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Air Quality & IT Specialists

Air Emission Inventory – Hawke's Bay Region – 2005

HBRC Publication No. 4851
Report No. SD16-23

Air Emission Inventory – Hawke's Bay Region – 2005

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June 2005

Executive Summary

Air quality monitoring in Napier and Hastings indicates concentrations of PM_{10} in excess of the Ministry for the Environment's ambient air quality guideline and National Environmental Standard of 50 μgm^{-3} (24-hour average). The NES is effective from September 2005. The development of management measures to reduce concentrations of PM_{10} requires detailed information on sources contributing to PM_{10} concentrations in these areas.

This report evaluates sources of PM_{10} and other contaminants in the Hawke's Bay Region using an emission inventory. The inventory separately examines emissions in the areas of Napier, Hastings, Flaxmere, Havelock North, the three areas of Wairoa, Waipawa and Waipukurau jointly and the rest of the Region. Contaminants included in the assessment were particles (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide and benzene. This report primarily focuses on emissions of particles (PM_{10}) as this contaminant exceeds the NES and is therefore a priority for air quality monitoring. The PM_{10} sources included in the inventory assessment were domestic heating, motor vehicles, industrial and commercial activities, outdoor burning, orchard heaters, shipping and aviation.

Emissions from domestic home heating were evaluated using the results of a household survey of heating methods and fuels carried in each of the study areas. The main methods of heating varied with location with gas (47%) and wood burners (38%) being the most common methods of heating the main living areas in Napier. Wood burners were the most common method in Hastings (51%), Flaxmere (63%), Wairoa, Waipawa and Waipukarau (65%) and in the rest of the Region (73%). In Havelock North wood burners and electricity were both common methods used by 50% and 47% of households respectively. Many households used more than one method of heating the main living area.

Domestic home heating was found to be the major source of PM_{10} emissions in all areas accounting for 78% to 92% of total daily winter emissions. Motor vehicles typically contributed 2-5% of the PM_{10}, industry 1-7% and outdoor burning 5-10% of the daily wintertime PM_{10}. The contribution of orchard heaters and burning of vineyard and orchard prunings was minimal. Aviation and marine emissions each contributed 1% of the PM_{10} emissions in Napier.

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1 Introduction

Air quality monitoring in the Hawke's Bay Region has been carried out in Napier from 1997, and Hastings from August 2003. Concentrations of suspended particulate in excess of the MfE guideline for this contaminant (50 μgm^{-3} averaged over 24-hours) have been measured in both Napier and Hastings. Suspended particulate (PM_{10}) refers to particles in the air less than 10 microns in diameter. The Ministry for the Environment's National Environmental Standards (NES) for ambient air quality include a standard for PM_{10} of 50 $\mu g\ m^{-3}$ (24-hour average) with one allowable breach per year. The standards are effective from September 2005.

The maximum measured 24-hour average PM_{10} concentration in Napier was 70 $\mu g\ m^{-3}$, measured in July 2004. In Hastings a maximum 24-hour average PM_{10} concentration of 84 $\mu g\ m^{-3}$ was measured in June 2004. The number of measured guideline exceedences for 2004 was two in Napier and six in Hasting. As monitoring is only carried out in each location every third day, the number of exceedences could be six and 18 for Napier and Hastings respectively, if data are extrapolated for non-sample days.

Air quality monitoring in Napier suggests that annual average PM_{10} concentrations are well below the Ministry for the Environment's (MfE, 2002) ambient air quality guideline of 20 $\mu g\ m^{-3}$. In Hastings, however, monitoring from August 2003 to August 2004 indicates an annual average concentration of around 19 $\mu g\ m^{-3}$. Collection of emissions information across a whole year is necessary to evaluate the contribution of different sources to annual average concentrations.

A number of investigations are required to assist with the management of air quality in the Hawke's Bay Region to reduce PM_{10} concentrations and meet the NES. In particular, an assessment of the relative contribution of different PM_{10} sources and an estimate of the amount of PM_{10} discharged into the air is necessary. The primary method of assessing sources of PM_{10} in New Zealand is through an emission inventory. This involves an assessment of PM_{10} emissions from a number of sources and traditionally includes surveying households for home heating methods and fuel, examining data from industries and transportation as well as other potential sources of air discharges in the Region. This report collates information from these sources and estimates emissions of PM_{10} and other contaminants based on these data.

2 Inventory Design

The main ambient air quality issue for the Hawke's Bay Region is concentrations of PM_{10} in urban areas. This inventory has been designed with a focus on emissions of PM_{10}, although estimates of emissions of other contaminants are included. Monitoring of carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) in Hawke's Bay shows concentrations of contaminants well within guideline values..

2.1 Selection of sources

The inventory includes estimates of emissions from domestic heating, outdoor burning, motor vehicles, industry, orchard heaters, shipping and aviation. Emissions from a number of other sources are discussed in the report. These include:

- lawn mowers
- railways
- vegetation
- dusts from farming activities
- marine aerosol

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), fine particles ($PM_{2.5}$) and benzene.

Emissions of PM_{10}, CO, SOx and NOx are included as these contaminants comprise class one air quality indicators as described by MfE (2002) and because NES have been created for PM_{10}, CO, NO_2 and SO_2. Inventory estimates are made for total oxides for the latter two contaminants because of uncertainties in estimating specifically NO_2 and SO_2.

Carbon dioxide is typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. In its proposed ambient air quality guidelines (2000), the Ministry for the Environment includes a guideline for hazardous air pollutants including benzene, and a guideline for $PM_{2.5}$ will be considered within the next few years. Consequently both have been included in the emissions assessment.

Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. While not generally of concern in most areas of New Zealand, VOC emissions have been retained in the inventory to allow for assessments of photochemical pollution should this become a priority in the future. Note, however, sources are selected on the basis of contribution to PM_{10} and potential sources of VOCs, for example vegetation, are not included in the assessment. Thus results may not represent a comprehensive VOC emission assessment.

2.3 Selection of areas

The Hawke's Bay Region was broken down into the following study areas:

- Napier
- Hastings
- Flaxmere
- Hastings / Flaxmere
- Havelock North
- Wairoa, Waipawa, Waipukurau
- Rest of the Region

The census area units comprising each of the above areas are detailed in Appendix A. Figure 2.1 provides an overview of the location of each area within the Region. The data for Hastings and Flaxmere were presented separately for each area then collectively for the Hastings/ Flaxmere area.

2.4 Temporal distribution

The main focus of the study is on daily PM_{10} emissions during the winter period as this is when concentrations in Napier and Hastings have exceeded the ambient air quality guidelines and NES for PM_{10} (24-hour average). In addition, the inclusion of an annual average guideline for PM_{10} in the 2000 ambient air quality guidelines (MfE, 2000) increases the importance of including emission estimates for different seasons. The inventory has therefore also been designed for the collection of seasonal data.

Data are also presented for four different time of day periods. For domestic heating these are based on time of day distributions from other inventory studies as it is not possible to collect information on both time of day and seasonal variations in fuel use, owing to issues of survey length. The time of day breakdown is as follows:

- 6am to 10am
- 10am to 4pm
- 4pm to 10 pm
- 10pm to 6am

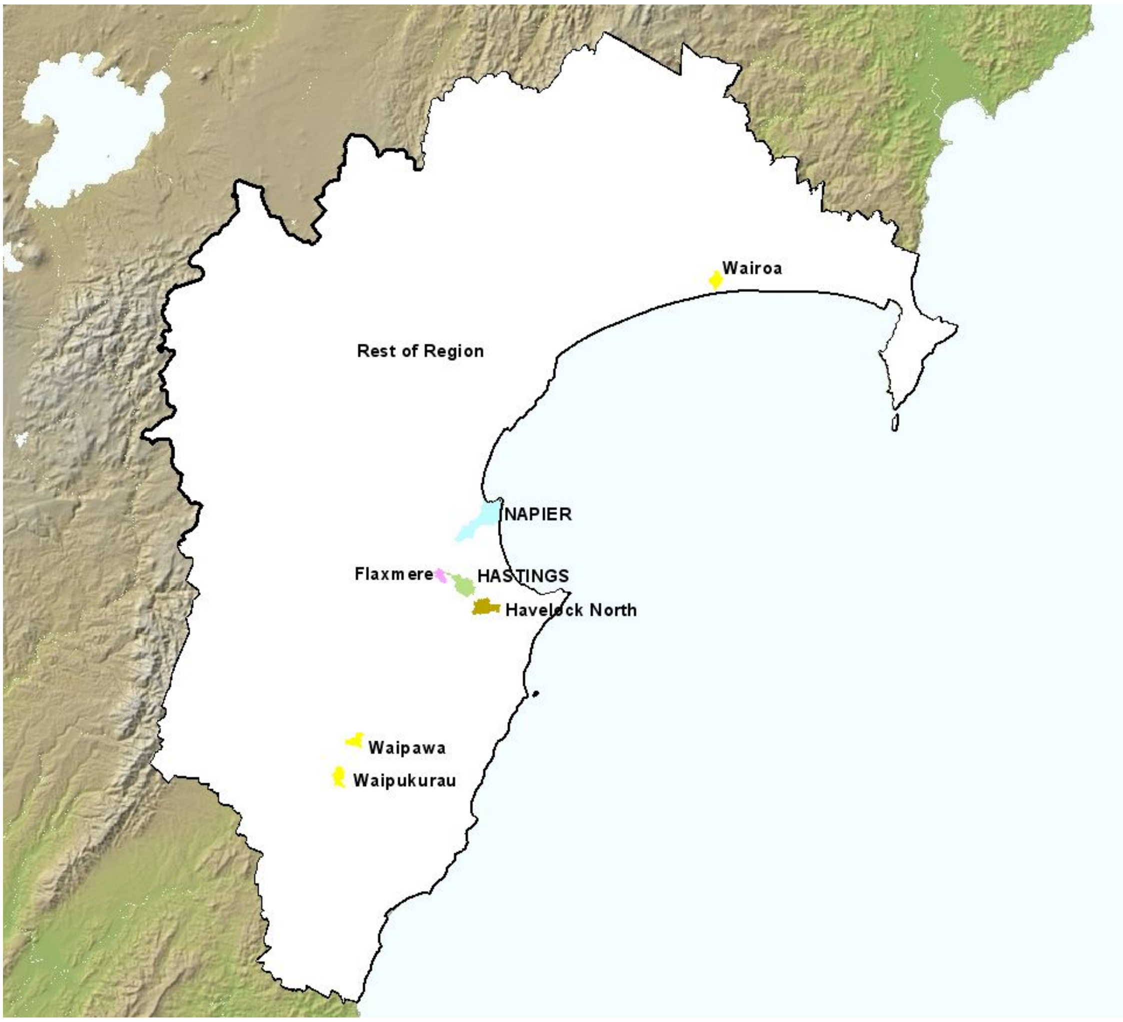

Figure 2.1: Location of study areas within the Hawke's Bay Region

3 Domestic Heating

3.1 Methodology

The domestic heating emission inventory data was collected using a telephone survey of 1375 households during April 2005. The survey was carried out by Digipol using the emission inventory survey questionnaire detailed in Appendix B. This survey is based on fairly standard survey methodology adopted in emission inventories throughout New Zealand. Emission factors were then applied to these data to provide an estimate of emissions for each study area. Summary data for the survey and study areas are shown in Table 3.1.

Table 3.1: Home heating survey area and sample details

	Households	Sample size	Area (ha)	Sample error
Napier	19521	310	3321	5.5%
Hastings	10746	195	1436	6.9%
Flaxmere	2733	115	482	8.9%
Hastings/ Flaxmere	13479	250	1918	6.0%
Havelock North	3927	300	1341	5.4%
Wairoa, Waipawa, Waipukurau	3822	215	2137	6.5%
Rest of Region	11905	236	1408079	6.3%

Home heating methods were classified as electricity, open fires, pre 1994 wood burners, 1995-1999 wood burners, post 1999 wood burners, pellet burners, multi fuel burners, gas burners and oil burners.

Table 3.2 shows the emission factors used to estimate emissions from domestic home heating. Emission factors used for domestic home heating have been developed based on emission testing of appliances under simulated operating conditions. For wood burners, emission factors are higher on average for older burners. Further details on the derivation of these factors is given in Appendix C.

