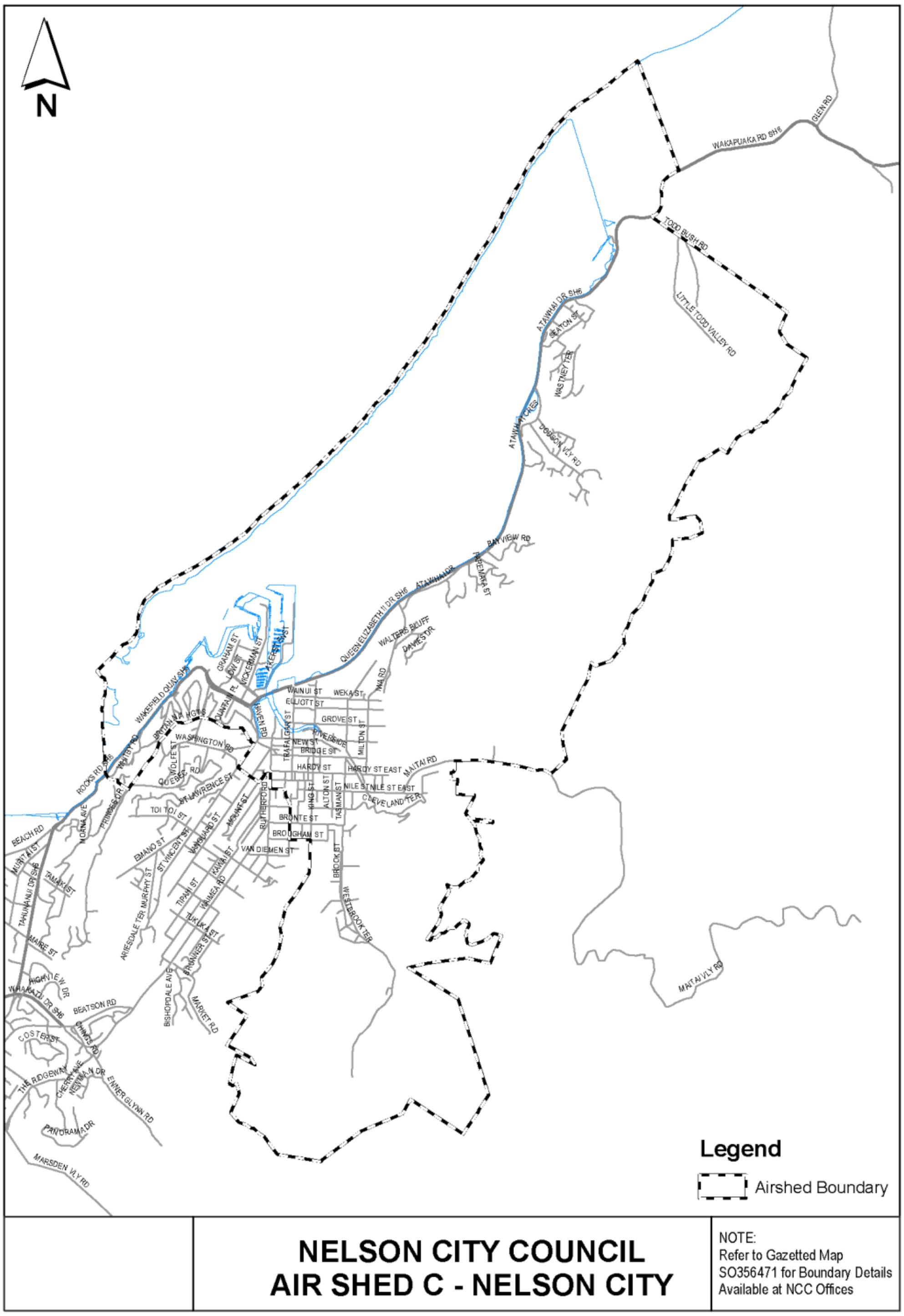

Figure 2-3: Area boundaries for Airshed C (source Nelson City Council).

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. Limited time of day breakdowns were obtained for the data.

3 DOMESTIC HEATING

3.1 Methodology

Domestic heating methods and fuel use used by households in Nelson Airsheds was collected using a household survey carried out by Digipol during July 2014 (Appendix A). Table 3.1 shows the number of households based on 2013 census data for the Airshed area and survey details.

Table 3.1: Summary household, area and survey data for the Nelson Airsheds.

	Households by census area unit 2013	Sample size	Area (ha)	Sample error
Airshed A	4425	320	998	5%
Airshed B1	2259	320	758	5%
Airshed B2	6756	350	2898	5%
Airshed C	4611	347	4662	5%

Home heating methods were classified as; electricity, open fires, wood burners 10 years or older (pre 2004), wood burners five to 10 years old (2005-2009), wood burners less than five years old (post 2009), pellet fires, multi fuel burners, gas burners and oil burners. The post 2005-2009 and post 2009 wood burner categories would contain wood burners meeting the NES design criteria, although the latter was introduced in September 2005 and so the 2005-2009 wood burner category may therefore include some burners installed early 2005 that do not comply with the NES.

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	BaP g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97	0.002
Open fire - coal	21	80	4	5.0	15	2600	0.00065	2.70E-06
Pre 2004 burners	9	90	0.5	0.2	24	1600	0.97	0.003
Post 2004 burners	4.5	45	0.5	0.2	12	1600	0.97	0.003
Pellet burners	2	20	0.5	0.2	12	1600	0.97	0.003
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	0.97	0.002
Multi-fuel[1] – coal	28	120	1.2	3.0	15	2600	0.97	2.70E-06
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 represents the most comprehensive assessment of average fuel weight. A burner emission testing programme carried out in Tokoroa during 2005 gave an average log weight of 1.3 kilograms. A similar study was carried out in Nelson, Rotorua and Taumaranui (Wilton & Bluett, 2012). Results of fuel use from that study indicated an average fuel weight of 1.7 kilograms per log. The previous inventory for Nelson used an average wood weight of 1.9 kilograms per piece of wood.

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 1.7 kilograms.
- The average weight of a bucket of coal is 9 kilograms.

3.2 Home heating methods Airshed A

Electricity is the main heating method in Airshed A with 73% of households using this method to heat their main living area (Table 3.3). Heat pumps were the most common method type of electric heating method being used by 64% of households using electricity (Figure 3.1). Around 8% of households used gas for home heating. No households reported using open fires or 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 30 tonnes of wood is burnt per typical winters night in Airshed A. This compares with around 35 tonnes of wood and one tonne of coal in Airshed A during 2006.

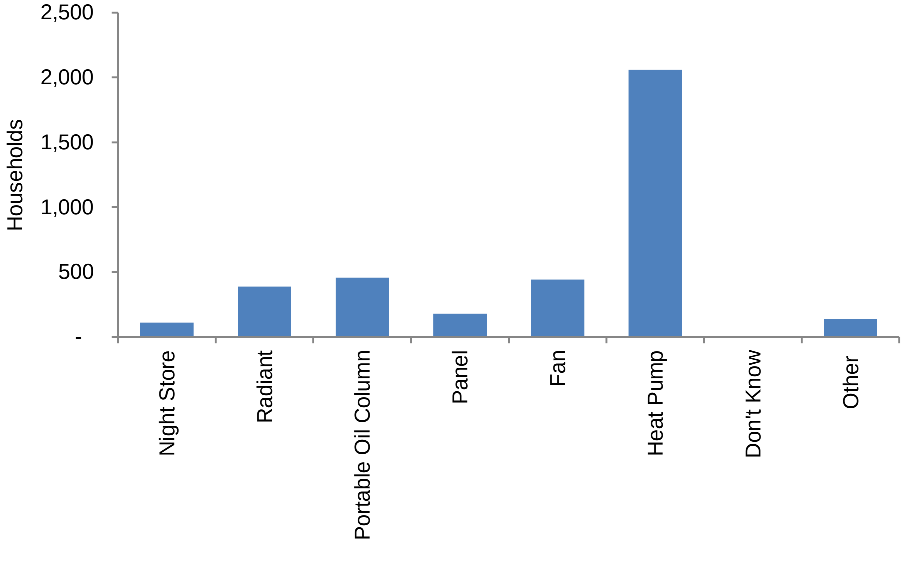

Figure 3-1: Electric heating options for Airshed A households (main living area)

Table 3.3: Home heating methods and fuels in Airshed A.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	73%	3,222		
Total Gas	8%	360	0.1	0%
Flued gas	4%	194		
Unflued gas	4%	166		
Oil	1%	28	0.02	0%
Open fire	0%	0		
Open fire - wood	0%	0	0.0	0%
Open fire - coal	0%	0	0.0	0%
Total Woodburner	35%	1,535	28.2	89%
Pre-2004 wood burner	5%	206	3.8	12%
2005-2009 wood burner	10%	443	8.1	26%
Post-2009 wood burner	20%	886	16.3	51%
Multi-fuel burners	0.3%	14		
Multi-fuel burners-wood	0.3%	14	0.1	0%
Multi-fuel burners-coal	0%	0	0.0	0%
Pellet burners	4%	166	1.7	5%
Total wood	35%	1,549	30	100%
Total coal	0%	0	0	0%
Total		4,425	30	

3.3 Home heating methods Airshed B1

Table 3.4 shows electricity is the main heating method in Airshed B1 with 75% of households using this method to heat their main living area. Heat pumps were the most common method type of electric heating method with 64% of households using electricity using them (Figure 3.2). No households reported using open fires or 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 16 tonnes of wood is burnt per typical winters night in Airsehd B1. This compares with around 19 tonnes of wood and half a tonne of coal in Airshed B1 during 2006.

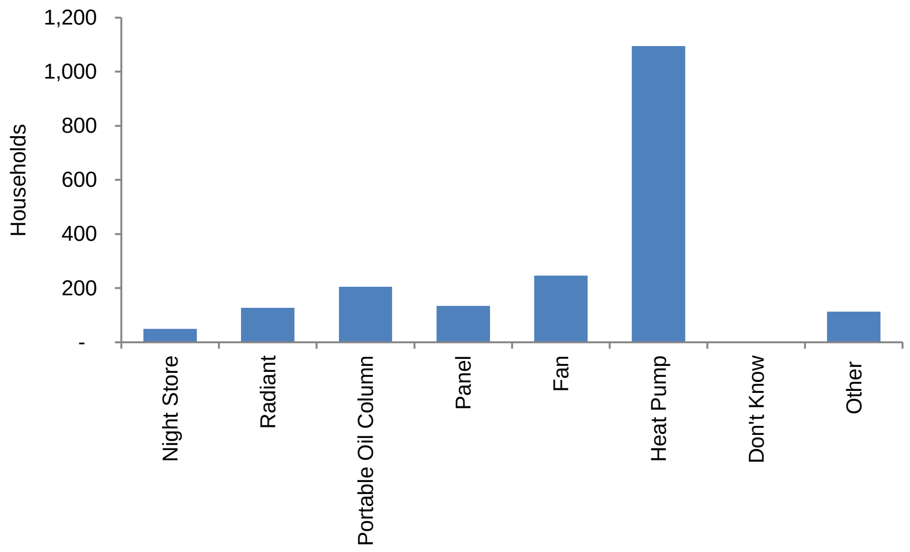

Figure 3-2: Electric heating options for Airshed B1 households (main living area)

Table 3.4: Home heating methods and fuels in Airshed B1.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	75%	1,701		
Total Gas	9%	205	0.1	0%
Flued gas	5%	106		
Unflued gas	4%	99		
Oil	0%	7	0.0	0%
Open fire	0%	0		
Open fire - wood	0%	0	0.0	0%
Open fire - coal	0%	0	0.0	0%
Total Wood burner	35%	791	16.2	97%
Pre-2004 wood burner	5%	116	2.4	14%
2005-2009 wood burner	9%	194	4.0	24%
Post-2009 wood burner	21%	481	9.9	59%
Multi-fuel burners	1%	14		
Multi-fuel burners-wood	1%	14	0.2	1%
Multi-fuel burners-coal	0%	0	0.0	0%
Pellet burners	1%	28	0.3	1.6%
Total wood	36%	805	16	98%
Total coal	0%	0	0	0%
Total		2,259	17	

3.4 Home heating methods Airshed B2

Electricity is the most common heating methods in Airshed B2 with 88% of households using this method (Table 3.5). Heat pumps were the most common method type of electric heating method with 80% of households using electricity using them (Figure 3.3). No households reported using open fires. A small proportion of households reported using coal on a multi-fuel burner. Table 3.5 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 39 tonnes of wood and half a tonne of coal is burnt per typical winters night in Airshed B2. This compares with around 46 tonnes of wood and half a tonne of coal during 2006.