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	$PM_{2.5}$ g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97	10
Open fire - coal	21	80	4	5.0	15	2600	0.00065	21
Pre 1994 wood burner	11	110	0.5	0.2	33	1600	0.97	11
1994-1999 wood burner	7	70	0.5	0.2	21	1600	0.97	7
Post 1999 wood burner	6	60	0.5	0.2	18	1600	0.97	6
Multi fuel[1] – wood	13	130	0.5	0.2	39	1600	0.97	13
Multi fuel[1] – coal	28	120	1.2	3.0	15	2600	0.00065	28
Pellet burner	2	20	0.5	0.2	6	1600	0.97	2
Oil	0.3	0.6	2.2	3.8	0.25	3200	2.160E-05	0.219
Gas	0.03	0.18	1.3	7.56E-09		2500	2.13E-03	0.03

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

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

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

Where:

CE = contaminant emission
EF = emission factor
FB = fuel burnt

Emissions calculated for the worst-case winter's day were based on the assumption that all households that used solid fuel for home heating were using it at the same time. Average winter's day emissions were also calculated. For this estimate, the daily fuel use was adjusted based on the average number of days per week each household used their heating method.

Daily emissions were also calculated for each month of the year to give an indication of the annual profile of PM_{10} emissions. These data were based on the average fuel use allowing for households not using particular heating methods on some nights during the week.

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.9 kg. This weight was based on a survey carried out in Christchurch during 2002 (Lamb, 2003).
- The average weight of a bucket of coal is 9 kg.

There are uncertainties in both the estimates of fuel use and the emission factors used to estimate emissions from solid fuel burning. Fuel use uncertainties include the ability of householders to accurately estimate their daily fuel consumption, the conversion of pieces of wood to kilograms of fuel and in the case of small subgroups of appliance types, for example open fires, the applicability of the average fuel use of the small number of respondents in the sample size to the rest of the population of that burner category.

It is likely that some houses will overestimate average daily fuel consumption and some will underestimate consumption. For the larger appliance categories (e.g., wood and multi fuel burners) these are likely to balance out. There is a much higher degree of uncertainty for the smaller appliance categories such as open fires and pellet burners. While comparisons to average fuel use for different appliance types for other locations may give some indication of the general ballpark for these categories, differences in climate and other factors such as lifestyle make comparisons difficult. For example, variations in demographics can impact on the proportion of households that heat homes during the daytime, which in turn impacts on the daily fuel consumption.

The main potential for systematic bias in the estimates is the fuel wood conversion factor. In the absence of better data on wood weight, data from a survey of wood use in Christchurch was used (Lamb, 2002). It is possible that the size of logs of wood used in the Hawke's Bay Region is different on average to those used in Christchurch. However, reasons for such differences on average are unclear.

The uncertainty surrounding emission factors for domestic home heating is also high. Emission factors used are based on results of laboratory simulations of real life operation, rather than emissions from "in situ" measurements and operated by householders in real life. Further studies on real life emissions from domestic wood burners are being carried out during 2005. Emission factors used in this report are based on current best available information.

3.2 Home heating methods

The main methods of home heating vary with location within the Hawke's Bay Region. In Napier, gas is the most common method of heating the main living area, with 47% of households using this method. Wood burners and electricity are also common heating methods in Napier with 38% of households using each of these methods. Many households use more than one method of heating the main living area (Table 3.3).

In Hastings, wood burning is the most common heating method (51%), followed by gas (44%) and electricity (35%). In Flaxmere, 63% of households use wood burners with 44% using gas and 23% using electricity. Electricity and wood burner use in Havelock North are similar with 47% and 50% of households using these methods respectively. In Wairoa, Waipawa and Waipukurau around 65% of households use wood burners with only 27% and 33% of households using electricity and gas respectively. The main method of home heating in the rest of the Region is wood burners (72%).

In all areas, open fires are used by 10-11% of households and multi fuel burners are used by less than 10% of households. Coal use is not common in Flaxmere or Wairoa, Waipawa and Waipukurau, and is used by less than 3% of households in all other areas.

Table 3.4 shows average daily fuel use during the month of July in each area of the Region. In all areas, most of the wood is burnt in wood burners. Coal use is split between open fires and multi fuel burners in Napier and Hastings. In Havelock North and the more rural areas coal is primarily burnt on enclosed multi fuel burners. Around 827 tonnes of wood and 25 tonnes of coal are burnt per day during the winter in the Hawke's Bay Region.

Table 3.3: Home heating methods in the Hawke's Bay Region

	Napier		Hastings		Flaxmere		Havelock North		Wairoa, Waipawa, Waipukurua		Rest of Region	
	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Electricity	38%	7,460	35%	3,763	23%	624	47%	1,877	27%	992	25%	2,966
Total Gas	47%	9,294	44%	4,745	44%	1,224	28%	1,111	33%	1,231	34%	4,072
Flued gas	15%	2,921	12%	1,315	7%	182	8%	303	8%	299	8%	928
Unflued gas	33%	6,373	32%	3,430	38%	1,042	20%	808	25%	932	27%	3,144
Oil	1%	126	1%	55	1%	24	2%	66	1%	51	2%	201
Open fire	11%	2,086	5%	545	10%	264	10%	410	10%	359	11%	1,257
Open fire - wood	10%	2,023	5%	545	10%	264	10%	383	9%	342	11%	1,257
Open fire – coal	2%	379	1%	109	0%	-	1%	53	0%	-	0%	50
Total Wood burner	38%	7,460	51%	5,509	63%	1,752	50%	1,996	65%	2,377	72%	8,496
Pre 1994 wood burner	18%	3,477	25%	2,721	30%	834	23%	932	28%	1,013	31%	3,691
1994-1999 wood burner	12%	2,318	15%	1,659	18%	501	14%	562	21%	760	20%	2,402
Post 1999 wood burner	8%	1,666	10%	1,128	15%	417	13%	503	16%	604	20%	2,402
Multi fuel burners	7%	1,391	5%	545	6%	168	7%	278	7%	257	8%	955
Multi fuel burners-wood	7%	1,391	5%	545	6%	168	7%	278	7%	257	8%	955
Multi fuel burners-coal	1%	253	2%	164	0%	-	2%	79	0%	-	1%	151
Pellet burners	0%	-	1%	55	0%	-	0%	-	0%	-	0%	-
Total wood	55%	10,874	61%	6,599	79%	2,184	67%	2,657	81%	2,976	90%	10,708
Total coal	3%	632	3%	273	0%	-	3%	132	0%	-	2%	201
Total	0%	19,599	0%	10,853	0%	2,760	0%	3,966	0%	3,677	0%	11,864

Table 3.4: Home heating fuel use in the Hawke's Bay Region

	Napier		Hastings		Flaxmere		Havelock North		Wairoa, Waipawa, Waipukurua		Rest of Region	
	t/day	%	t/day	%	t/day	%	t/day	%	t/day	%	t/day	%
Electricity												
Total Gas	7	3%	2	2%	0.5	1%	1	1%	1	1%	2	1%
Flued gas												
Unflued gas												
Oil	1	0%	0	0%	0.1	0%	0	1%	0	0%	1	0%
Open fire												
Open fire - wood	29	12%	16	12%	6	11%	7	13%	8	12%	31	9%
Open fire – coal	2	1%	1	1%	-	0%	0	0%	-	0%	0	0%
Total Wood burner	177	75%	101	79%	44	84%	41	76%	50	77%	263	79%
Pre 1994 wood burner	63	27%	48	38%	19	37%	23	42%	24	37%	104	31%
1994-1999 wood burner	99	42%	35	28%	12	23%	12	23%	19	30%	135	41%
Post 1999 wood burner	15	6%	17	14%	13	24%	6	11%	6	10%	25	8%
Multi fuel burners												
Multi fuel burners-wood	20	9%	6	5%	2	4%	3	6%	6	9%	16	5%
Multi fuel burners-coal	1	0%	1	1%	-	0%	2	4%	-	0%	18	5%
Pellet burners	-	0%	0	0%	-	0%	-	0%	-	0%	-	0%
Total wood	226	96%	123	96%	52	99%	51	94%	64	98%	311	94%
Total coal	3	1%	2	2%	-	0%	2	4%	-	0%	18	5%
Total	236		128		53		54		65		332	0%

Figure 3.1 shows gas use by appliance type in Napier and Hastings. In both areas less than one-third of the households using gas to heat their main living area have flued gas systems. While this proportion is higher than many other urban areas of New Zealand the predominance of unflued gas is of concern because of indoor air quality issues associated with this heating method.

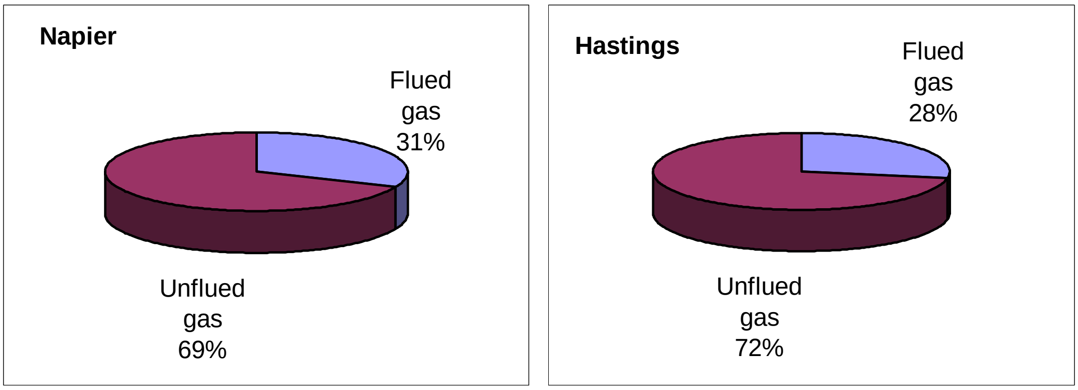

Figure 3.1: Gas use by appliance type in Napier and Hastings

3.3 Emissions from domestic home heating

3.3.1 Napier

Estimates of contaminant emissions for Napier for different domestic heating methods for winter worst-case and winter average are shown in Tables 3.5 and 3.6. The emission estimates indicate the following:

- Just less then 4 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are quite a bit less at about 2 tonnes per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- About 96% of the domestic PM_{10} emissions come from the burning of wood with just 4% from the burning of coal.
- The greatest amount of PM_{10} from domestic heating comes from pre 1996 wood burners (66%). Open fires contribute around 16% of the PM_{10} emissions from domestic home heating (Figure 3.2).

Monthly variations in appliance use and average days per week used are shown in Figures 3.3 and 3.4. Although the number of days burners are used on average increases for some categories in November (Figure 3.4), the proportion of households using burners decreases at this time (Figure 3.3). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.7 shows seasonal variations in contaminant emissions.

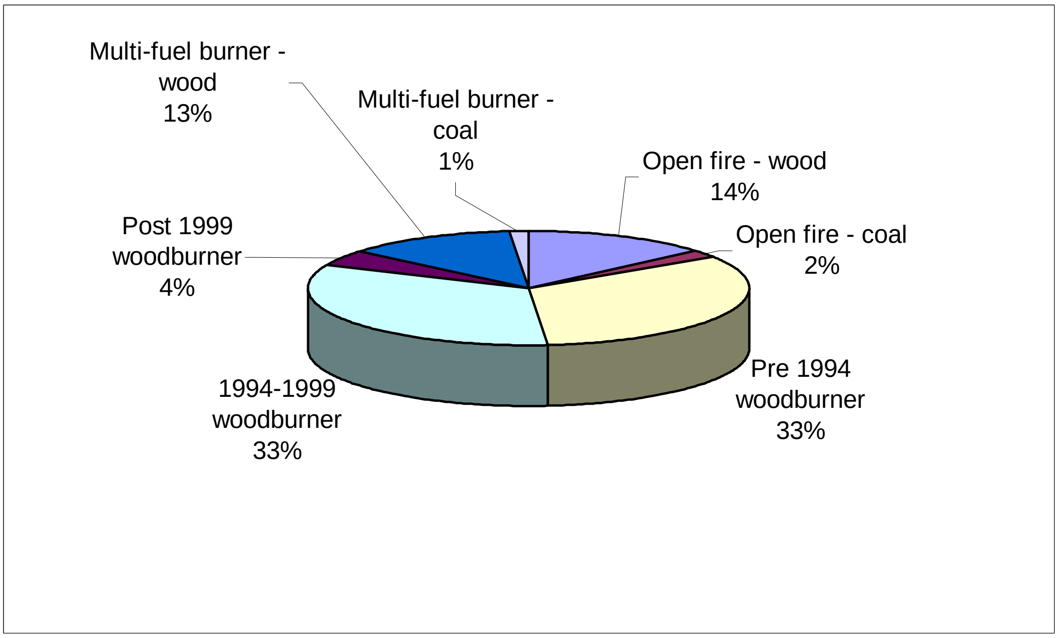

Figure 3.2: Relative contribution of different heating methods to average daily PM_{10} from domestic heating in Napier

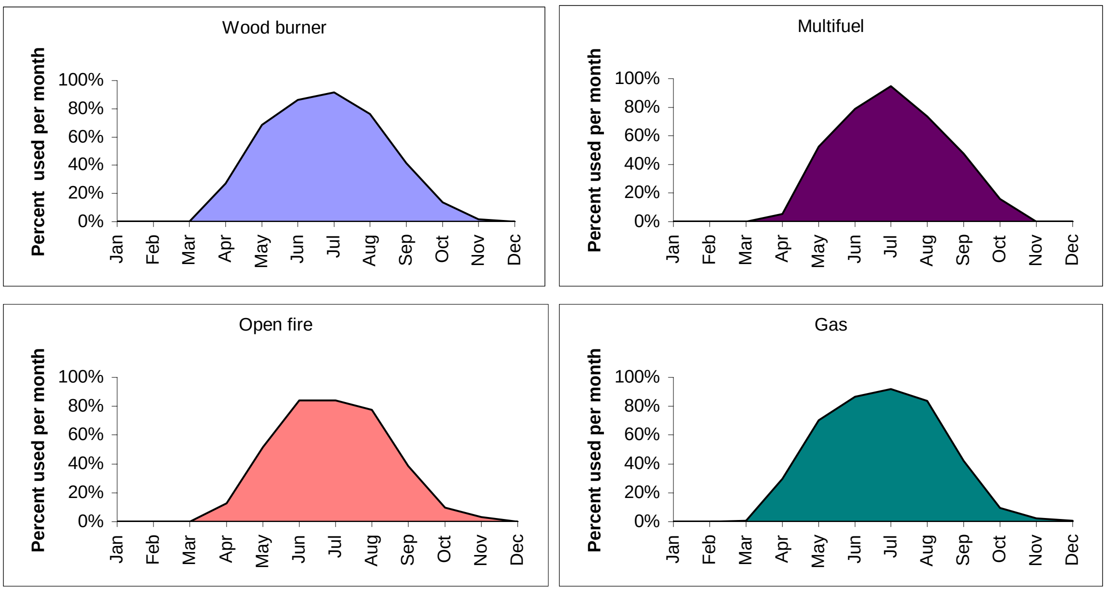

Figure 3.3: Monthly variations in appliance use in Napier

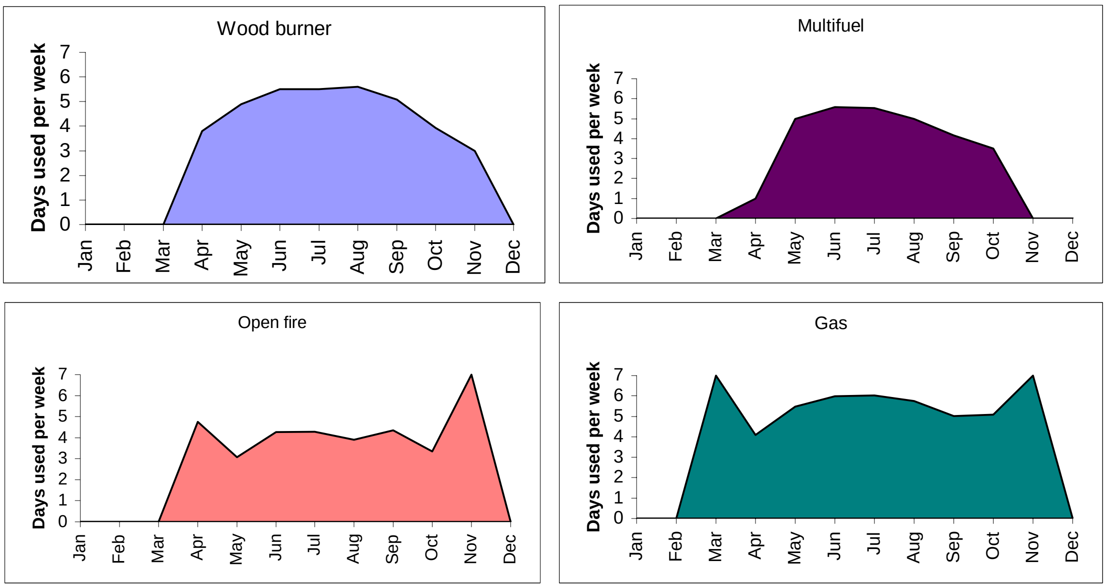

Figure 3.4: Average number of days per week appliances are used in Napier per month

Table 3.5: Napier worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	50.7	13%	507	153	13%	5074	1528	13%	81	24	29%	10	3	9%	1522	458	13%	81	24	12%	507	153	13%	49	15	13%
Open fire - coal	4.8	1%	100	30	3%	382	115	1%	19	6	7%	24	7	22%	72	22	1%	12	4	2%	57	17	1%	0	0	0%
Wood burner																										
Pre 1994 wood burner	113.9	28%	1253	377	32%	12528	3773	33%	57	17	20%	23	7	21%	3758	1132	33%	182	55	28%	1253	377	32%	110	33	30%
1994-1999 wood burner	75.9	19%	531	160	13%	5315	1601	14%	38	11	13%	15	5	14%	1594	480	14%	121	37	19%	531	160	14%	74	22	20%
Post 1999 wood burner	54.6	14%	327	99	8%	3274	986	9%	27	8	10%	11	3	10%	982	296	9%	87	26	13%	327	99	8%	53	16	14%
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 burner - wood	89.4	22%	1162	350	29%	11618	3499	30%	45	13	16%	18	5	17%	3486	1050	30%	143	43	22%	1162	350	30%	87	26	23%
Multi fuel burner – coal	2.3	1%	64	19	2%	273	82	1%	3	1	1%	7	2	6%	34	10	0%	6	2	1%	36	11	1%	0	0	0%
Gas	8.6	2%	0	0	0%	2	0	0%	12	3	4%	0	0	0%	0	0	0%	22	6	3%	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	0	0%
Total Wood	384	96%	3781	1139	96%	37809	11386	98%	248	75	88%	77	23	71%	11343	3416	99%	615	185	94%	3781	1139	98%	373	112	100%
Total Coal	7	2%	164	49	4%	655	197	2%	22	7	8%	31	9	29%	106	32	1%	18	6	3%	94	28	2%	0	0	0%
Total	400		3945	1188		38466	11584		281	85		108	32		11449	3448		655	197		3875	1167		373	112	

Table 3.6: Napier average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	28.7	12%	287	86	14%	2869	864	14%	46	14	28%	6	2	9%	861	259	14%	46	14	12%	287	86	14%	28	8	13%
Open fire - coal	2.0	1%	43	13	2%	164	49	1%	8	2	5%	10	3	17%	31	9	1%	5	2	1%	25	7	1%	0	0	0%
Wood burner																											
Pre 1994 wood burner	62.8	27%	690	208	33%	6905	2079	34%	31	9	19%	13	4	21%	2071	624	34%	100	30	26%	690	208	33%	61	18	28%
1994-1999 wood burner	99.0	42%	693	209	33%	6929	2087	34%	49	15	30%	20	6	32%	2079	626	34%	158	48	41%	693	209	34%	96	29	44%
Post 1999 wood burner	15.2	6%	91	27	4%	909	274	4%	8	2	5%	3	1	5%	273	82	4%	24	7	6%	91	27	4%	15	4	7%
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	0	0%
Multi fuel burner																											
Multi fuel burner - wood	20.2	9%	263	79	13%	2628	791	13%	10	3	6%	4	1	7%	788	237	13%	32	10	8%	263	79	13%	20	6	9%
Multi fuel burner - coal	1.1	0%	30	9	1%	130	39	1%	1	0	1%	3	1	5%	16	5	0%	3	1	1%	17	5	1%	0	0	0%
Gas	6.8	3%	0	0	0%	1	0	0%	9	3	6%	0	0	0%	0	0	0%	17	5	4%	0	0	0%	0	0	0%
Oil	0.7	0%	0	0	0%	0	0	0%	1	0	1%	2	1	4%	0	0	0%	2	1	1%	0	0	0%	0	0	0%
Total Wood	225.8	96%	2024	610	96%	20239	6095	99%	144	44	88%	45	14	74%	6072	1829	99%	361	109	93%	2024	610	98%	219	66	100%
Total Coal	3.1	1%	73	22	3%	294	89	1%	9	3	6%	13	4	22%	47	14	1%	8	2	2%	42	13	2%	0	0	0%
Total	236		2098	632		20535	6184		165	50		61	18		6119	1843		389	117		2066	622		219	66	

Table 3.7: Monthly variations in contaminant emissions in Napier

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0
April	326	2967	27	18	869	62	306	32
May	1178	11660	88	30	3485	226	1169	129
June	1985	19449	153	55	5796	369	1956	208
July	2098	20535	163	59	6119	386	2066	219
August	1564	15301	126	46	4563	299	1540	168
September	780	7795	54	17	2338	141	780	82
October	95	951	6	2	285	18	95	10
November	16	157	1	0	47	3	16	2
December	0	0	0	0	0	0	0	0
Total (kg/ year)	246170	2412915	18953	6951	719533	46100	242703	26055

3.3.2 Hastings

Estimates of contaminant emissions for Hastings for different heating methods for winter worst-case and winter average are shown in Tables 3.8 and 3.9. The emission estimates indicate the following:

- Around 1.5 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at about 1.2 tonnes per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- About 96% of the PM_{10} emissions come from the burning of wood with 4% from the burning of coal.
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (45%). Multi fuel burners burning wood contribute 10% and open fires contribute 15% of the PM_{10} emissions from domestic home heating (Figure 3.5).

Monthly variations in appliance use and average days per week used are shown in Figures 3.6 and 3.7. Table 3.10 shows seasonal variations in contaminant emissions.

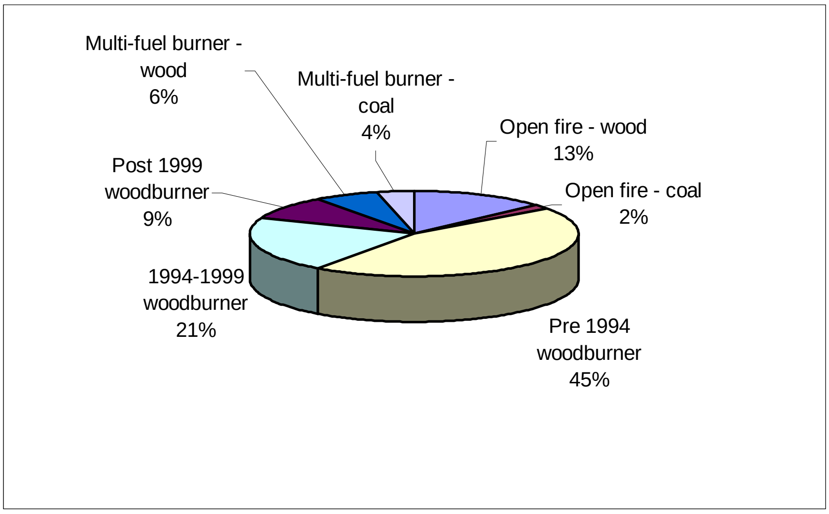

Figure 3.5: Relative contribution of different heating methods to PM_{10} from domestic heating in Hastings