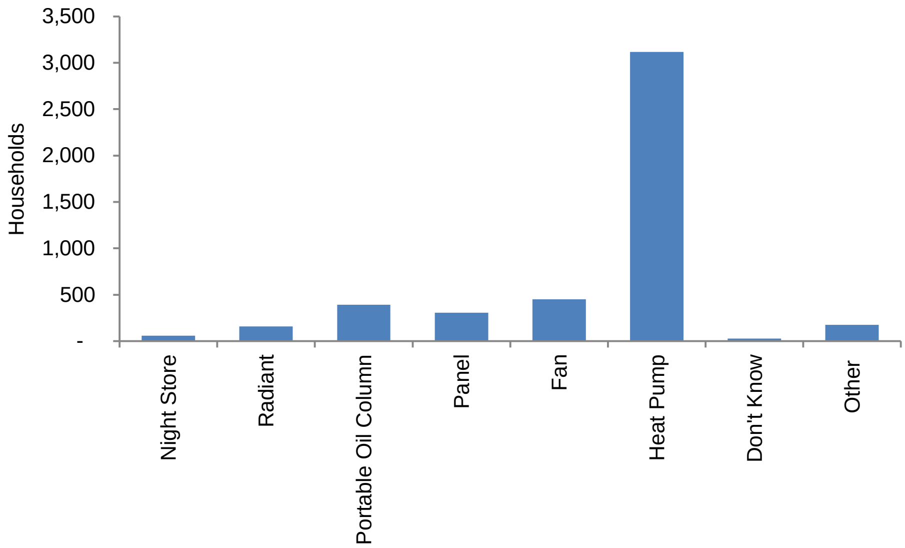

Figure 3-3: Electric heating options for Airshed B2 households (main living area)

Table 3.5: Home heating methods and fuels in Airshed B2.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	117%	5,173		
Total Gas	10%	444	0.2	1%
Flued gas	6%	257		
Unflued gas	4%	187		
Oil	0%	19	0.1	0%
Open fire	0%	0		
Open fire - wood	0%	0	0.0	0%
Open fire - coal	0%	0	0.0	0%
Total Wood burner	46%	2,046	37.9	95%
Pre-2004 wood burner	8%	364	6.7	17%
2005-2009 wood burner	10%	455	8.4	21%
Post-2009 wood burner	28%	1,228	22.7	57%
Multi-fuel burners	1%	39		
Multi-fuel burners-wood	1%	39	0.5	1%
Multi-fuel burners-coal	1%	39	0.5	1%
Pellet burners	2%	97	0.8	1.96%

Total wood	47%	2085	39	98%
Total coal	1%	39	0.5	1%
Total		6,756	40	

3.5 Home heating methods Airshed C

Electricity is the most common heating methods in Airshed C with 83% of households using this method (Table 3.5). Heat pumps were the most common method type of electric heating method and were used by 70% of households using electricity in their main living area (Figure 3.3). No households reported using open fires. Coal was reported to be used in multi fuel burners by 1% of households in Airshed C.

Around 27 tonnes of wood and one tonne of coal are burnt per typical winters night in Airshed C in 2014. This compares with around 33 tonnes of wood and half a tonne of coal during 2006.

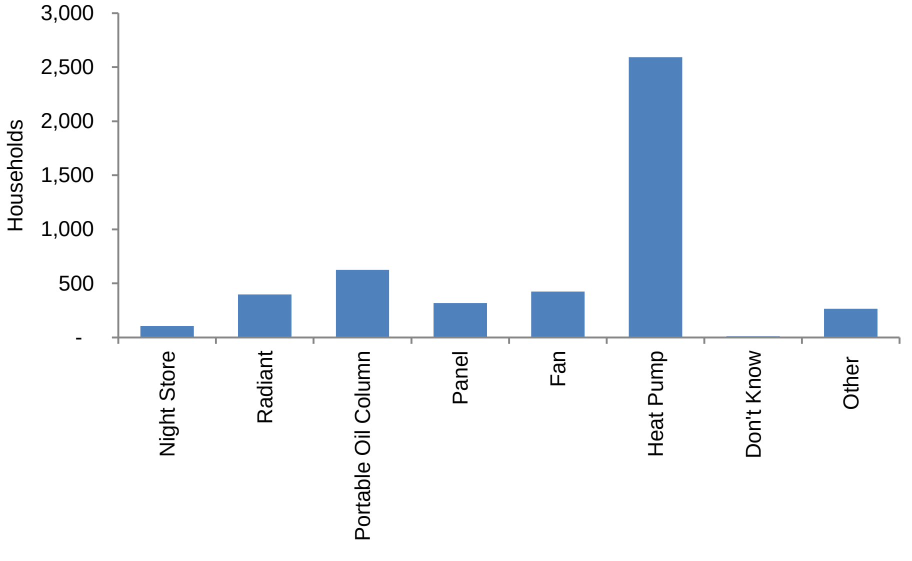

Figure 3-4: Electric heating options for Airshed C households (main living area)

Table 3.6: Home heating methods and fuels in Airshed C.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	83%	3,681		
Total Gas	8%	332	0.6	2%
Flued gas	6%	249		
Unflued gas	2%	83		
Oil	1%	27	0.0	0%
Open fire	0%	0		
Open fire - wood	0%	0	0.0	0%
Open fire - coal	0%	0	0.0	0%
Total Wood burner	32%	1,409	25	92%

Pre-2004 wood burner	14%	618	11	40%
2005-2009 wood burner	10%	464	8	30%
Post-2009 wood burner	7%	326	6	21%
Multi-fuel burners	1%	53		
Multi-fuel burners-wood	1%	27	0	2%
Multi-fuel burners-coal	1%	27	0	1%
Pellet burners	1.2%	53	0.9	3.30%
Total wood	34%	1488	26	97%
Total coal	1%	27	0	1%
Total		4,611	27	

3.6 Emissions from domestic heating Airshed A

Around 149 kilograms of PM_{10} are emitted from domestic home heating in Airshed A on an average winters night (Table 3.7). Days when households may not be using specific home heating methods are accounted for in this method. This may increase to around 168 kilograms if all households are using their wood burners on a given night (Table 3.8).

The majority of the daily PM_{10} emissions from domestic heating during the winter are from post 2009 wood burners because the largest number of dwellings have modern burners (Figure 3.5). Wood burners installed pre 2004 contribute 23% of the daily winter PM_{10} and comprise only 13% of households using wood. Pellet burners contribute around 2% of the daily winter PM_{10} emissions.

The seasonal variation in contaminant emissions is shown in Table 3.9. Figure 3.6 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

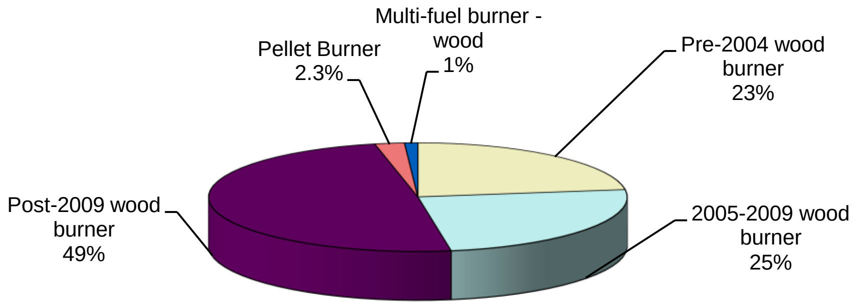

Figure 3-5: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Airshed A.

Table 3.7: Airshed A winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	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%	0.00	0.00	0%
Wood burner	29.9																									
Pre 2004 wood burner	3.8	13%	34	34	23%	416	417	21%	2	2	12%	1	1	12%	125	125	21%	6	6	12%	4	4	13%	0.01	0.01	13%
2005-2009 wood burner	8.1	27%	37	37	25%	570	571	28%	4	4	27%	2	2	27%	171	171	28%	13	13	27%	8	8	27%	0.02	0.02	27%
Post 2009 wood burner	16.3	54%	73	73	49%	978	980	49%	8	8	54%	3	3	54%	293	294	49%	26	26	54%	16	16	54%	0.05	0.05	54%
Pellet Burner	1.7	6%	3.4	3	2%	34	34	2%	1	1	6%	0	0	6%	10	10	2%	3	3	6%	2	2	6%	0.01	0.01	6%
Multi fuel burner																										
Multi fuel– wood	0.1	0%	2	2	1%	15	15	1%	0	0	0%	0	0	0%	5	5	1%	0	0	0%	0	0	0%	0.00	0.00	0%
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%	0.00	0.00	0%
Gas	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0.00	0.00	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	0%
Total Wood	30.0	100%	149	149	100%	2013	2017	100%	15	15	99%	6	6	99%	604	605	100%	48	48	99%	29	29	100%	0.09	0.09	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%	0.0	0.0	0%
Total	30		149	149		2013	2017		15	15		6	6		604	605		48	49		29	29		0.1	0.1	

Table 3.8: Airshed A winter daily domestic heating emissions by appliance type (worst case average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	31.8																									
Pre 2004 wood burner	4.3	12%	38	38	23%	469	470	21%	2	2	12%	1	1	12%	141	141	21%	7	7	12%	4	4	13%	0.0	0.0	13%
2005-2009 wood burner	9.2	27%	41	41	25%	643	644	28%	5	5	27%	2	2	27%	193	193	28%	15	15	27%	9	9	27%	0.0	0.0	27%
Post 2009 wood burner	18.4	54%	83	83	49%	1102	1104	49%	9	9	53%	4	4	53%	331	331	49%	29	29	54%	18	18	54%	0.1	0.1	54%
Pellet Burner	2.1	6%	4	4	3%	42	42	2%	1	1	6%	0	0	6%	13	13	2%	3	3	6%	2	2	6%	0.0	0.0	6%
Multi fuel burner																										
Multi fuel– wood	0.1	0%	2	2	1%	15	15	1%	0	0	0%	0	0	0%	5	5	1%	0	0	0%	0	0	0%	0.0	0.0	0%
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%	0.0	0.0	0%
Gas	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0.0	0.0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	34	100%	168	168	100%	2271	2275	100%	17	17	99%	7	7	99%	681	683	100%	54	55	99%	33	33	100%	0.1	0.1	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%	0.0	0.0	0%
Total	34		168	168		2271	2275		17	17		7	7		681	683		55	55		33	33		0.1	0.1	

Table 3.9: Monthly variations in contaminant emissions from domestic heating in Airshed A.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	6	0	0	2	0	0	0.0
February	0	6	0	0	2	0	0	0.0
March	5	66	0	0	20	2	1	0.0
April	16	216	2	1	65	5	3	0.0
May	74	1006	8	3	302	24	14	0.0
June	138	1875	14	6	562	45	27	0.1
July	149	2013	15	6	604	48	29	0.1
August	134	1812	14	6	543	44	26	0.1
September	60	819	6	2	246	19	12	0.0
October	18	240	2	1	72	6	3	0.0
November	3	36	0	0	11	1	1	0.0
December	1	11	0	0	3	0	0	0.0
Total (kg/year)	18327	248301	1875	752	74490	5968	3594	11

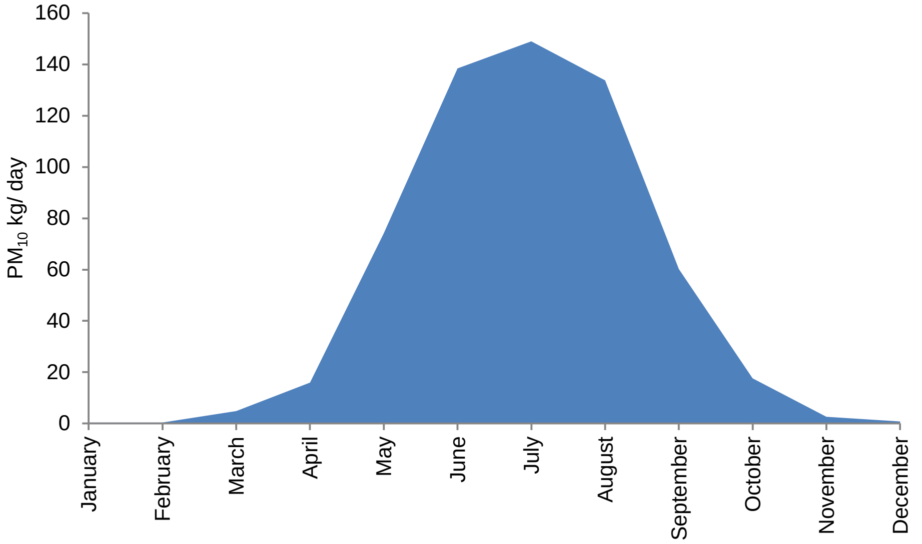

Figure 3-6: Monthly variations in PM_{10} emissions from domestic heating in Airshed A as a proportion of annual emissions.