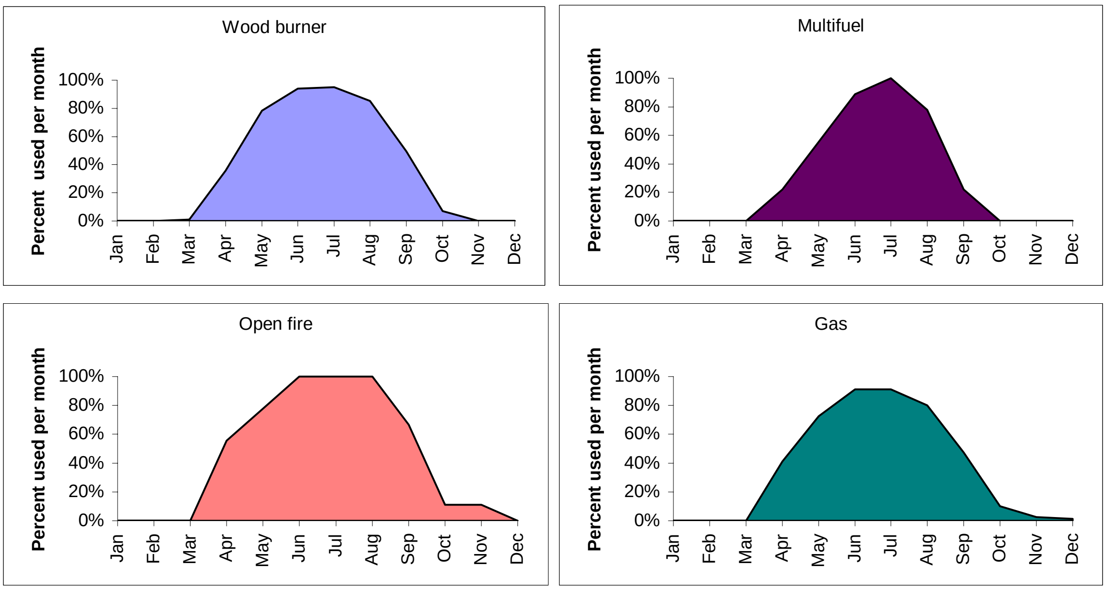

Figure 3.6: Monthly variations in appliance use in Hastings

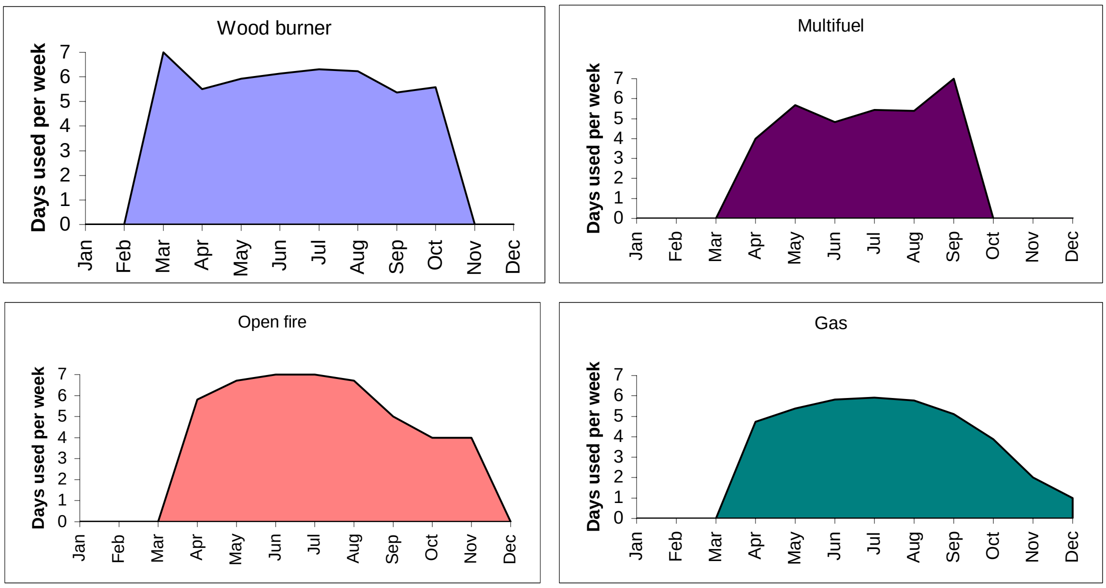

Figure 3.7: Average number of days per week appliances are used in Hastings per month

Table 3.8: Hastings worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	17.8	11%	178	124	12%	1782	1241	12%	29	20	26%	4	2	9%	535	372	12%	29	20	11%	178	124	12%	17	12	11%
Open fire - coal	1.0	1%	21	14	1%	79	55	1%	4	3	4%	5	3	12%	15	10	0%	3	2	1%	12	8	1%	0	0	0%
Wood burner																										
Pre 1994 wood burner	65.7	40%	722	503	48%	7225	5030	49%	33	23	30%	13	9	32%	2167	1509	49%	105	73	39%	722	503	48%	64	44	41%
1994-1999 wood burner	40.0	24%	280	195	18%	2803	1952	19%	20	14	18%	8	6	19%	841	586	19%	64	45	24%	280	195	19%	39	27	25%
Post 1999 wood burner	27.2	16%	163	114	11%	1634	1138	11%	14	9	12%	5	4	13%	490	341	11%	44	30	16%	163	114	11%	26	18	17%
Pellet Burner	0.1	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																										
Multi fuel burner – wood	8.6	5%	112	78	7%	1123	782	8%	4	3	4%	2	1	4%	337	234	8%	14	10	5%	112	78	8%	8	6	5%
Multi fuel burner - coal	1.5	1%	41	29	3%	177	123	1%	2	1	2%	4	3	11%	22	15	1%	4	3	1%	24	16	2%	0	0	0%
Gas	3.2	2%	0	0	0%	1	0	0%	4	3	4%	0	0	0%	0	0	0%	8	6	3%	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	0	0%
Total Wood	159	97%	1457	1014	96%	14568	10143	98%	99	69	91%	32	22	77%	4370	3043	99%	255	178	95%	1457	1014	98%	155	108	100%
Total Coal	2	1%	62	43	4%	255	178	2%	6	4	5%	9	6	23%	37	26	1%	6	4	2%	35	25	2%	0	0	0%
Total	165		1519	1057		14823	10321		109	76		41	29		4407	3068		269	188		1492	1039		155	108	

Table 3.9: Hastings average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	15.8	12%	158	110	13%	1575	1097	14%	25	18	29%	3	2	9%	473	329	14%	25	18	12%	158	110	14%	15	11	13%
Open fire - coal	1.0	1%	21	14	2%	79	55	1%	4	3	4%	5	3	14%	15	10	0%	3	2	1%	12	8	1%	0	0	0%
Wood burner																											
Pre 1994 wood burner	48.0	38%	528	368	45%	5281	3677	46%	24	17	27%	10	7	28%	1584	1103	47%	77	53	37%	528	368	46%	47	32	39%
1994-1999 wood burner	35.4	28%	248	173	21%	2481	1728	22%	18	12	20%	7	5	20%	744	518	22%	57	39	27%	248	173	22%	34	24	29%
Post 1999 wood burner	17.5	14%	105	73	9%	1049	731	9%	9	6	10%	3	2	10%	315	219	9%	28	19	13%	105	73	9%	17	12	14%
Pellet Burner	0.1	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																											
Multi fuel burner - wood	5.9	5%	76	53	6%	761	530	7%	3	2	3%	1	1	3%	228	159	7%	9	7	4%	76	53	7%	6	4	5%
Multi fuel burner - coal	1.5	1%	41	29	4%	177	123	2%	2	1	2%	4	3	13%	22	15	1%	4	3	2%	24	16	2%	0	0	0%
Gas	2.5	2%	0	0	0%	0	0	0%	3	2	4%	0	0	0%	0	0	0%	6	4	3%	0	0	0%	0	0	0%
Oil	0.3	0%	0	0	0%	0	0	0%	1	0	1%	1	1	3%	0	0	0%	1	1	0%	0	0	0%	0	0	0%
Total Wood	122.6	96%	1115	776	95%	11149	7763	98%	79	55	89%	25	17	70%	3345	2329	99%	196	137	94%	1115	776	97%	119	83	100%
Total Coal	2.5	2%	62	43	5%	255	178	2%	6	4	6%	9	6	27%	37	26	1%	6	4	3%	35	25	3%	0	0	0%
Total	128		1177	819		11404	7940		88	61		35	24		3381	2354		210	146		1150	801		119	83	

Table 3.10: Monthly variations in contaminant emissions in Hastings

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0
April	336	3363	29	7	1009	62	336	36
May	942	9293	75	25	2779	172	933	99
June	1098	10612	84	32	3144	197	1071	112
July	1177	11404	88	34	3381	209	1150	119
August	1088	10520	83	32	3116	195	1062	111
September	695	6949	46	16	2085	127	695	76
October	122	1223	8	3	367	23	122	14
November	6	59	1	0	18	1	6	1
December	0	0	0	0	0	0	0	0
Total (kg/ year)	167255	1635132	12658	4588	486589	30130	164533	17352

3.3.3 Flaxmere

Estimates of contaminant emissions for Flaxmere for different heating methods for winter worst-case and winter average are shown in Tables 3.11 and 3.12. The emission estimates indicate the following:

- Around 0.7 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at just under half a tonne per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- Coal and oil are not widely used in Flaxmere for domestic home heating.
- Wood burning is the main source of PM_{10} in Flaxmere.
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (46%). Multi fuel burners burning wood contribute 6% and open fires contribute 13% of the PM_{10} emissions from domestic home heating (Figure 3.8).

Monthly variations in appliance use and average days per week used are shown in Figures 3.9 and 3.10. Although the number of days burners are used on average increases for some categories in November (Figure 3.10), the proportion of households using burners decreases at this time (Figure 3.9). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.16 shows seasonal variations in contaminant emissions.

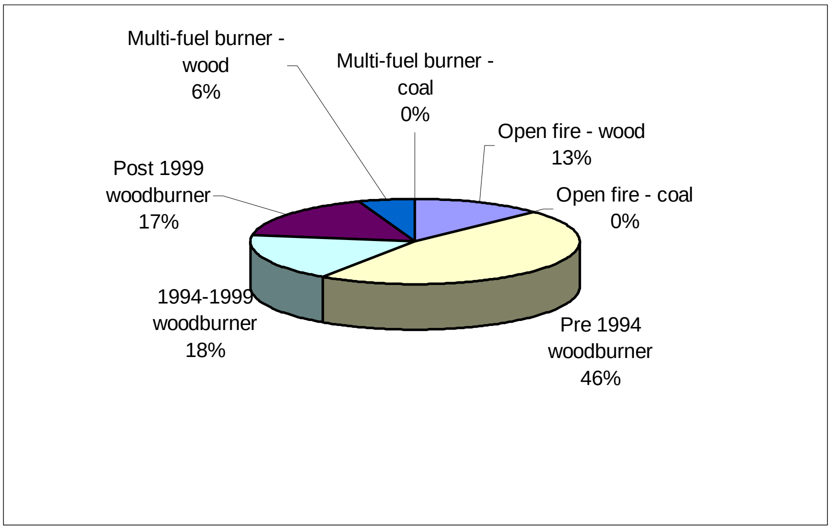

Figure 3.8: Relative contribution of different heating methods to PM_{10} from domestic heating in Flaxmere

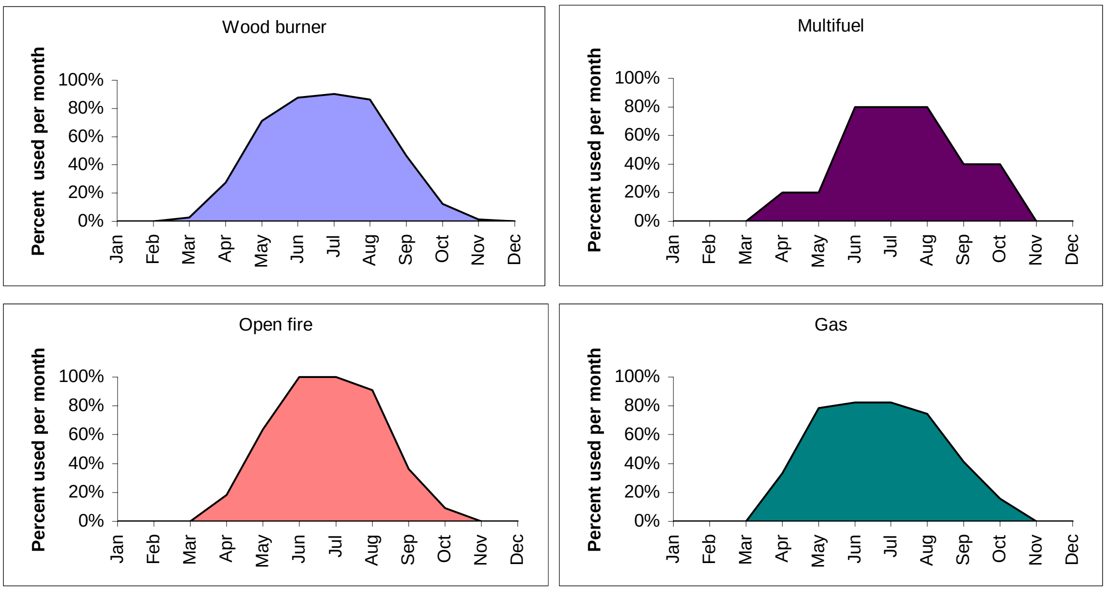

Figure 3.9: Monthly variations in appliance use in Flaxmere

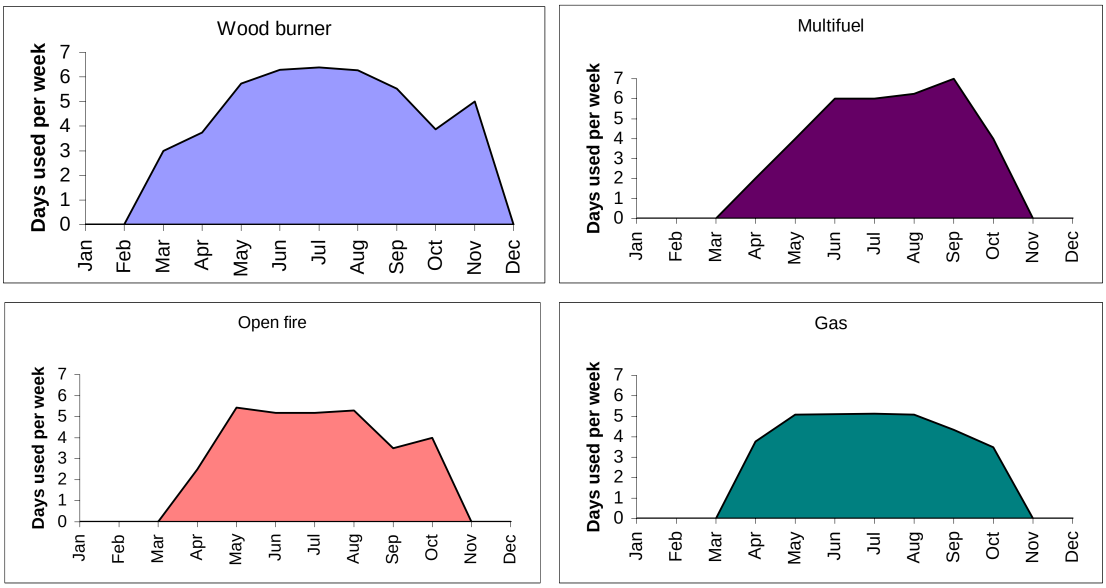

Figure 3.10: Average number of days per week appliances are used in Flaxmere per month

Table 3.11: Flaxmere worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	7.4	9%	74	154	10%	744	1545	10%	12	25	24%	1	3	9%	223	463	10%	12	25	9%	74	154	10%	7	15	9%
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%
Wood burner																										
Pre 1994 wood burner	32.8	41%	361	750	50%	3611	7497	50%	16	34	33%	7	14	41%	1083	2249	50%	53	109	40%	361	750	50%	32	66	41%
1994-1999 wood burner	19.7	24%	138	286	19%	1379	2863	19%	10	20	20%	4	8	25%	414	859	19%	32	65	24%	138	286	19%	19	40	25%
Post 1999 wood burner	16.4	20%	98	204	14%	985	2045	14%	8	17	17%	3	7	20%	295	613	14%	26	55	20%	98	204	14%	16	33	20%
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	0	0%
Multi fuel burner																										
Multi fuel burner – wood	3.8	5%	49	101	7%	488	1012	7%	2	4	4%	1	2	5%	146	304	7%	6	12	5%	49	101	7%	4	8	5%
Multi fuel burner - 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%
Gas	0.8	1%	0	0	0%	0	0	0%	1	2	2%	0	0	0%	0	0	0%	2	4	1%	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	0	0%
Total Wood	80	99%	721	1496	100%	7206	14962	100%	48	100	98%	16	33	100%	2162	4488	100%	128	266	98%	721	1496	100%	78	161	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%
Total	81		721	1496		7207	14962		49	102		16	33		2162	4488		130	270		721	1496		78	161	

Table 3.12: Flaxmere average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	t/day	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	5.9	11%	59	123	13%	594	1232	13%	9	20	28%	1	2	11%	178	370	13%	9	20	11%	59	123	13%	6	12	11%
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%
Wood burner																										
Pre 1994 wood burner	19.5	37%	214	445	47%	2142	4448	47%	10	20	29%	4	8	36%	643	1334	47%	31	65	37%	214	445	47%	19	39	37%
1994-1999 wood burner	12.0	23%	84	174	18%	837	1738	18%	6	12	18%	2	5	22%	251	521	18%	19	40	22%	84	174	18%	12	24	23%
Post 1999 wood burner	12.9	24%	77	160	17%	772	1603	17%	6	13	19%	3	5	24%	232	481	17%	21	43	24%	77	160	17%	12	26	25%
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	0	0%
Multi fuel burner																										
Multi fuel burner - wood	2.0	4%	26	54	6%	259	539	6%	1	2	3%	0	1	4%	78	162	6%	3	7	4%	26	54	6%	2	4	4%
Multi fuel burner - 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%
Gas	0.5	1%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	1	2	1%	0	0	0%	0	0	0%
Oil	0.1	0%	0	0	0%	0	0	0%	0	1	1%	0	1	4%	0	0	0%	0	1	0%	0	0	0%	0	0	0%
Total Wood	52.2	99%	460	956	100%	4605	9560	100%	33	68	97%	10	22	96%	1381	2868	100%	84	174	98%	460	956	100%	51	105	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%
Total	53		461	956		4605	9560		34	70		11	23		1381	2868		85	177		460	956		51	105	

Table 3.13: Monthly variations in contaminant emissions in Flaxmere

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0
April	120	1197	7	3	359	23	120	14
May	333	3325	25	8	998	63	333	37
June	478	4784	35	11	1435	89	478	53
July	460	4605	33	10	1381	85	460	51
August	376	3764	28	8	1129	69	376	41
September	246	2461	16	6	738	46	246	28
October	45	455	3	1	136	9	45	5
November	24	240	1	1	72	5	24	3
December	0	0	0	0	0	0	0	0
Total (kg/ year)	63706	637046	4546	1460	191110	11869	63706	7076

3.3.4 Hastings/ Flaxmere

Estimates of contaminant emissions for Hastings/ Flaxmere for different heating methods for winter worst-case and winter average are shown in Tables 3.14 and 3.15. The emission estimates indicate the following:

- Around 2.2 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at 1.6 tonnes per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- About 96% of the PM_{10} emissions come from the burning of wood with 4% from the burning of coal.
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (45%). Open fires contribute 14% of the PM_{10} and multi fuel burners around 9% (Figure 3.11).

Monthly variations in appliance use and average days per week used are shown in Figures 3.12 and 3.13. Although the number of days burners are used on average increases for some categories in November (Figure 3.13), the proportion of households using burners decreases at this time (Figure 3.12). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.16 shows seasonal variations in contaminant emissions.

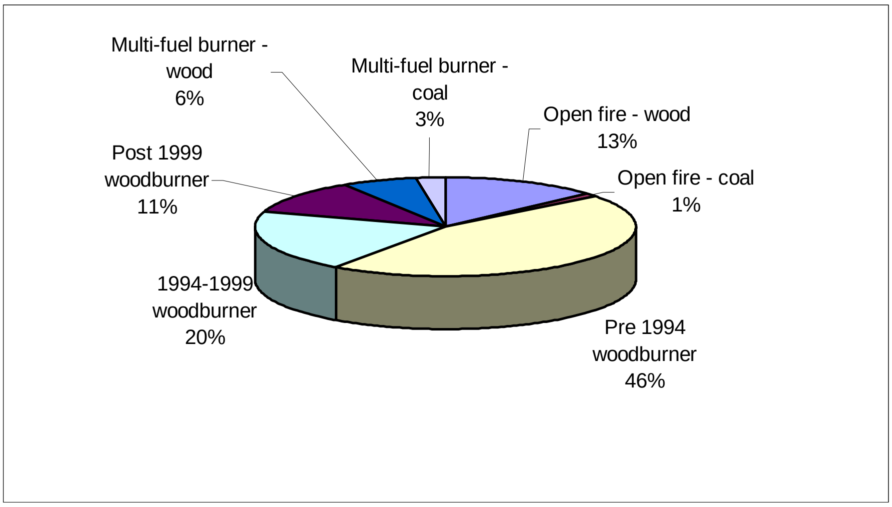

Figure 3.11: Relative contribution of different heating methods to PM_{10} from domestic heating in Hastings/ Flaxmere

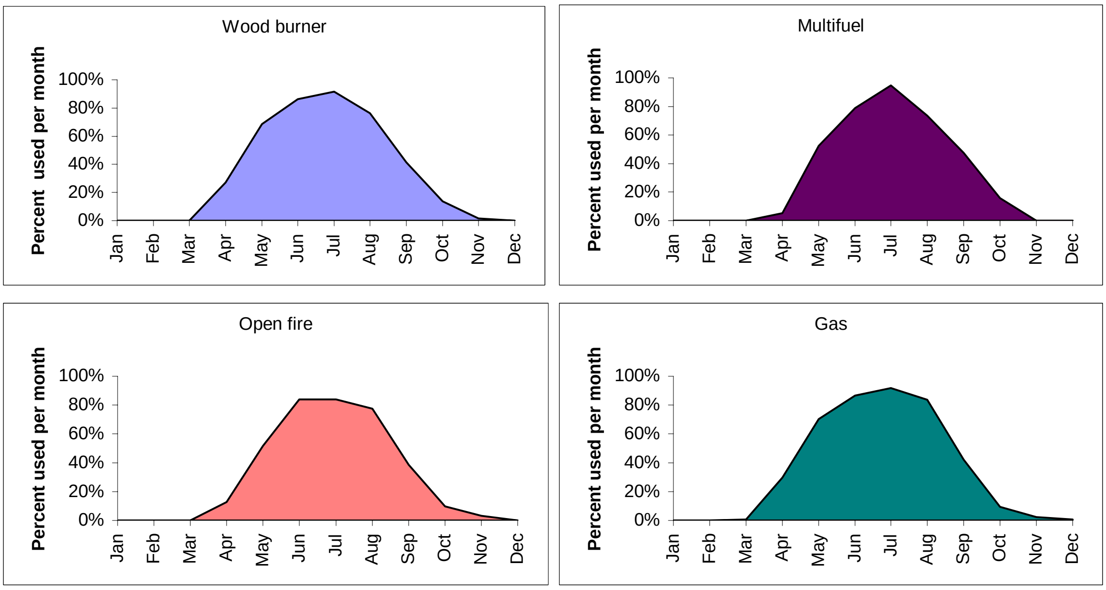

Figure 3.12: Monthly variations in appliance use in Hastings/ Flaxmere

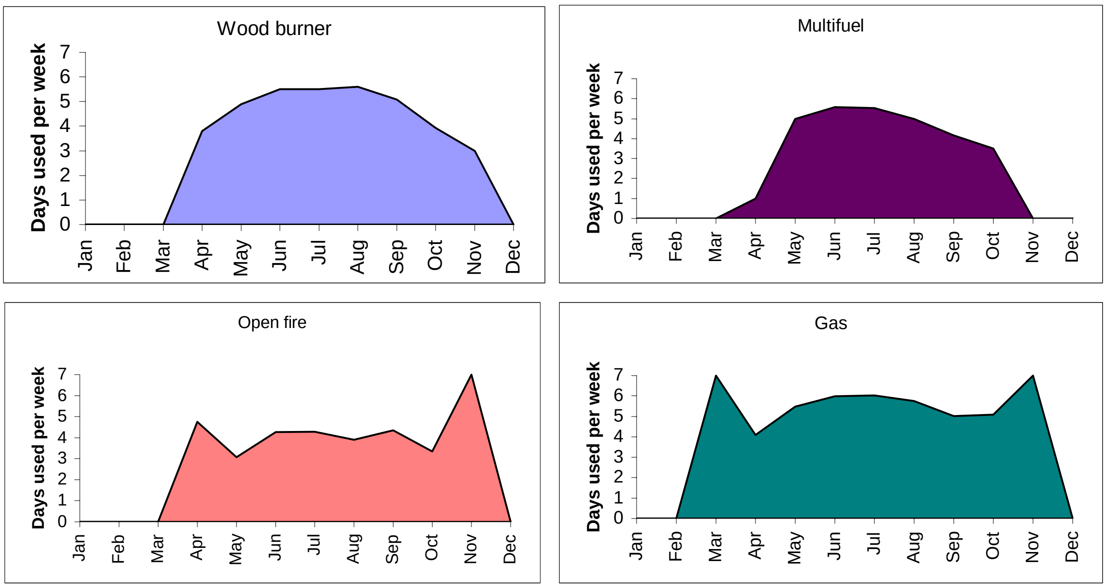

Figure 3.13: Average number of days per week appliances are used in Hastings/ Flaxmere per month