3.7 Emissions from domestic heating Airshed B1

Around 51% of the daily PM_{10} emissions from domestic heating during the winter are from post 2009 wood burners (Figure 3.1). Wood burners installed during the years 2005 to 2009 contribute to 20% and older wood burners 25% of the daily domestic heating PM_{10} emissions. Multi fuel burners contribute 3% of PM_{10} from domestic home heating and pellet burners one percent in Airshed B1.

Tables 3.10 and 3.11 show the estimates of emissions for different heating methods under average and worst-case scenarios. Average daily wintertime PM_{10} emissions are around 87 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method. Under the worst-case scenario around 91 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night.

The seasonal variation in contaminant emissions is shown in Table 3.12. Figure 3.8 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

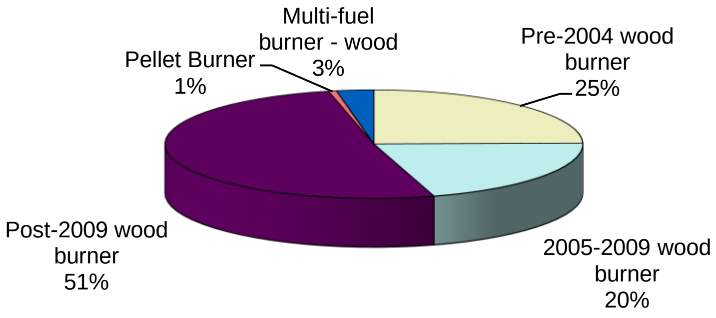

Figure 3-7: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Airshed B1.

Table 3.10: Airshed B1 winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	16.5	98%																								
Pre 2004 wood burner	2.4	14%	21	28	25%	263	346	23%	1	2	14%	0	1	14%	79	104	23%	4	5	14%	2	3	14%	0.0	0.0	14%
2005-2009 wood burner	4.0	24%	18	24	21%	279	367	24%	2	3	24%	1	1	24%	84	110	24%	6	8	24%	4	5	24%	0.0	0.0	24%
Post 2009 wood burner	9.9	59%	44	59	51%	592	781	51%	5	7	58%	2	3	59%	178	234	51%	16	21	59%	10	13	59%	0.0	0.0	59%
Pellet Burner	0.3	2%	0.5	1	1%	5	7	0%	0	0	2%	0	0	2%	2	2	0%	0	1	2%	0	0	2%	0.0	0.0	2%
Multi fuel burner																										
Multi fuel– wood	0.2	1%	2	3	3%	25	33	2%	0	0	1%	0	0	1%	7	10	2%	0	0	1%	0	0	1%	0.0	0.0	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%	0.0	0.0	0%
Gas	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0.0	0.0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	16.7	100%	87	115	100%	1164	1535	100%	8	11	99%	3	4	99%	349	461	100%	27	35	99%	16	21	100%	0.0	0.1	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%	0.0	0.0	0%
Total	17		87	115		1164	1535		8	11		3	4		349	461		27	35		16	21		0.0	0.1	

Table 3.11: Airshed B1 winter daily domestic heating emissions by appliance type (worst case average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	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%	0.00	0.00	0%
Wood burner	16.9	96%																								
Pre 2004 wood burner	2.5	14%	22	30	25%	274	361	23%	1	2	14%	0	1	14%	82	108	23%	4	5	14%	2	3	14%	0.01	0.01	14%
2005-2009 wood burner	4.1	24%	19	25	21%	290	383	24%	2	3	23%	1	1	24%	87	115	24%	7	9	24%	4	5	24%	0.01	0.02	24%
Post 2009 wood burner	10.3	59%	46	61	51%	617	815	51%	5	7	58%	2	3	58%	185	244	51%	16	22	58%	10	13	59%	0.03	0.04	59%
Pellet Burner	0.4	2%	1	1	1%	7	9	1%	0	0	2%	0	0	2%	2	3	1%	1	1	2%	0	0	2%	0.00	0.00	2%
Multi fuel burner																										
Multi fuel– wood	0.2	1%	2	3	3%	25	33	2%	0	0	1%	0	0	1%	7	10	2%	0	0	1%	0	0	1%	0.00	0.00	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%	0.00	0.00	0%
Gas	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0.00	0.00	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	0%
Total Wood	17	100%	91	120	100%	1214	1601	100%	9	12	99%	3	5	99%	364	480	100%	28	37	99%	17	22	100%	0.05	0.07	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%	0.00	0.00	0%
Total	18		91	120		1214	1601		9	12		4	5		364	480		28	37		17	22		0.1	0.1	

Table 3.12: Monthly variations in contaminant emissions from domestic heating in Airshed B1.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	0	0	0	0	0	0	0.00
February	0	0	0	0	0	0	0	0.00
March	0	0	0	0	0	0	0	0.00
April	7	89	1	0	27	2	1	0.00
May	43	573	4	2	172	13	8	0.02
June	80	1077	8	3	323	25	15	0.05
July	87	1164	8	3	349	27	16	0.05
August	78	1048	8	3	314	24	15	0.05
September	26	357	3	1	107	8	5	0.02
October	5	73	1	0	22	2	1	0.00
November	0	6	0	0	2	0	0	0.00
December	0	0	0	0	0	0	0	0.00
Total (kg/year)	10044	134487	970	386	40346	3091	1864	6

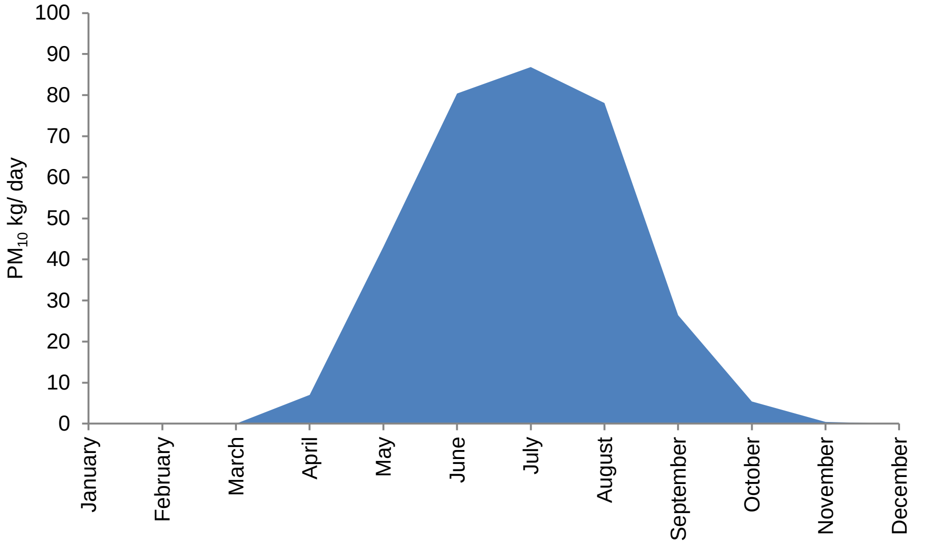

Figure 3-8: Monthly variations in PM_{10} emissions from domestic heating in Airshed B1 as a proportion of annual emissions.

3.8 Emissions from domestic heating Airshed B2

Around 223 kilograms of PM_{10} are emitted from domestic home heating in Airshed B2 on an average winters night (Table 3.13). Days when households may not be using specific home heating methods are accounted for in this method. This may increase to around 239 kilograms if all households are using their wood burners on a given night (Table 3.14).

The majority (46%) of the daily PM_{10} emissions from domestic heating during the winter are from post 2009 wood burners because more dwellings have modern burners (Figure 3.9). Wood burners installed pre 2004 contribute 27% and burners installed between 2005 and 2009 17% of the daily winter PM_{10}. Multi fuel burners burning coal contribute 6% and burning wood 3% of the daily winter PM_{10} emissions.

The seasonal variation in contaminant emissions is shown in Table 3.9. Figure 3.6 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

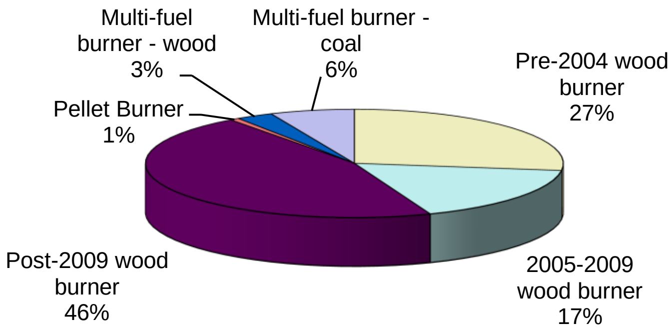

Figure 3-9: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Airshed B2.

Table 3.13: Airshed B2 winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	38.6																									
Pre 2004 wood burner	6.7	17%	61	21	27%	740	256	26%	3	1	16%	1	0	14%	222	77	26%	11	4	17%	7	2	17%	0.0	0.0	17%
2005-2009 wood burner	8.4	21%	38	13	17%	589	203	21%	4	1	20%	2	1	17%	177	61	21%	13	5	21%	8	3	21%	0.0	0.0	22%
Post 2009 wood burner	22.7	57%	102	35	46%	1363	470	48%	11	4	55%	5	2	47%	409	141	49%	36	13	56%	22	8	58%	0.1	0.0	58%
Pellet Burner	0.8	2%	1.6	1	1%	16	5	1%	0	0	2%	0	0	2%	5	2	1%	1	0	2%	1	0	2%	0.0	0.0	2%
Multi fuel burner																										
Multi fuel– wood	0.5	1%	6	2	3%	64	22	2%	0	0	1%	0	0	1%	19	7	2%	1	0	1%	0	0	1%	0.0	0.0	1%
Multi fuel – coal	0.5	1%	15	5	7%	63	22	2%	1	0	3%	2	1	16%	8	3	1%	1	0	2%	0	0	0%	0.0	0.0	0%
Gas	0.2	1%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	1	0	1%	0	0	0%	0.0	0.0	0%
Oil	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	3%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	39.1	98%	209	72	93%	2772	957	98%	20	7	95%	8	3	81%	832	287	99%	63	22	97%	38	13	100%	0.1	0.0	100%
Total Coal	0.5	1%	15	5	7%	63	22	2%	1	0	3%	2	1	16%	8	3	1%	1	0	2%	0	0	0%	0.0	0.0	0%
Total	40		223	77		2835	978		21	7		10	3		839	290		65	22		38	13		0.1	0.0	

Table 3.14: Airshed B2 winter daily domestic heating emissions by appliance type (worst case average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	40.7																									
Pre 2004 wood burner	7.2	17%	65	22	27%	797	275	26%	4	1	16%	1	0	14%	239	82	27%	12	4	17%	7	2	17%	0.0	0.0	17%
2005-2009 wood burner	9.1	21%	41	14	17%	634	219	21%	5	2	20%	2	1	18%	190	66	21%	14	5	21%	9	3	21%	0.0	0.0	22%
Post 2009 wood burner	24.4	57%	110	38	46%	1467	506	48%	12	4	55%	5	2	47%	440	152	49%	39	13	56%	24	8	58%	0.1	0.0	58%
Pellet Burner	0.9	2%	2	1	1%	19	7	1%	0	0	2%	0	0	2%	6	2	1%	2	1	2%	1	0	2%	0.0	0.0	2%
Multi fuel burner																										
Multi fuel– wood	0.5	1%	6	2	3%	64	22	2%	0	0	1%	0	0	1%	19	7	2%	1	0	1%	0	0	1%	0.0	0.0	1%
Multi fuel – coal	0.5	1%	15	5	6%	63	22	2%	1	0	3%	2	1	15%	8	3	1%	1	0	2%	0	0	0%	0.0	0.0	0%
Gas	0.3	1%	0	0	0%	0	0	0%	0	0	2%	0	0	0%	0	0	0%	1	0	1%	0	0	0%	0.0	0.0	0%
Oil	0.08	0%	0	0	0%	0	0	0%	0	0	1%	0	0	3%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	42	98%	224	77	94%	2980	1028	98%	21	7	95%	8	3	82%	894	309	99%	67	23	97%	41	14	100%	0.1	0.0	100%
Total Coal	1	1%	15	5	6%	63	22	2%	1	0	3%	2	1	15%	8	3	1%	1	0	2%	0	0	0%	0.0	0.0	0%
Total	43		239	82		3043	1050		22	8		10	4		902	311		70	24		41	14		0.1	0.0	

Table 3.15: Monthly variations in contaminant emissions from domestic heating in Airshed B2.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	0	0	0	0	0	0	0.0
February	0	0	0	0	0	0	0	0.0
March	0	0	0	0	0	0	0	0.0
April	12	161	1	0	48	4	2	0.0
May	116	1476	11	5	437	33	20	0.1
June	197	2487	18	9	735	57	33	0.1
July	223	2835	21	10	839	65	38	0.1
August	194	2442	18	8	722	56	33	0.1
September	74	881	6	3	256	20	11	0.0
October	13	174	1	0	52	4	2	0.0
November	1	18	0	0	5	0	0	0.0
December	0	0	0	0	0	0	0	0.0
Total (kg/year)	25448	321090	2320	1100	94915	7284	4268	13

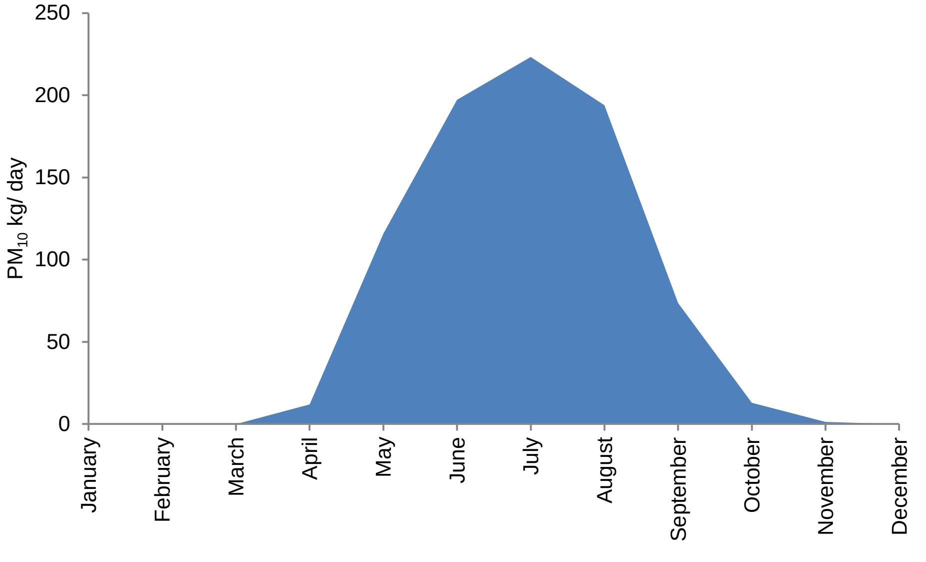

Figure 3-10: Monthly variations in PM_{10} emissions from domestic heating in Airshed B2 as a proportion of annual emissions.

3.9 Emissions from domestic heating Airshed C

Unlike the other three airsheds the main source of PM_{10} is the older pre 2004 wood burners which contribute 56% of daily PM_{10} emissions from domestic heating during the winter (Figure 3.1). This group of burners emit more PM_{10} than modern burners per kilogram of fuel burnt. Other contributors are burners installed from 2005 to 2009 (21%), post 2009 burners (15%) and multi fuel burners (wood 3% and coal 4%).

Tables 3.16 and 3.17 show the estimates of emissions for different heating methods under average and worst-case scenarios. Average daily wintertime PM_{10} emissions are around 174 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method. Under the worst-case scenario around 194 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night.

The seasonal variation in contaminant emissions is shown in Table 3.8. Figure 3.4 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

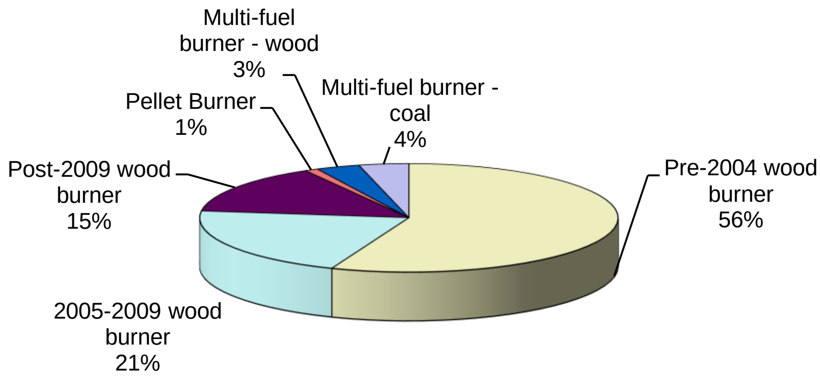

Figure 3-11: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Airshed C.

Table 3.16: Airshed C winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	25.5																									
Pre 2004 wood burner	10.8	40%	97	21	56%	1190	255	54%	5	1	38%	2	0	36%	357	77	54%	17	4	39%	10	2	42%	0.0	0.0	42%
2005-2009 wood burner	8.1	30%	37	8	21%	568	122	26%	4	1	29%	2	0	27%	170	37	26%	13	3	30%	8	2	31%	0.0	0.0	31%
Post 2009 wood burner	5.7	21%	26	6	15%	343	74	16%	3	1	20%	1	0	19%	103	22	16%	9	2	21%	6	1	22%	0.0	0.0	22%
Pellet Burner	0.9	3%	1.8	0	1%	18	4	1%	0	0	3%	0	0	3%	5	1	1%	1	0	3%	1	0	3%	0.0	0.0	3%
Multi fuel burner																										
Multi fuel– wood	0.5	2%	6	1	3%	59	13	3%	0	0	2%	0	0	1%	18	4	3%	1	0	2%	0	0	2%	0.0	0.0	1%
Multi fuel – coal	0.2	1%	7	1	4%	29	6	1%	0	0	2%	1	0	12%	4	1	1%	1	0	1%	0	0	0%	0.0	0.0	0%
Gas	0.6	2%	0	0	0%	0	0	0%	1	0	6%	0	0	0%	0	0	0%	2	0	4%	0	0	0%	0.0	0.0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	2%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	26.0	97%	167	36	96%	2178	467	99%	13	3	92%	5	1	86%	653	140	99%	42	9	95%	25	5	100%	0.1	0.0	100%
Total Coal	0.2	1%	7	1	4%	29	6	1%	0	0	2%	1	0	12%	4	1	1%	1	0	1%	0	0	0%	0.0	0.0	0%
Total	27		174	37		2206	473		14	3		6	1		657	141		44	9		25	5		0.1	0.0	

Table 3.17: Airshed C winter daily domestic heating emissions by appliance type (worst case average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	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%	0.0	0.0	0%
Wood burner	27.7																									
Pre 2004 wood burner	12.1	40%	109	23	56%	1336	287	54%	6	1	38%	2	1	36%	401	86	55%	19	4	40%	12	3	42%	0.0	0.0	42%
2005-2009 wood burner	9.1	30%	41	9	21%	638	137	26%	5	1	29%	2	0	27%	191	41	26%	15	3	30%	9	2	31%	0.0	0.0	32%
Post 2009 wood burner	6.4	21%	29	6	15%	385	83	16%	3	1	20%	1	0	19%	115	25	16%	10	2	21%	6	1	22%	0.0	0.0	22%
Pellet Burner	0.9	3%	2	0	1%	18	4	1%	0	0	3%	0	0	3%	5	1	1%	1	0	3%	1	0	3%	0.0	0.0	3%
Multi fuel burner																										
Multi fuel– wood	0.5	2%	6	1	3%	59	13	2%	0	0	1%	0	0	1%	18	4	2%	1	0	1%	0	0	2%	0.0	0.0	1%
Multi fuel – coal	0.2	1%	7	1	3%	29	6	1%	0	0	2%	1	0	11%	4	1	0%	1	0	1%	0	0	0%	0.0	0.0	0%
Gas	0.8	3%	0	0	0%	0	0	0%	1	0	7%	0	0	0%	0	0	0%	2	0	4%	0	0	0%	0.0	0.0	0%
Oil	0.04	0%	0	0	0%	0	0	0%	0	0	1%	0	0	2%	0	0	0%	0	0	0%	0	0	0%	0.0	0.0	0%
Total Wood	29	96%	187	40	97%	2435	522	99%	15	3	91%	6	1	87%	731	157	100%	46	10	94%	28	6	100%	0.1	0.0	100%
Total Coal	0	1%	7	1	3%	29	6	1%	0	0	2%	1	0	11%	4	1	0%	1	0	1%	0	0	0%	0.0	0.0	0%
Total	30		194	42		2464	529		16	3		7	1		734	157		49	11		28	6		0.1	0.0	

Table 3.18: Monthly variations in contaminant emissions from domestic heating in Airshed C.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	0	0	0	0	0	0	0.0
February	0	0	0	0	0	0	0	0.0
March	0	0	0	0	0	0	0	0.0
April	14	185	1	0	55	3	2	0.0
May	84	1066	7	3	317	21	12	0.0
June	150	1890	12	5	562	37	21	0.1
July	174	2206	14	6	657	44	25	0.1
August	159	2013	13	6	599	40	23	0.1
September	52	681	4	2	204	13	8	0.0
October	13	169	1	0	51	3	2	0.0
November	2	26	0	0	8	1	0	0.0
December	0	5	0	0	2	0	0	0.0
Total (kg/year)	19863	252681	1596	680	75278	4968	2877	9

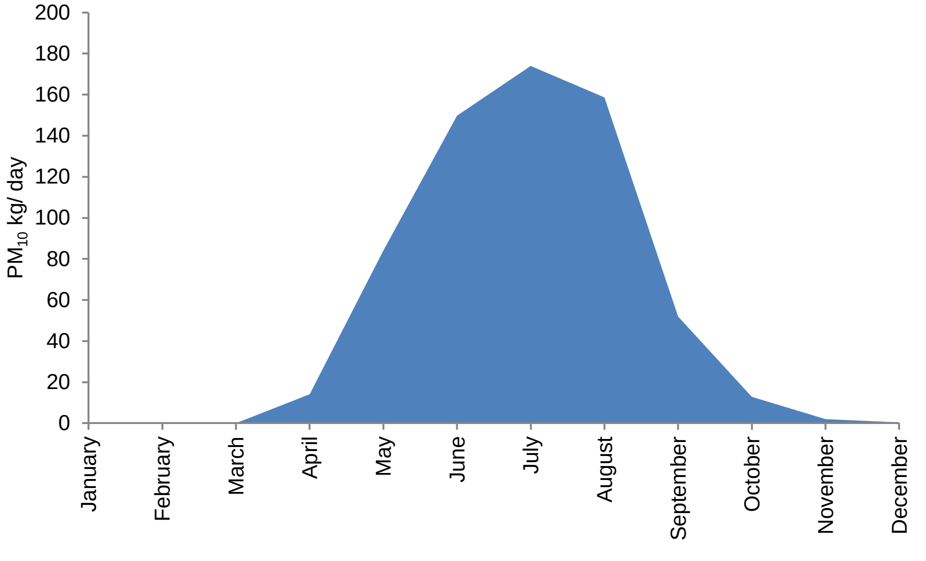

Figure 3-12: Monthly variations in PM_{10} emissions from domestic heating in Airshed C as a proportion of annual emissions.