Table 3.14: Hastings/ Flaxmere worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	25.7	11%	257	134	12%	2571	1341	12%	41	21	26%	5	3	9%	771	402	12%	41	21	10%	257	134	12%	25	13	11%
Open fire - coal	0.8	0%	16	9	1%	63	33	0%	3	2	2%	4	2	7%	12	6	0%	2	1	1%	9	5	0%	0	0	0%
Wood burner																											
Pre 1994 wood burner	96.8	40%	1065	555	49%	10646	5551	49%	48	25	31%	19	10	35%	3194	1665	49%	155	81	39%	1065	555	49%	94	49	41%
1994-1999 wood burner	58.8	24%	412	215	19%	4115	2146	19%	29	15	19%	12	6	22%	1235	644	19%	94	49	24%	412	215	19%	57	30	25%
Post 1999 wood burner	42.1	17%	252	132	12%	2524	1316	12%	21	11	13%	8	4	15%	757	395	12%	67	35	17%	252	132	12%	41	21	18%
Pellet Burner	0.0	0%	0	0	0%	1	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 burner - wood	12.2	5%	159	83	7%	1591	829	7%	6	3	4%	2	1	4%	477	249	7%	20	10	5%	159	83	7%	12	6	5%
Multi fuel burner - coal	1.2	0%	33	17	1%	141	73	1%	1	1	1%	4	2	6%	18	9	0%	3	2	1%	19	10	1%	0	0	0%
Gas	4.0	2%	0	0	0%	1	0	0%	5	3	3%	0	0	0%	0	0	0%	10	5	3%	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	0	0%
Total Wood	236	98%	2145	1118	98%	21448	11183	99%	146	76	94%	47	25	86%	6434	3355	100%	377	197	96%	2145	1118	99%	229	119	100%
Total Coal	2	1%	49	26	2%	203	106	1%	4	2	3%	7	4	14%	29	15	0%	5	3	1%	28	15	1%	0	0	0%
Total	241.6		2194	1144		21652	11290		156	81		55	28		6464	3370		392	204		2173	1133		229	119	

Table 3.15: Hastings/ Flaxmere average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	21.7	12%	217	113	13%	2169	1131	14%	35	18	28%	4	2	9%	651	339	14%	35	18	12%	217	113	13%	21	11	12%
Open fire - coal	1.0	1%	21	11	1%	79	41	0%	4	2	3%	5	3	11%	15	8	0%	3	1	1%	12	6	1%	0	0	0%
Wood burner																										
Pre 1994 wood burner	67.5	37%	742	387	45%	7423	3871	46%	34	18	28%	13	7	29%	2227	1161	47%	108	56	37%	742	387	46%	65	34	39%
1994-1999 wood burner	47.4	26%	332	173	20%	3319	1730	21%	24	12	19%	9	5	21%	996	519	21%	76	40	26%	332	173	21%	46	24	27%
Post 1999 wood burner	30.4	17%	182	95	11%	1821	950	11%	15	8	12%	6	3	13%	546	285	11%	49	25	16%	182	95	11%	29	15	17%
Pellet Burner	0.1	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																										
Multi fuel burner - wood	7.9	4%	102	53	6%	1021	532	6%	4	2	3%	2	1	3%	306	160	6%	13	7	4%	102	53	6%	8	4	4%
Multi fuel burner - coal	1.5	1%	41	21	3%	177	92	1%	2	1	1%	4	2	10%	22	12	0%	4	2	1%	24	12	1%	0	0	0%
Gas	2.9	2%	0	0	0%	1	0	0%	4	2	3%	0	0	0%	0	0	0%	7	4	2%	0	0	0%	0	0	0%
Oil	0.4	0%	0	0	0%	0	0	0%	1	0	1%	2	1	3%	0	0	0%	1	1	0%	0	0	0%	0	0	0%
Total Wood	174.8	97%	1575	821	96%	15754	8214	98%	111	58	91%	35	18	76%	4726	2464	99%	280	146	95%	1575	821	98%	170	88	100 %
Total Coal	2.5	1%	62	32	4%	255	133	2%	6	3	5%	9	5	20%	37	19	1%	6	3	2%	35	18	2%	0	0	0%
Total	180.6		1637	854		16010	8347		122	63		46	24		4763	2483		295	154		1611	840		170	88	

Table 3.16: Monthly variations in contaminant emissions in Hastings/ Flaxmere

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0
April	456	4563	37	10	1369	85	456	50
May	1274	12611	101	33	3774	235	1265	137
June	1577	15403	118	43	4581	285	1550	164
July	1637	16008	121	44	4763	293	1611	170
August	1463	14270	111	41	4241	263	1437	152
September	940	9404	62	21	2821	173	940	104
October	168	1677	11	4	503	32	168	19
November	30	304	2	1	91	5	30	3
December	0	0	0	0	0	0	0	0
Total (kg/ year)	230918	2271754	17205	6047	677572	41999	228196	24427

3.3.5 Havelock North

Estimates of contaminant emissions for Havelock North for different heating methods for winter worst-case and winter average are shown in Tables 3.17 and 3. 18. The emission estimates indicate the following:

- Around 0.7 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at just over half a tonne per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- About 85% of the PM_{10} emissions come from the burning of wood with 15% from the burning of coal.
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (46%). Multi fuel burners contribute 17% and open fires contribute 14% of the PM_{10} emissions from domestic home heating (Figure 3.14).

Monthly variations in appliance use and average days per week used are shown in Figures 3.15 and 3.16. Although the number of days burners are used on average increases for some categories in October, November and December (Figure 3.16), the proportion of households using burners decreases at this time (Figure 3.15). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.19 shows seasonal variations in contaminant emissions.

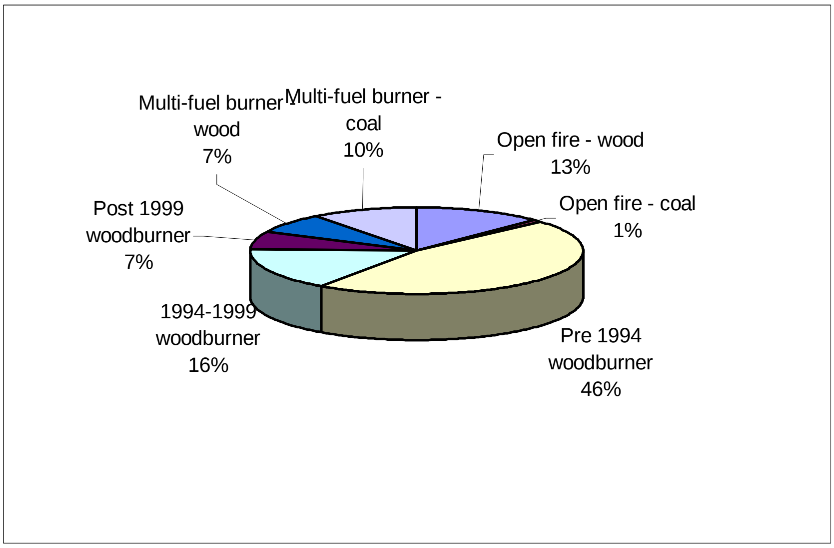

Figure 3.14: Relative contribution of different heating methods to PM_{10} from domestic heating in Havelock North

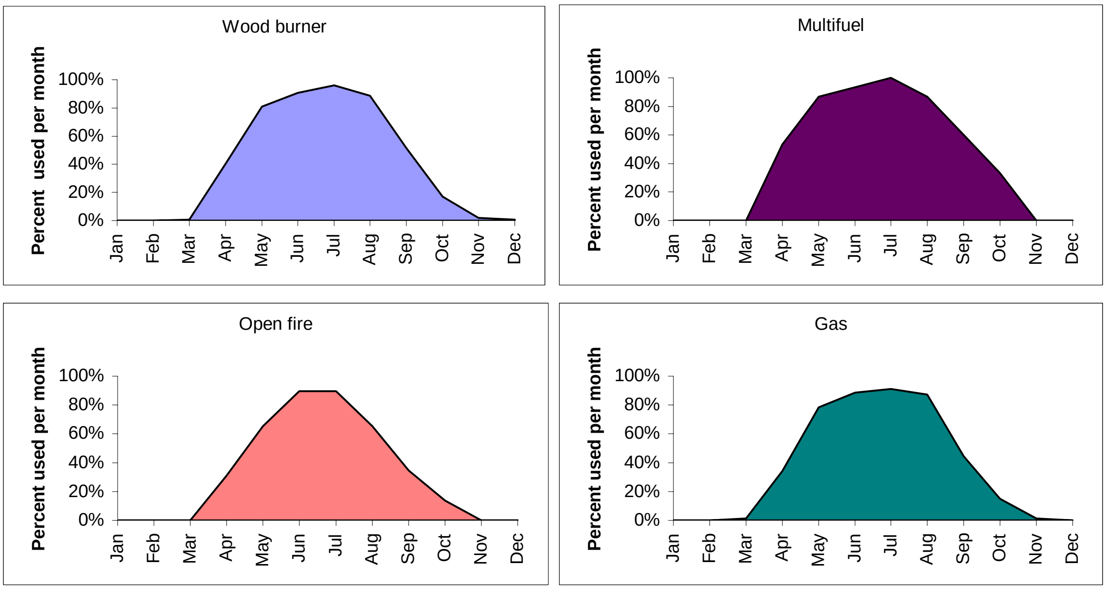

Figure 3.15: Monthly variations in appliance use in Havelock North

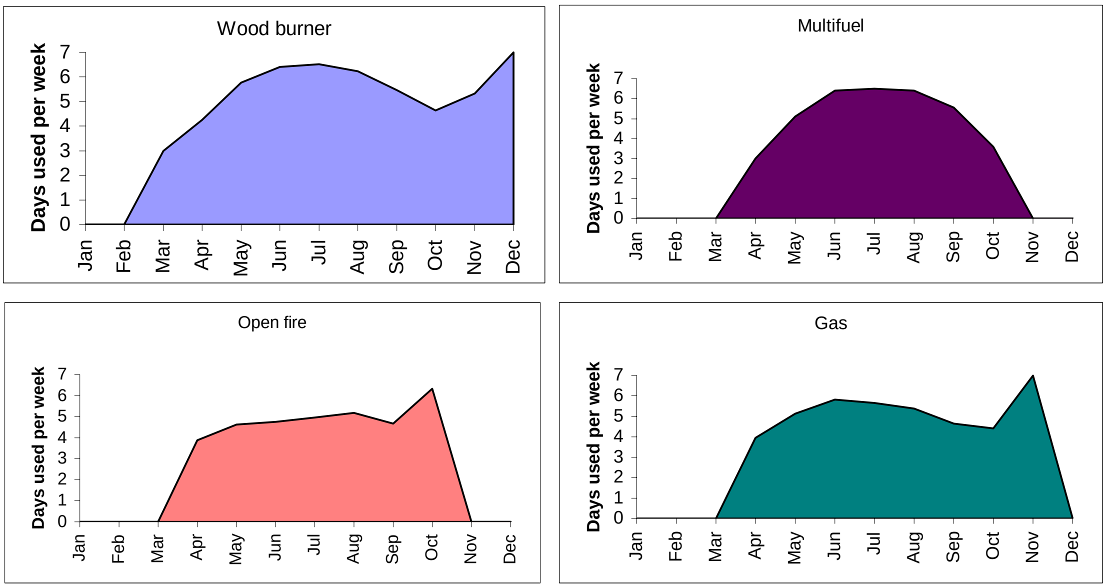

Figure 3.16: Average number of days per week appliances are used in Havelock North per month