4 TRANSPORT

4.1 Methodology

Motor vehicle emissions to air include tailpipe emissions 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. Default settings were used for all variables except for the vehicle fleet profile which was based on Nelson vehicle registration data for the year ending 31 May 2014 and the annual average temperature was based on temperature data for Nelson. An average vehicle speed of 42 kilometres per hour was assumed for the derivation of emission factors. 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. No emission factors for benzo(a)pyrene (BaP) were available for motor vehicle emissions for New Zealand.

The number of vehicle kilometres travelled (VKT) for the airshed was estimated using the New Zealand Transport Authority (NZTA) VKT data for 2013 available at the census area unit level. Previously road networking modelling carried out by Gabites Porter was used for VKT estimates for Nelson. The use of NZTA VKT data was considered the best available information for this purpose by Nelson City Council Transport staff. Table 4.4 shows the estimated VKTs distributed by time of day splits from the 2006 Gabites Porter transport model (Table 4.3).

Table 4.1: Vehicle registrations in Nelson for the year ending May 2014.

	Petrol	Diesel	LPG	Other	Total
Cars	29,703	2,986	5	1	32,695
LCV	1,778	2,837	5	0	4,620
Bus	36	246			282
HCV		2,242			2,242
Miscellaneous	867	408	21	0	1,296
Motorcycle	2,190				2,190
Total	34574	8719	31	1	43,325

Table 4.2: Emission factors for 2014 for Nelson vehicle fleet

Driving Conditions	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
Nelson	4.6	240	0.279	0.631	0.029	0.010	0.015

Table 4.3: VKT apportionment by time of day for Nelson (based on 2006 Gabites Porter model output).

	Time of day			
	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Airshed A	24%	39%	32%	6%
Airshed B1	24%	40%	31%	6%
Airshed B2	24%	39%	32%	6%
Airshed C	23%	40%	31%	6%

Table 4.4: VKT by time of day for Nelson for 2013.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Airshed A	183294	43538	71153	58011	10592
Airshed B1	101780	23999	40324	31695	5762
Airshed B2	263152	63370	101711	83060	15013
Airshed C	194365	45021	77782	60676	10885

Table 4.5: VKT data for 2006, 2010 and 2013.

	Gabites Porter model	VKT (NZTA data based on CAU)		
	2006	2006	2010	2013
Airshed A	224,959	179297	195174	183294
Airshed B1	191,046	95211	96178	101780
Airshed B2	358,738	253276	283819	263152
Airshed C	357,668	214864	216992	194365

Table 4.5 shows the change in VKTs by airshed since 2006 based on the New Zealand Transport Authority (NZTA) VKT data. A comparison of the 2006 NZTA data to the Gabites Porter data used in the 2006 inventory suggests a discrepancy in Airsheds B1, B2 and C VKTs with the model data overestimating relative

to the NZTA data. The NZTA data suggests no real changes in VKTs in Nelson since 2006 with the exception of a slight decrease in Airshed C.

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

Around seven kilograms per day of PM_{10} are estimated to occur from motor vehicle emissions in Airshed A, four in Airshed B1, 10 in Airshed B2 and eight in Airshed C. This compares with around 27 kilograms per day in Airshed A in the 2006 emission inventory and 23 kg, 42 kg and 41 kg in Airsheds B1, B2 and C respectively. The main cause of the difference is improved tailpipe emissions as well as an overestimate of VKTs for airsheds B1, B2 and C from the Gabites Porter model for 2006. Around 26% of the PM_{10} from motor vehicles is estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles for Airshed A include around 983 kilograms of CO, 136 kilograms of NOx and three kilograms of benzene (Table 4.5).

Table 4.6: Summary of daily motor vehicle emissions in Nelson

		PM10		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Airshed A	998	7	7	835	836	116	116	0	0
Airshed B1	758	4	5	463	611	64	85	0	0
Airshed B2	2898	10	10	1198	413	166	57	1	0
Airshed C	4662	8	16	885	304	123	42	0	0
		VOC		CO_2		Benzene			
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha		
Airshed A	998	51	51	44	44	3	3		
Airshed B1	758	28	37	24	32	2	2		
Airshed B2	2898	73	25	63	22	4	4		
Airshed C	4662	54	19	29	10	3	3		

5 INDUSTRIAL AND COMMERCIAL

5.1 Methodology

Identification of industrial or commercial activities discharging to air in Nelson was based on a combination of data including the current resource consent database, evaluation of the 2006 air emission inventory industry sources and information provided by Nelson City Council on new small scale activities found through a drive by in new industrial and commercial areas.

Schools in Nelson were also surveyed to determine the source of their heating and those using wood or coal for heating fuels were included in the inventory. Emissions from gas and diesel boilers were not included in the inventory as the PM_{10} emissions from them are negligible for small to medium size boilers. Twenty six industrial and commercial premises were included in the inventory with five in airshed A, 10 in Airshed B1, six in Airshed B2 and five in Airshed C.

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 a few industries included in the assessment site specific emissions data was available from the resource consent application or other Council records. In these cases 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, 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 a phone and email survey. Data were collected for winter, autumn, spring and summer.

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 & Baynes, (2010). Other emission factors are from the USEPA AP42 database1.

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
Boiler with bag filter	0.47	3	3.8	18.0	0.1	2400
Wood boiler	1.6	6.8	0.8	0.0	0.1	1069
LFO Boiler	1.3	0.67	6.3	40.0	0.2	3194
Pellet boiler	0.8	6.8	0.8	0.0	0.1	1069
Diesel boiler	0.3	0.67	3.2	0.1	0.2	3194
Meat smoking	26					
Abrasive blasting	0.69					

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

Waste oil	1.40	0.7	2.7	0.02	0.14	3105
Concrete batching	0.003					
Foundry – steel electric	0.05					

5.2 Industrial and commercial emissions

The main area with significant industrial activities with discharges to air of PM_{10} is Airshed B1 (Table 5.2). In this area winter daily PM_{10} emissions have decreased since 2006 by around 19 kilograms per day (23%). Airshed A, B2 and C all emitted around nine kilograms of PM_{10} to air in 2006. Table 5.2 shows a reduction in PM_{10} emissions in these areas with Airshed A and B2 emissions at around eight kilograms per day and Airshed C emissions decreasing to five kilograms a day.

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

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Airshed A	998	9	9	58	58	33	33	142	143
Airshed B1	758	65	85	483	637	961	1267	12	16
Airshed B2	2898	8	3	11	4	27	9	35	12
Airshed C	4662	5	1	0	0	4	1	24	5

		VOC		CO2		BaP	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha
Airshed A	998	1	1	24	24	0.01	0
Airshed B1	758	54	71	1111	1466	0.00	0
Airshed B2	2898	1	0	15	5	0.00	0
Airshed C	4662	0	0	2	0	0.00	0

6 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 during the year include airport emissions (from take-off and landing cycles), dusts (a portion of which occur in the PM_{10} size fraction) and sea spray.

A previous estimate (Wilton & Simpson, 2001) of PM_{10} emissions from aircraft in the Tahunanui area estimated around 40 kilograms per day from this source may occur, although there was a high degree of uncertainty relating to emissions data used to derive this estimate2. It is likely that only a small proportion of this would be emitted at a height that may impact on ground level concentrations of PM_{10}. For the purposes of this assessment, a value of 4 kilograms per day has been assumed. Shipping emissions are unlikely to be a significant contributor to PM10 concentrations measured in Nelson.

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[3].

[2] . The estimate is based on aircraft larger than those that frequent the Nelson airport and is likely to over-represent potential emissions from this source.

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

7 TOTAL EMISSIONS

7.1 Total emission Airshed A

Around 164 kilograms of PM_{10} is discharged to air in Airshed A on an average winter's day. This compares with an estimated 373 kilograms per day for 2006 (once adjusting for slight changes in methodology) indicating a reduction in emissions of around 56% since 2006 and 68% since 2001 (Figure 7.1). Figure 7.2 shows that domestic home heating is the main source of PM_{10} emissions contributing 91% of the daily wintertime emissions. Transport contributes four percent and industry five percent to total daily wintertime PM_{10} emissions.

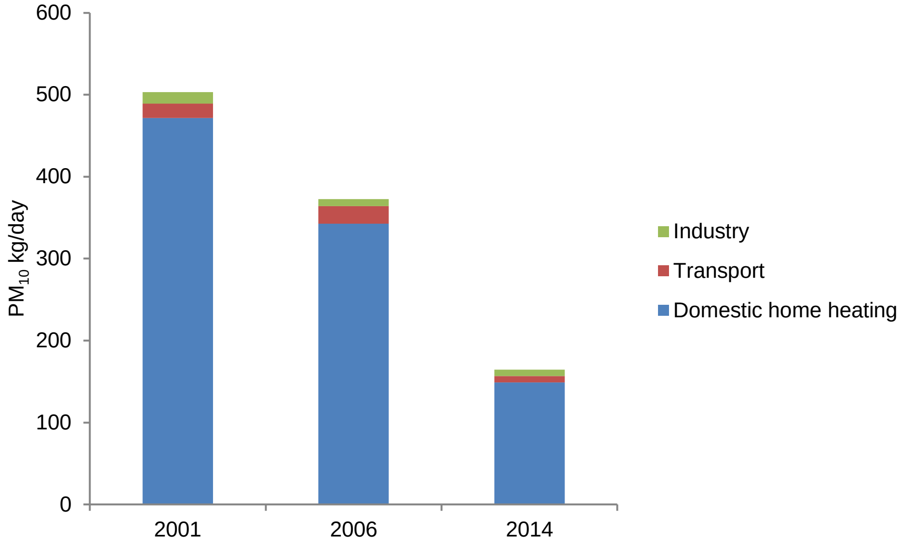

Figure 7-1: Comparison of estimated changes in PM_{10} emissions in Airshed A from 2006 to 2014

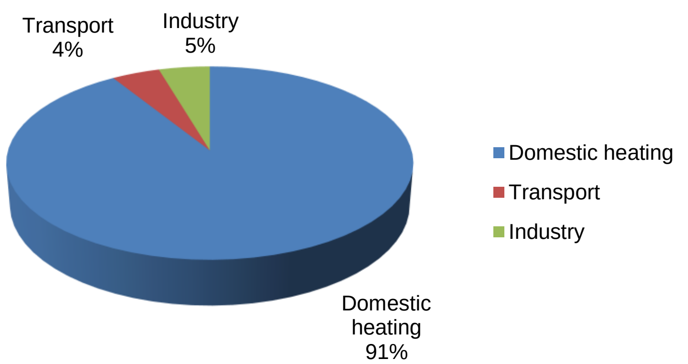

Figure 7-2: Relative contribution of sources to daily winter PM_{10} emissions in Airshed A.

Domestic home heating is also the main source of CO, and VOCs in Airshed A. Motor vehicles are the main source of NOx and industry is the main source of SO_2 (Figure 7.3).

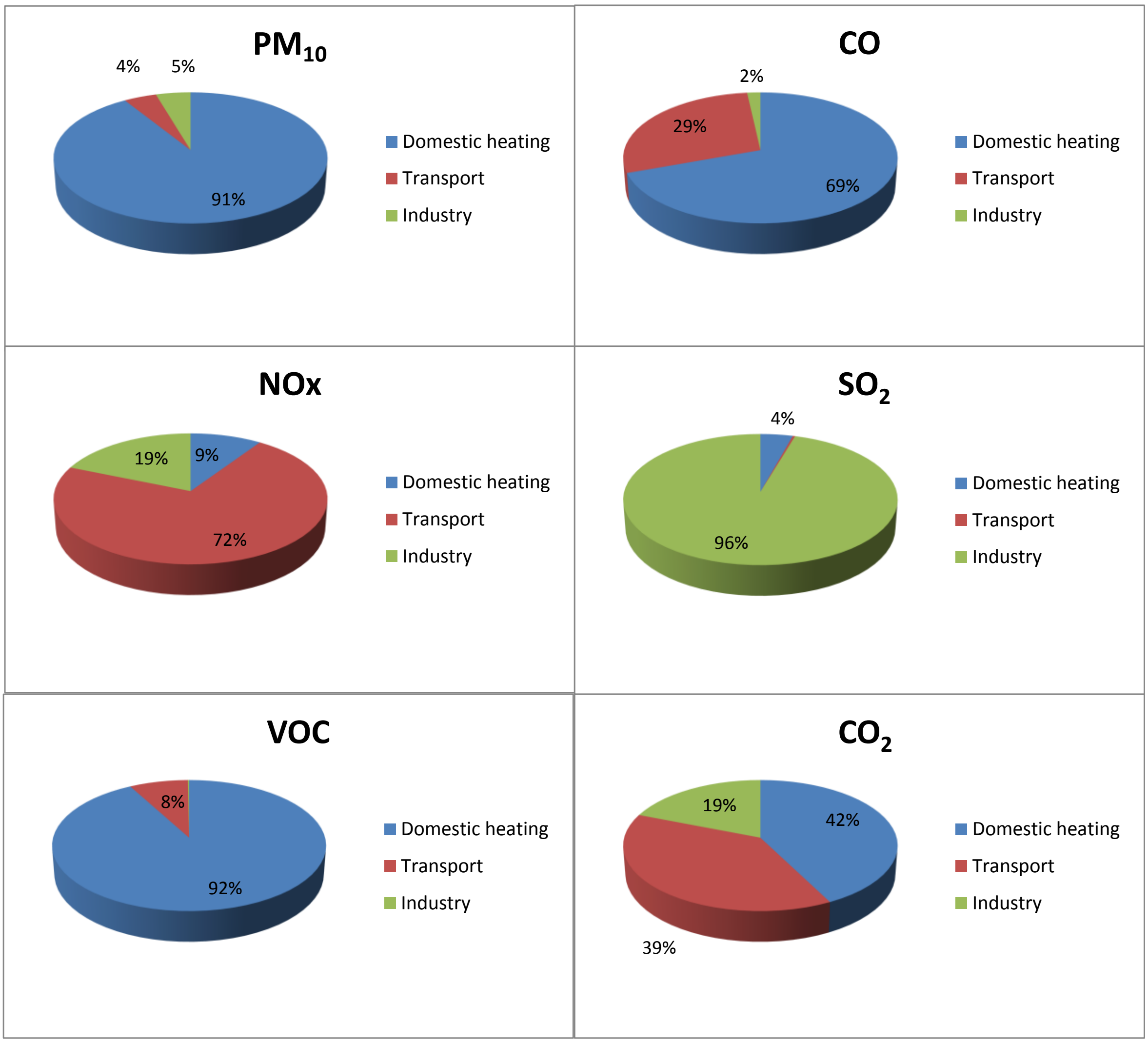

Figure 7-3: Relative contribution of sources to contaminant emissions in Airshed A.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 7.1. Table 7.2 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 motor vehicles is the main contributor to PM_{10} emissions.

Table 7.1: Daily contaminant emissions from all sources in Airshed A (winter average).

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	149	149	2013	2017	15	15	6	6
Transport	7	7	835	836	116	116	0	0
Industry	8	8	51	51	30	30	136	136
			0					
Total	164	164	2899	2904	161	161	142	143
	VOC		CO_2		Benzene			
	kg	g/ha	kg	g/ha	kg	g/ha		
Domestic home heating	604	605	48	49	30	30		
Transport	51	51	44	44	3	3		
Industry	1	1	22	22	0	0		
Total	656	657	114	114	33	33		

Table 7.2: Monthly variations in daily PM_{10} emissions in Airshed A.

	Domestic Heating		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	4%	2	24%	7	72%	10
February	0	4%	3	27%	7	69%	10
March	5	30%	4	23%	7	46%	15
April	16	58%	4	14%	7	26%	27
May	74	87%	4	4%	7	8%	85
June	138	90%	8	5%	7	5%	153
July	149	91%	8	5%	7	4%	164
August	134	90%	7	5%	7	5%	148
September	60	84%	4	5%	7	10%	71
October	18	60%	4	13%	7	25%	29
November	3	18%	4	28%	7	52%	14
December	1	7%	2	23%	7	69%	10
Total kg year	18327	4%	1594		2591		

7.2 Total emission Airshed B1

Around 159 kilograms of PM_{10} is discharged to air in Airshed B1 on an average winter's day. This compares with an estimated 285 kilograms per day for 2006 indicating a reduction in emissions of around 44% since 2006 (Figure 7.3). Figure 7.4 shows that domestic home heating contributes 54% of PM_{10} emissions contributing and industry contributes 41% with five percent from transportation (motor vehicles and airport emissions).

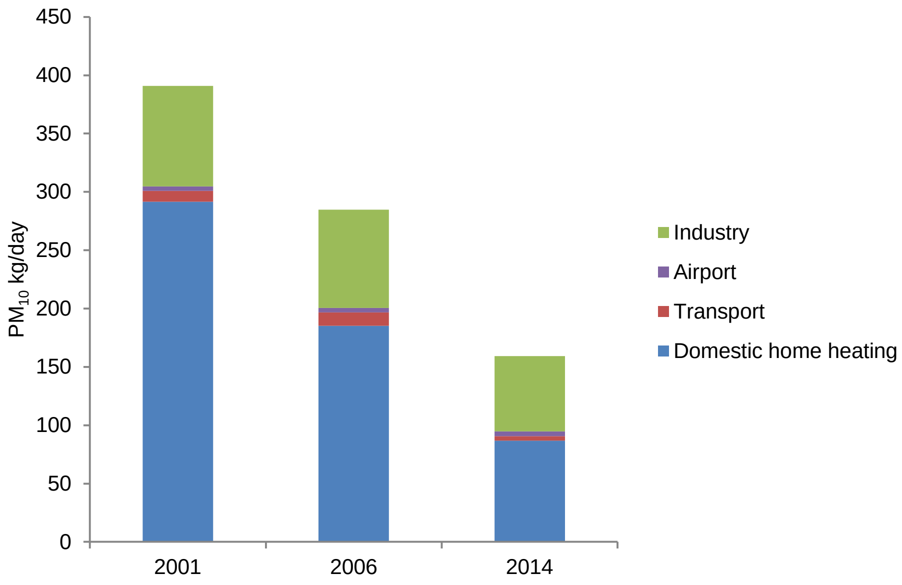

Figure 7-4: Comparison of estimated changes in PM_{10} emissions in Airshed B1 from 2006 to 2014

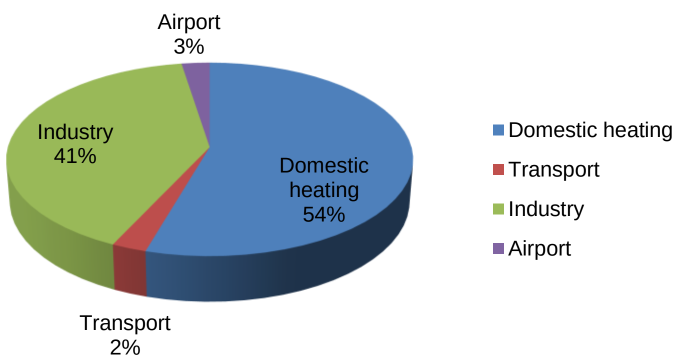

Figure 7-5: Relative contribution of sources to daily winter PM_{10} emissions in Airshed B1.

Industry is the main source of SO_2, and CO_2, domestic home heating is the main source of PM_{10}, CO, and VOCs and motor vehicles is the main source of NOx in Airshed B1 (Figure 7.6).

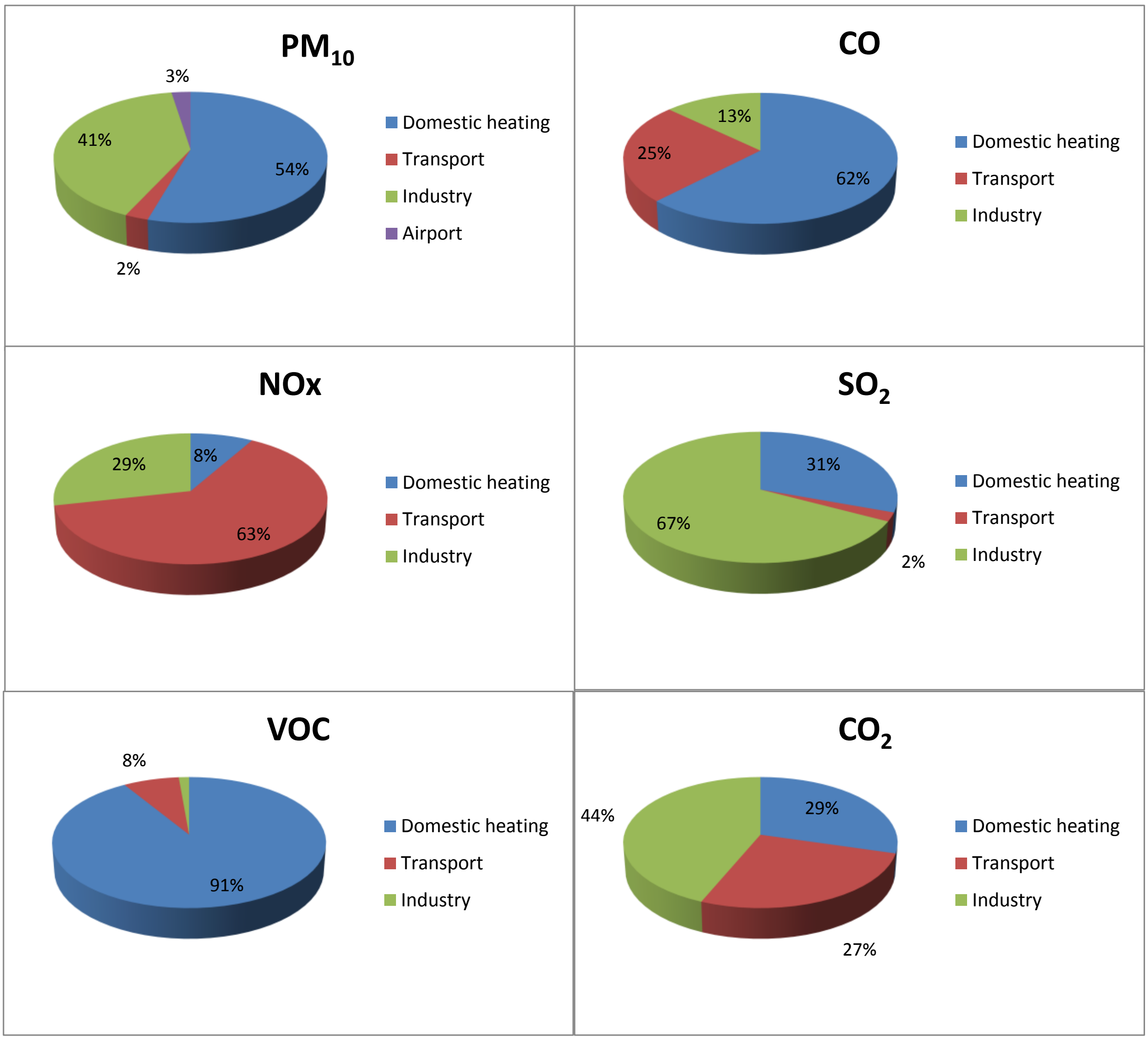

Figure 7-6: Relative contribution of sources to daily winter contaminant emissions in Airshed B1.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 7.3. Table 7.4 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, motor vehicles and outdoor burning are the dominant contributors to PM_{10} emissions.

Table 7.3: Daily contaminant emissions from all sources in Airshed B1 (winter average).