Table 3.17: Havelock North worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	9.0	12%	90	67	12%	896	668	13%	14	11	28%	2	1	7%	269	200	14%	14	11	12%	90	67	13%	9	6	13%
Open fire - coal	0.6	1%	13	10	2%	51	38	1%	3	2	5%	3	2	12%	10	7	0%	2	1	1%	8	6	1%	0	0	0%
Wood burner																										
Pre 1994 wood burner	25.7	35%	282	211	39%	2824	2105	42%	13	10	25%	5	4	19%	847	632	44%	41	31	33%	282	211	41%	25	19	37%
1994-1999 wood burner	15.5	21%	108	81	15%	1084	808	16%	8	6	15%	3	2	11%	325	242	17%	25	18	20%	108	81	16%	15	11	23%
Post 1999 wood burner	13.9	19%	83	62	11%	831	620	12%	7	5	13%	3	2	10%	249	186	13%	22	17	18%	83	62	12%	13	10	20%
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	0	0%
Multi fuel burner																										
Multi fuel burner – wood	4.7	6%	62	46	8%	617	460	9%	2	2	5%	1	1	4%	185	138	10%	8	6	6%	62	46	9%	5	3	7%
Multi fuel burner - coal	3.4	5%	95	71	13%	407	303	6%	4	3	8%	10	8	38%	51	38	3%	9	7	7%	54	40	8%	0	0	0%
Gas	0.9	1%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	2	2	2%	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	0	0%
Total Wood	69	93%	625	466	85%	6252	4661	93%	44	33	85%	14	10	51%	1876	1398	97%	110	82	90%	625	466	91%	67	50	100%
Total Coal	4	5%	108	81	15%	458	341	7%	6	5	13%	13	10	49%	60	45	3%	10	8	9%	62	46	9%	0	0	0%
Total	74		734	547		6710	5002		52	39		27	20		1936	1443		123	91		687	512		67	50	

Table 3.18: Havelock North average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	6.8	13%	68	51	13%	683	509	13%	11	8	29%	1	1	7%	205	153	14%	11	8	12%	68	51	13%	7	5	49%
Open fire - coal	0.2	0%	4	3	1%	15	11	0%	1	1	2%	1	1	5%	3	2	0%	0	0	1%	2	2	0%	0	0	1%
Wood burner																										
Pre 1994 wood burner	22.8	42%	250	187	46%	2503	1866	49%	11	8	30%	5	3	25%	751	560	51%	36	27	40%	250	187	49%	22	16	22%
1994-1999 wood burner	12.4	23%	87	65	16%	870	648	17%	6	5	16%	2	2	14%	261	195	18%	20	15	22%	87	65	17%	12	9	12%
Post 1999 wood burner	6.0	11%	36	27	7%	357	266	7%	3	2	8%	1	1	6%	107	80	7%	10	7	11%	36	27	7%	6	4	6%
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	0	0%
Multi fuel burner																										
Multi fuel burner – wood	3.1	6%	40	30	7%	401	299	8%	2	1	4%	1	0	3%	120	90	8%	5	4	5%	40	30	8%	3	2	3%
Multi fuel burner - coal	2.0	4%	56	42	10%	239	178	5%	2	2	6%	6	4	32%	30	22	2%	5	4	6%	32	24	6%	0	0	7%
Gas	0.7	1%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	2	1	2%	0	0	0%	0	0	0%
Oil	0.3	1%	0	0	0%	0	0	0%	1	1	2%	1	1	7%	0	0	0%	1	1	1%	0	0	0%	0	0	0%
Total Wood	51.1	94%	481	359	89%	4814	3589	95%	33	25	88%	10	8	56%	1444	1077	98%	82	61	91%	481	359	93%	50	37	92%
Total Coal	2.2	4%	59	44	11%	253	189	5%	3	2	8%	7	5	37%	33	24	2%	6	4	6%	34	25	7%	0	0	8%
Total	54		541	403		5068	3778		38	28		18	14		1477	1101		90	67		515	384		50	37	

Table 3.19: Monthly variations in contaminant emissions in Havelock North

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	1	7	0	0	2	0	1	0
April	270	2451	17	10	703	43	251	23
May	409	3819	26	13	1110	68	389	38
June	509	4774	35	16	1392	84	485	47
July	541	5068	37	17	1477	89	515	50
August	446	4150	28	15	1205	73	423	40
September	364	3384	23	12	983	59	345	33
October	117	1174	8	2	352	20	117	12
November	24	239	1	1	72	4	24	3
December	15	145	1	0	44	3	15	2
Total (kg/ year)	82411	770651	5388	2610	224354	13524	78406	7522

3.3.6 Wairoa, Waipawa and Waipukurau

Estimates of contaminant emissions for Wairoa, Waipawa and Waipukurau for different heating methods for winter worst-case and winter average are shown in Tables 3.20 and 3.21. The emission estimates indicate the following:

- Just less than 0.8 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at just less than 0.6 tonnes per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- This arises largely from the burning of wood as coal is not commonly used in Wairoa, Waipawa and Waipukurau
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (45%). Multi fuel burners and open fires each contribute 13% of the PM_{10} emissions from domestic home heating (Figure 3.17).

Monthly variations in appliance use and average days per week used are shown in Figures 3.18 and 3.19. Although the number of days burners are used on average increases for some categories in October, November and December (Figure 3.19), the proportion of households using burners decreases at this time (Figure 3.18). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.22 shows seasonal variations in contaminant emissions.

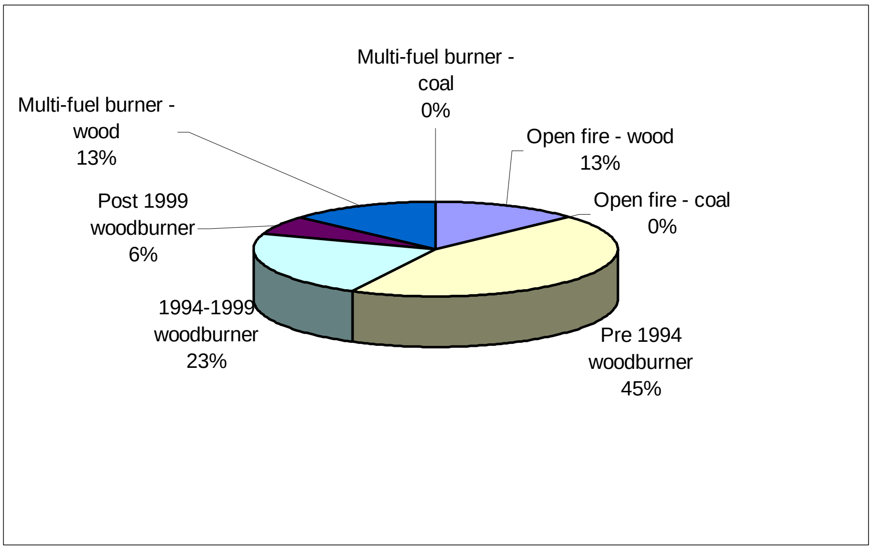

Figure 3.17: Relative contribution of different heating methods to PM_{10} from domestic heating in Wairoa, Waipawa and Waipukurau

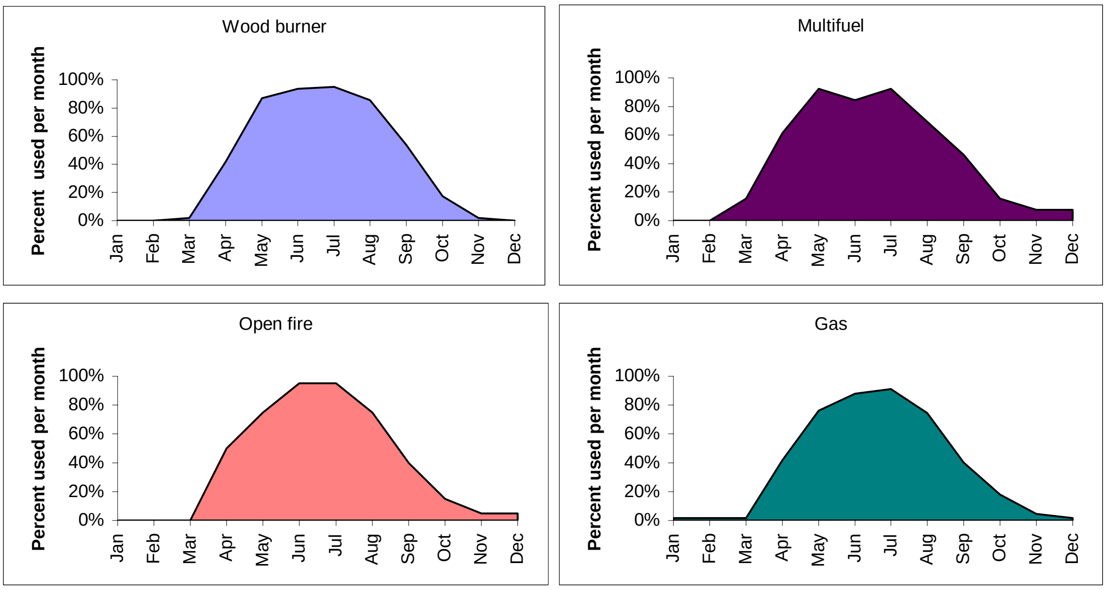

Figure 3.18: Monthly variations in appliance use in Wairoa, Waipawa and Waipukurau

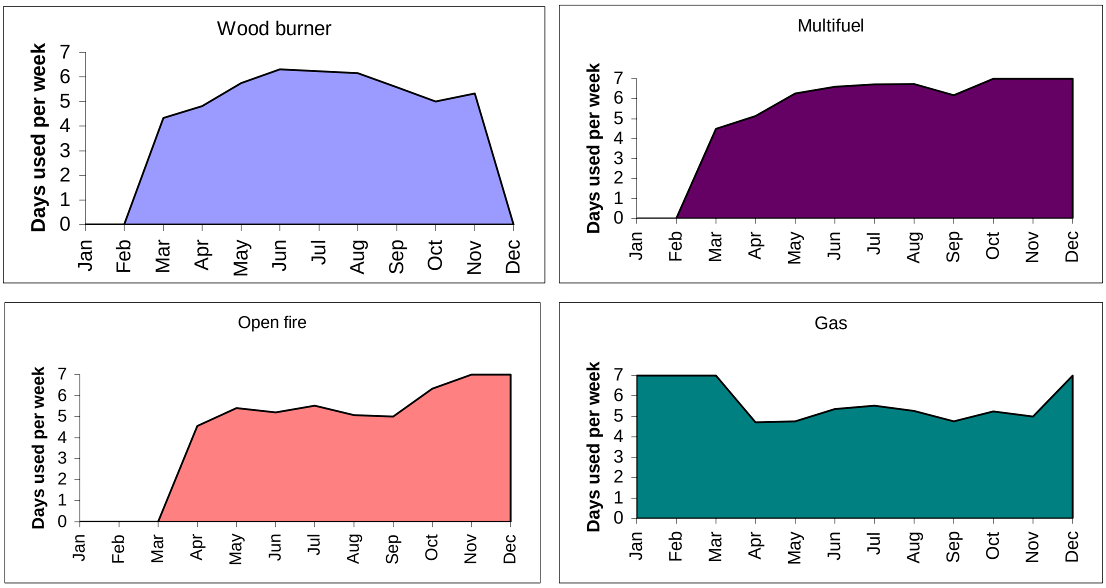

Figure 3.19: Average number of days per week appliances are used in Wairoa, Waipawa and Waipukurau per month