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	87	115	1164	1535	8	11	3	4
Transport	4	5	463	611	64	85	0	0
Industry	65	85	242	319	29	38	7	10
Airport	4	5	0	0	0	0	0	0
Total	159	210	1869	2465	102	134	11	15
	VOC		CO_2		Benzene			
	Kg	g/ha	kg	g/ha	kg	g/ha		
Domestic home heating	349	461	27	35	17	22		
Transport	28	37	24	32	2	2		
Industry	5	7	40	53	1	1		
Airport	0	0	0	0				
Total	383	505	91	120	19	25		

Table 7.4: Monthly variations in daily PM_{10} emissions in Airshed B1.

	Domestic Heating		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	64.8	89%	8	11%	73
February	0	0%	64.8	89%	8	11%	73
March	0	0%	64.8	89%	8	11%	73
April	7	9%	64.8	81%	8	10%	80
May	43	37%	64.9	56%	8	7%	116
June	80	52%	64.6	42%	8	5%	153
July	87	54%	64.5	40%	8	5%	159
August	78	52%	64.5	43%	8	5%	151
September	26	27%	64.6	65%	8	8%	99
October	5	7%	64.5	82%	8	10%	78
November	0	1%	64.5	88%	8	11%	73
December	0	0%	64.8	89%	8	11%	73
Total kg year	10044		23605		2899		

7.3 Total emissions Airshed B2

Around 223 kilograms of PM_{10} is discharged to air in Airshed B2 on an average winter's day. This compares with an estimated 394 kilograms per day for 2006 indicating a reduction in emissions of around 39% since 2006 and 68% since 2001 (Figure 7.7). Figure 7.8 shows that domestic home heating is the main source of PM_{10} emissions contributing 93% of the daily wintertime emissions. Industry contributes around 3% of the daily winter PM_{10} emissions and motor vehicles contribute 4%.

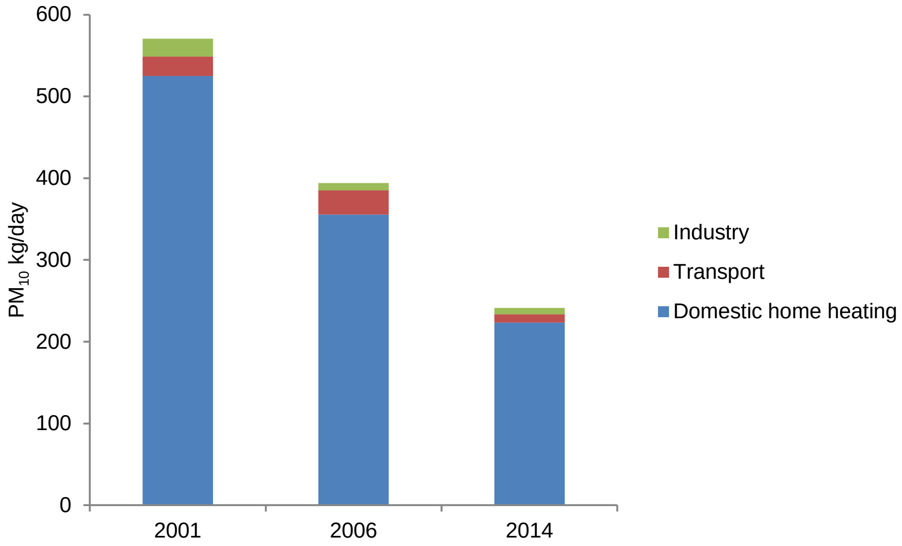

Figure 7-7: Comparison of estimated changes in PM_{10} emissions in Airshed B2 from 2006 to 2014

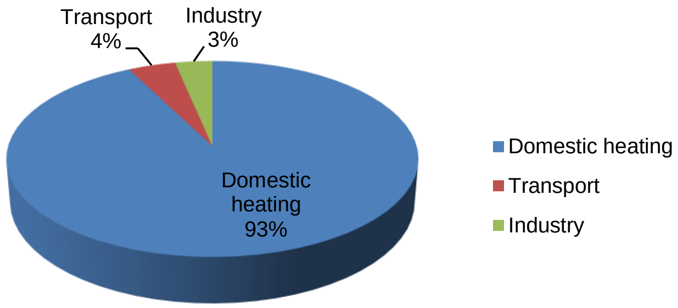

Figure 7-8: Relative contribution of sources to daily winter PM_{10} emissions in Airshed B2.

Domestic home heating is also the main source of CO and VOCs in Airshed B2. Industry is the main source of SOx, and motor vehicles are the main source of NOx (Figure 7.3).

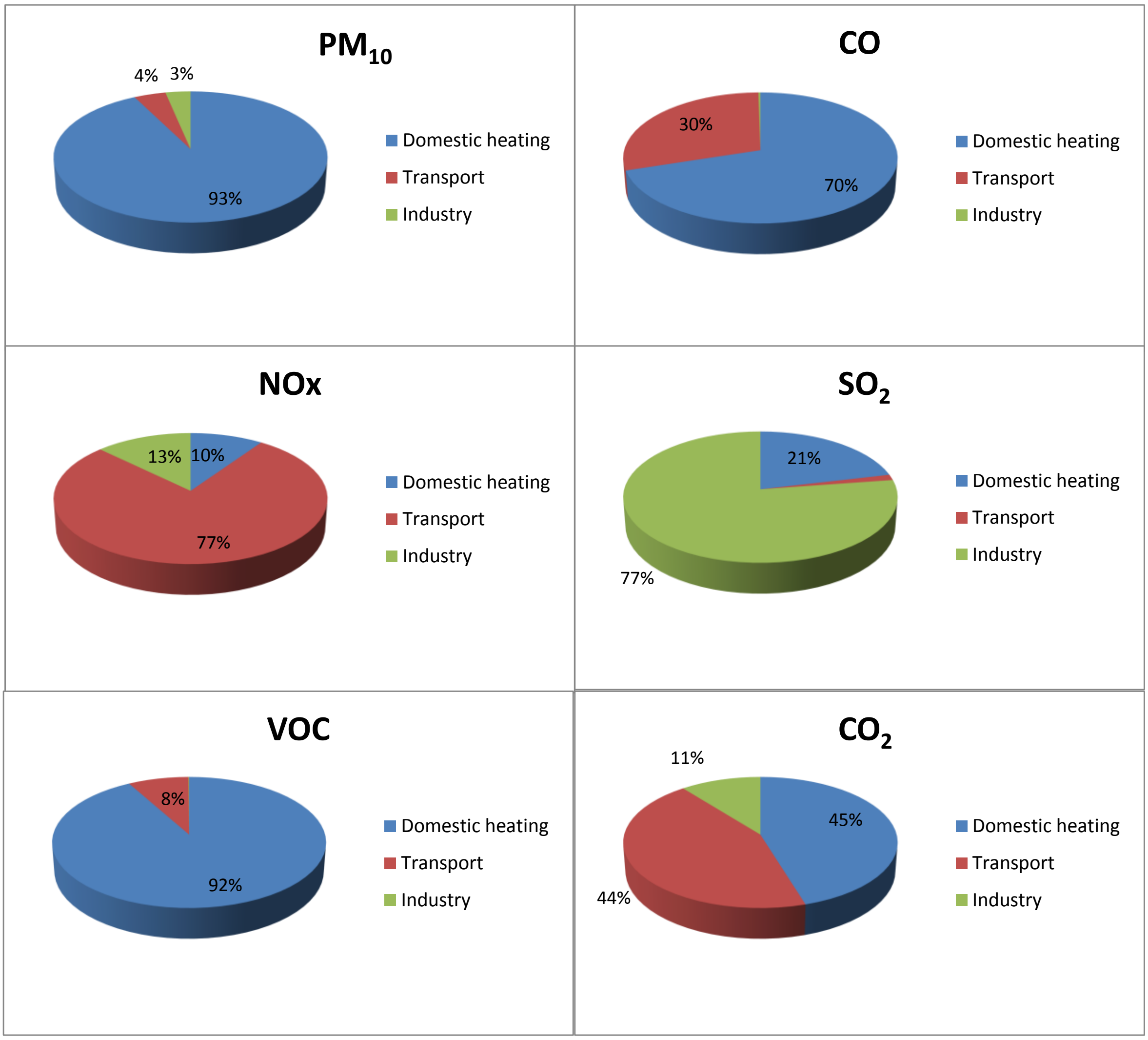

Figure 7-9: Relative contribution of sources to contaminant emissions in Airshed B2.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 7.5. Table 7.6 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, motor vehicles and outdoor burning are the dominant contributors to PM_{10} emissions.

Table 7.5: Daily contaminant emissions from all sources in Airshed B2 (winter average).

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	223	77	2835	978	21	7	10	3
Transport	10	4	1198	413	166	57	24	8
Industry	8	3	11	4	27	9	35	12
Total	241	83	4044	1395	214	74	46	16

	VOC		CO_2		Benzene	
	Kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	839	290	65	22	39	14
Transport	73	25	63	22	4	1
Industry	1	0	15	5	0	0
Total	914	315	143	49	43	15

Table 7.6: Monthly variations in daily PM_{10} emissions in Airshed B2.

	Domestic Heating		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	8	43%	10	57%	18
February	0	0%	8	45%	10	55%	18
March	0	0%	8	43%	10	57%	18
April	12	40%	8	26%	10	34%	30
May	116	87%	8	6%	10	8%	134
June	197	91%	8	4%	10	5%	216
July	223	92%	8	3%	10	4%	241
August	194	91%	8	4%	10	5%	212
September	74	80%	8	9%	10	11%	92
October	13	42%	8	25%	10	33%	31
November	1	9%	4	23%	10	68%	15
December	0	0%	4	26%	10	74%	14
Total kg year	25448		2602		3720		

7.4 Total emission Airshed C

Around 186 kilograms of PM_{10} is discharged to air in Airshed C on an average winter's day. This compares with an estimated 344 kilograms per day for 2006 indicating a reduction in emissions of around 46% since 2006 and 65% since 2001 (Figure 7.10). Figure 7.11 shows that domestic home heating is the main source of PM_{10} emissions contributing 93% of the daily wintertime emissions. Transport contributes five percent, and industry has a two percent contribution to total wintertime PM_{10} emissions.

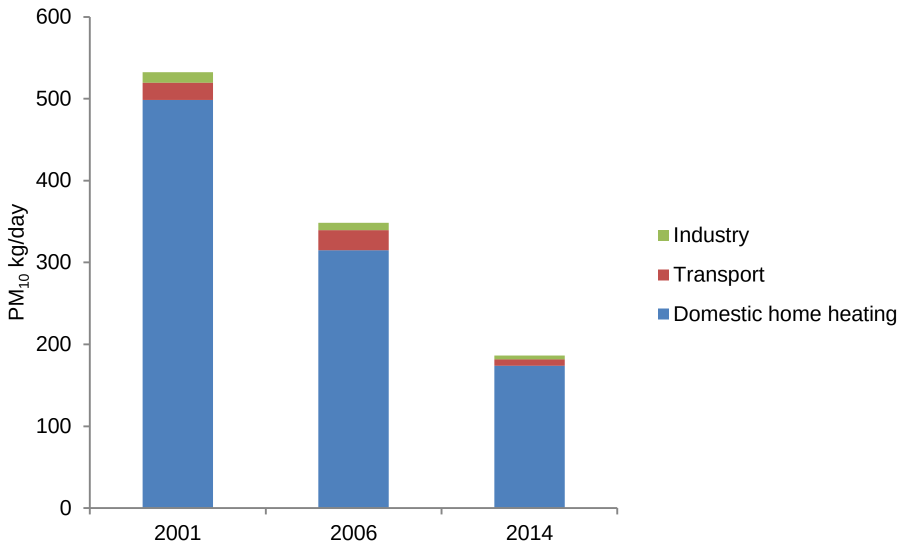

Figure 7-10: Comparison of estimated changes in PM_{10} emissions in Airshed C from 2006 to 2014

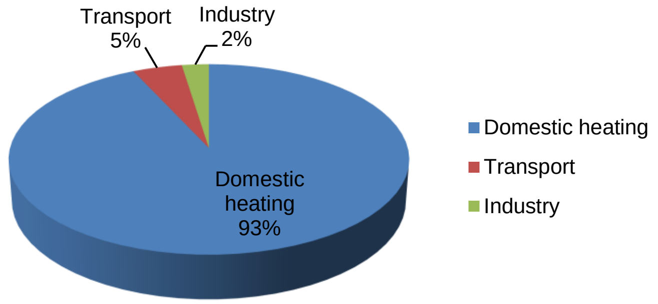

Figure 7-11: Relative contribution of sources to daily winter PM_{10} emissions in Airshed C.

Domestic home heating is also the main source of CO, VOCs and CO_2 in Airshed A. Motor vehicles are the main source of NOx and industry is the main source of SO_2 (Figure 7.12).

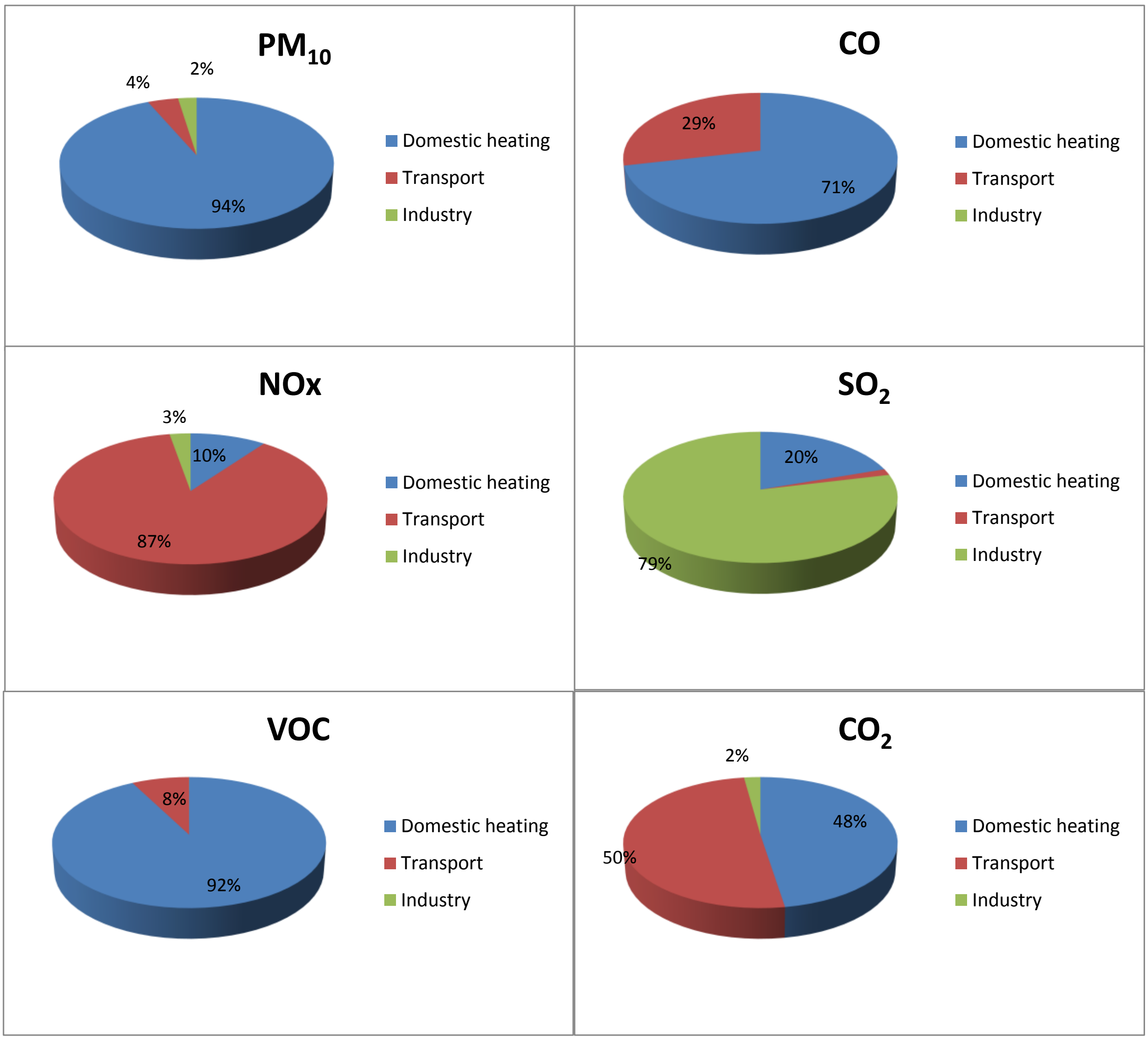

Figure 7-12: Relative contribution of sources to contaminant emissions in Airshed C.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 7.7. Table 7.8 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, motor vehicles and industry are the dominant contributors to PM_{10} emissions.

Table 7.7: Daily contaminant emissions from all sources in Airshed C (winter average).

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	174	37	2206	473	14	3	6	1
Transport	8	2	885	190	123	26	0	0
Industry	5	1	0	0	4	1	24	5
Total	186	40	3092	663	141	30	31	7
	VOC		CO2		Benzene			
	Kg	g/ha	kg	g/ha	kg	g/ha		
Domestic home heating	657	141	44	9	26	6		
Transport	54	12	47	10	3	1		
Industry	0	0	2	0	0	0		
Total	711	153	92	20	29	6		

Table 7.8: Monthly variations in daily PM_{10} emissions in Airshed C.

	Domestic Heating		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	5	36%	8	61%	12
February	0	0%	5	38%	8	59%	13
March	0	0%	5	36%	8	62%	12
April	9	41%	5	21%	8	35%	21
May	87	87%	5	5%	8	8%	99
June	148	92%	5	3%	8	5%	160
July	168	93%	5	3%	8	4%	180
August	146	92%	5	3%	8	5%	158
September	55	80%	5	7%	8	11%	68
October	10	42%	5	21%	8	34%	22
November	1	7%	5	35%	8	56%	14
December	0	0%	5	36%	8	61%	12
Total kg year	19120		1749		2747		

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APPENDIX A: QUESTIONNAIRE

Hi, I'm _________from DigiPoll and I am calling on behalf of the Nelson City Council.

May I please speak to an adult in your household who knows about your home and home heating systems?

We are currently undertaking a survey in your area on health, housing and methods of home heating. The survey will take about 5 minutes. Is it a good time to talk to you now?

We are not selling anything but only gathering your opinion.

The responses you give are anonymous and the Nelson City Council will not be given any information that could be used to identify individual households. Please be assured that all your responses will remain completely confidential.

The survey could be monitored or recorded for quality control purpose.

1. (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)*

2. (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.

3. (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?

4. (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?

5. (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?

(I) What proportion would be bought?

6. (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?

7. (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 ?

8. Does your home have insulation?

- ☐ Ceiling
- ☐ Under floor
- ☐ Wall
- ☐ Cylinder wrap

- ☐ Double glazing
- ☐ None
- ☐ Don't know
- ☐ Other

9. Which of the following most closely describes how you heat your home:

- ☐ One room (living room) in evening
- ☐ Whole house in evening
- ☐ Living area 24/7 and rest of house evening only
- ☐ One room (living room) all day
- ☐ whole house all day
- ☐ Do not heat home
- ☐ other (Specify)

10. Do you choose not to heat your home during the day because

- ☐ The house is not occupied
- ☐ Cost of heating
- ☐ other (Specify)

11. How would you rate the level of warmth in your home during winter?

- ☐ Too cold
- ☐ Adequate
- ☐ Warm

12. a) Does anyone living at this house have a respiratory illness or other problems with breathing that require treatment?

If yes how many people have a respiratory illness or other problems with breathing that require treatment.

b) Does anyone living at this house have any other long term health issues (excluding respiratory related issues) which require treatment? (long term means more than 6 months).

If yes how many people.

If yes, what type of health conditions are you/ they being treated for?

☐

13. Which option best describes where you live:

- ☐ One storey house/ unit
- ☐ Two or more storey house with living rooms and bedrooms
- ☐ Two or more storey house with living and bedrooms on one
- ☐ Apartment with living and bedrooms on one level
- ☐ Apartment with living and bedrooms on more than one level
- ☐ Other (Specify)

14. 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

15. With which ethnic group do you most closely relate?

Interviewer: tick gender.

How many people live at your address?

Do you own your home or rent it?

Approximately how old is your home?

How many bedrooms does your home have?

Thinking about your future housing needs in, say, in ten years time,

How many bedrooms are you most likely to want?

- One
- Two
- Three or more

What size section are you most likely to want?

- Small (ranging from a courtyard or balcony to a section less than 400 m2)
- An average size section (400 m2 –
- Large (750m2 or bigger)

Would you like to stay in the same suburb?

- Yes
- No
- Don't know

Can you tell me the household annual income – if boarder refer to personal income

What is your employment status:

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) and burners meeting the NES design criteria for wood burners (Bluett, Smith, Wilton, & Mallet, 2009; Smith, Bluett, Wilton, & Mallet, 2009) .

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 is typically used for coal burning on an open fire in New Zealand 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). An emission factor for PM_{10} for multi fuel burners burning coal of 28 g/kg has been used based on a weighted average of the test results available for different appliance types. No coal burning was carried out in Nelson in 2014. However, these factors are relevant for earlier inventories for Nelson.

The older wood burner emission rates were based on testing of older wood burners "in situ" in Tokoroa during 2005 as detailed in Wilton & Smith, (2006). The burner age category for the latter testing is older (pre 1994) than the category included here (pre 2004). However, the main difference in burner design is between the older burners and those meeting the NES design criteria of 1.5 g/kg so the older emission factor has only been adjusted slightly to allow for some more modern burners that may have been installed pre 2004. Post 2006 emission factors were based on an emission factor of 4.5 g/kg based on an analysis by Wilton (2013).

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.

Emissions factors for BaP were based on AP42 factors for conventional wood burners (no baffles) for open fires and on phase II burners (with baffles, non catalytic) for wood burners. Benzene emission factors were based on AP42 for conventional wood burners. Benzene emission factors for coal burning was based on AP42 coal fired boiler data because no domestic information was available. Emission factors for BaP for coal burning was based on AP42 factors for burning anthracite coal on open fires as no data were available for bituminous or sub bituminous coals.

APPENDIX C: SUMMARY SURVEY DATA

Figure 0-1: Proportion of firewood that is bought and self collected

Firewood	Airshed A	Airshed B1	Airshed B2	Airshed C
Bought	69%	68%	66%	70%
Self-collected	31%	32%	34%	30%

Figure 0-2: Prevalence of household insulation by type

Household insulation	Airshed A Households	Airshed B1 Households	Airshed B2 Households	Airshed C Households
Ceiling	3900	1955	4583	3947
Underfloor	2669	1122	2132	2312
Wall	2102	1165	2799	2551
Cylinder wrap	1369	755	1421	1555
Double glazing	982	480	1276	1316
None	180	127	131	186
Don't know	152	78	160	279
Other	28	0	58	66

Figure 0-3: How many bedrooms would you want in ten years time?

	Airshed A Households	Airshed B1 Households	Airshed B2 Households	Airshed C Households
One	6%	7%	10%	7%
Two	28%	38%	33%	36%
Three or more	63%	52%	53%	53%
Don't know	4%	4%	5%	3%

Figure 0-4: What size section would you mostly want?

	Airshed A Households	Airshed B1 Households	Airshed B2 Households	Airshed C Households
Small (ranging from a courtyard or balcony to < 400 m sq	31%	36%	37%	38%
Average size section (400 - 750 m sq	43%	38%	43%	40%
Large (bigger than 750 m sq)	22%	19%	15%	17%
Don't know	4%	7%	4%	5%

Figure 0-5: Would you still want to live in the same suburb?

	Airshed A Households	Airshed B1 Households	Airshed B2 Households	Airshed C Households
Yes	60%	67%	75%	75%
No	30%	24%	18%	18%
Don't know	9%	9%	7%	7%

Figure 0-6: How would you rate the level of warmth in your home during winter?

	Airshed A Households	Airshed B1 Households	Airshed B2 Households	Airshed C Households
Too cold	20%	22%	15%	12%
Adequate	45%	40%	43%	48%
Warm	35%	37%	41%	39%
Unsure/ refused	0%	1%	1%	1%