Table 3.20: Wairoa, Waipawa and Waipukurau worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	10.3	12%	103	48	13%	1034	484	13%	17	8	29%	2	1	12%	310	145	13%	17	8	12%	103	48	13%	10	5	12%
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%
Wood burner																										
Pre 1994 wood burner	28.3	32%	311	146	39%	3110	1455	39%	14	7	25%	6	3	33%	933	437	39%	45	21	32%	311	146	39%	27	13	33%
1994-1999 wood burner	21.2	24%	148	69	19%	1484	695	19%	11	5	19%	4	2	25%	445	208	19%	34	16	24%	148	69	19%	21	10	25%
Post 1999 wood burner	16.9	19%	101	47	13%	1011	473	13%	8	4	15%	3	2	20%	303	142	13%	27	13	19%	101	47	13%	16	8	20%
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	0	0%
Multi fuel burner																										
Multi fuel burner – wood	9.7	11%	127	59	16%	1267	593	16%	5	2	9%	2	1	11%	380	178	16%	16	7	11%	127	59	16%	9	4	11%
Multi fuel burner - 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%
Gas	1.2	1%	0	0	0%	0	0	0%	2	1	3%	0	0	0%	0	0	0%	3	1	2%	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	0	0%
Total Wood	86	99%	791	370	100%	7906	3700	100%	55	26	97%	17	8	100%	2372	1110	100%	138	65	98%	791	370	100%	84	39	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%
Total	88		791	370		7907	3700		56	26		17	8		2372	1110		141	66		791	370		84	39	

Table 3.21: Wairoa, Waipawa and Waipukurau average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	7.7	12%	77	36	13%	774	362	13%	12	6	29%	2	1	11%	232	109	13%	12	6	12%	77	36	13%	8	4	12%
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%
Wood burner																										
Pre 1994 wood burner	24.1	37%	265	124	45%	2652	1241	45%	12	6	29%	5	2	35%	796	372	45%	39	18	37%	265	124	45%	23	11	38%
1994-1999 wood burner	19.4	30%	136	64	23%	1359	636	23%	10	5	23%	4	2	28%	408	191	23%	31	15	30%	136	64	23%	19	9	30%
Post 1999 wood burner	6.4	10%	38	18	6%	381	179	6%	3	1	8%	1	1	9%	114	54	6%	10	5	10%	38	18	6%	6	3	10%
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	0	0%
Multi fuel burner																										
Multi fuel burner - wood	6.1	9%	79	37	13%	792	371	13%	3	1	7%	1	1	9%	238	111	13%	10	5	9%	79	37	13%	6	3	10%
Multi fuel burner - 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%
Gas	0.9	1%	0	0	0%	0	0	0%	1	1	3%	0	0	0%	0	0	0%	2	1	2%	0	0	0%	0	0	0%
Oil	0.3	0%	0	0	0%	0	0	0%	1	0	1%	1	0	7%	0	0	0%	1	0	1%	0	0	0%	0	0	0%
Total Wood	63.7	98%	596	279	100%	5958	2788	100%	40	19	96%	13	6	93%	1787	836	100 %	102	48	97%	596	279	100%	62	29	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%
Total	65		596	279		5958	2788		42	20		14	6		1787	837		105	49		596	279		62	29	

Table 3.22: Monthly variations in contaminant emissions in Wairoa, Waipawa and Waipukurau

	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	Benzene kg/day
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	26	261	2	1	78	5	26	3
April	261	2612	19	6	783	47	261	28
May	525	5254	36	11	1576	91	525	54
June	593	5932	41	13	1780	104	593	62
July	596	5958	42	13	1787	104	596	62
August	513	5129	36	11	1539	89	513	53
September	323	3231	23	7	969	59	323	35
October	125	1248	10	3	374	23	125	13
November	33	334	4	1	100	6	33	3
December	16	162	3	0	49	3	16	2
Total (kg/ year)	92163	921616	6601	1985	276478	16207	92163	9629

3.3.7 The rest of the Hawke's Bay Region

Estimates of contaminant emissions for the rest of the Hawke's Bay Region for different heating methods for winter worst-case and winter average are shown in Tables 3.23 and 3.24. The emission estimates indicate the following:

- Around 4 tonnes of PM_{10} are discharged under worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are slightly less at 3.2 tonnes per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- About 85% of the PM_{10} emissions come from the burning of wood with 15% from the burning of coal.
- The greatest amount of PM_{10} from domestic heating comes from older wood burners (35%). Multi fuel burners contribute 21%, of which 15% comes from the burning of coal (Figure 3.20).

Monthly variations in appliance use and average days per week used are shown in Figures 3.21 and 3.22. Although the number of days burners are used on average increases for some categories in October, November and December (Figure 3.22), the proportion of households using burners decreases at this time (Figure 3.21). Thus it is just a small number of households heating at this time, who burn on more days per week than most other households. Table 3.25 shows seasonal variations in contaminant emissions.

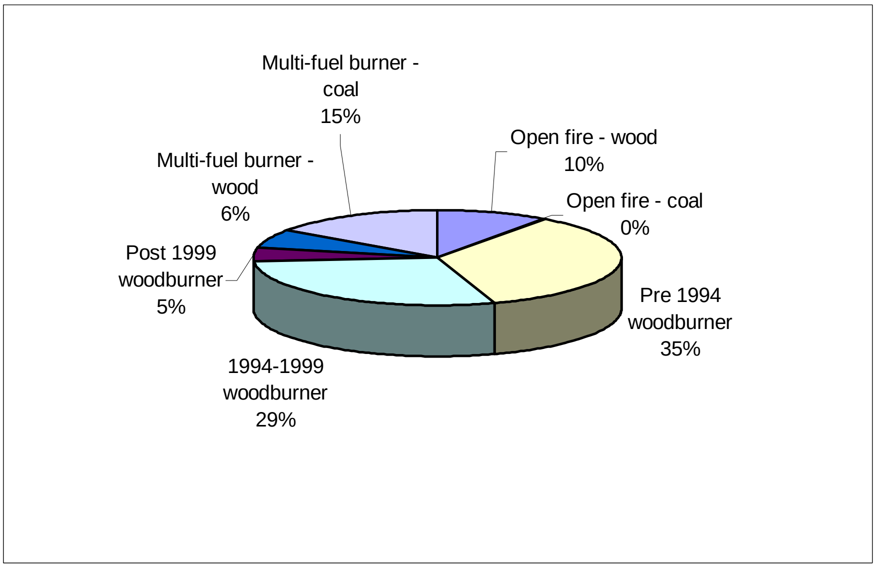

Figure 3.20: Relative contribution of different heating methods to PM_{10} from domestic heating in the rest of the Hawke's Bay Region

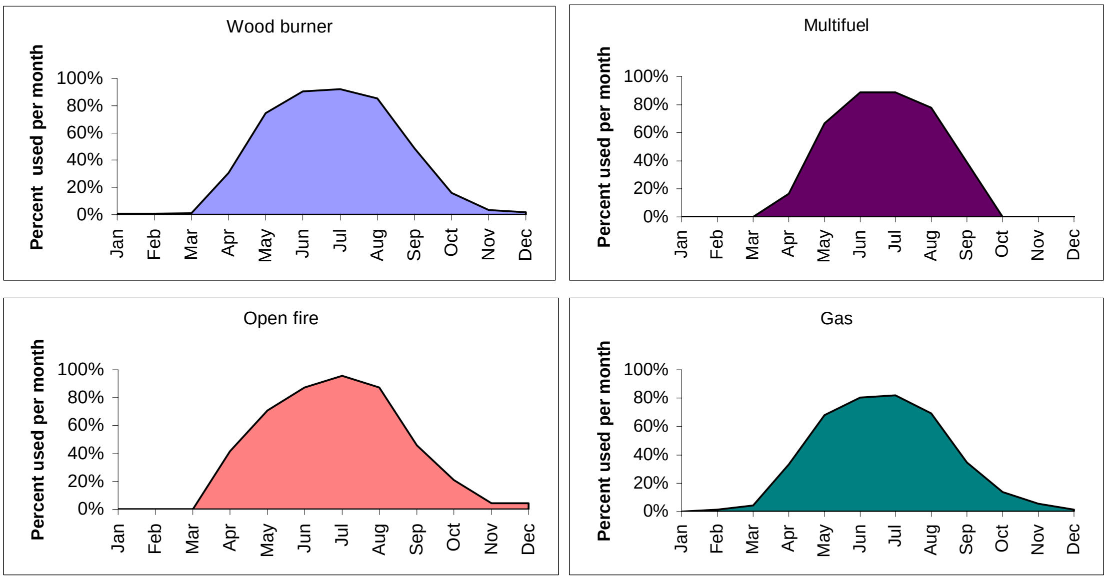

Figure 3.21: Monthly variations in appliance use in the rest of the Hawke's Bay Region

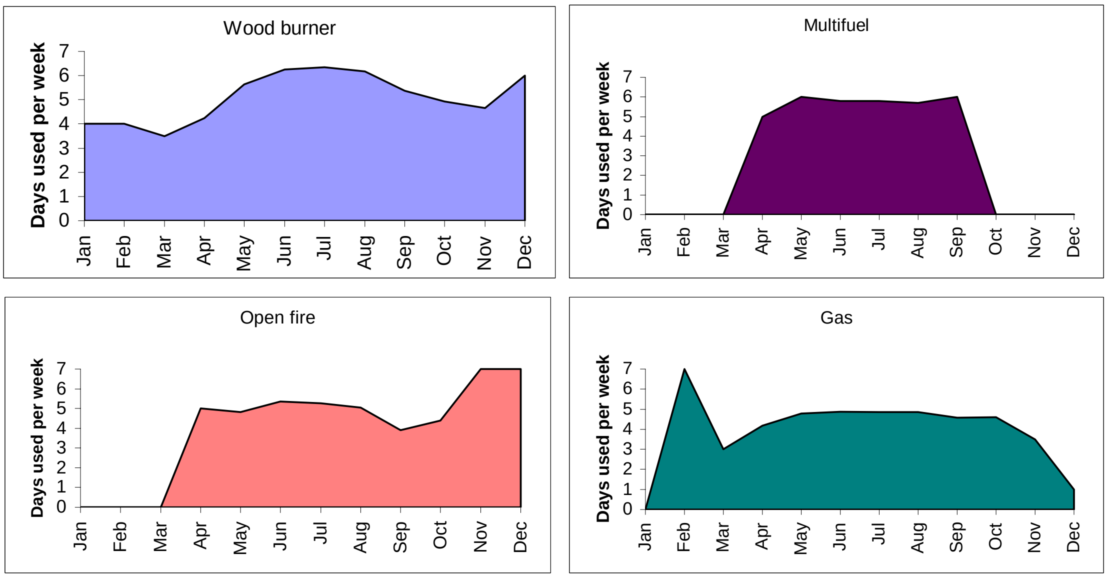

Figure 3.22: Average number of days per week appliances are used in the rest of the Hawke's Bay Region per month

Table 3.23: The rest of the Hawke's Bay Region worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	44.2	10%	442	0	11%	4416	3	11%	71	0	25%	9	0	6%	1325	1	12%	71	0	10%	442	0	11%	43	0	11%
Open fire - coal	0.5	0%	10	0	0%	36	0	0%	2	0	1%	2	0	2%	7	0	0%	1	0	0%	5	0	0%	0	0	0%
Wood burner																										
Pre 1994 wood burner	144.7	34%	1592	1	38%	15922	11	41%	72	0	26%	29	0	20%	4777	3	43%	232	0	33%	1592	1	41%	140	0	36%
1994-1999 wood burner	94.2	22%	659	0	16%	6594	5	17%	47	0	17%	19	0	13%	1978	1	18%	151	0	21%	659	0	17%	91	0	23%
Post 1999 wood burner	94.2	22%	565	0	14%	5652	4	15%	47	0	17%	19	0	13%	1696	1	15%	151	0	21%	565	0	14%	91	0	23%
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	0	0%
Multi fuel burner																										
Multi fuel burner – wood	29.1	7%	379	0	9%	3788	3	10%	15	0	5%	6	0	4%	1136	1	10%	47	0	7%	379	0	10%	28	0	7%
Multi fuel burner - coal	17.7	4%	496	0	12%	2125	2	6%	21	0	7%	53	0	37%	266	0	2%	46	0	6%	283	0	7%	0	0	0%
Gas	3.0	1%	0	0	0%	1	0	0%	4	0	1%	0	0	0%	0	0	0%	7	0	1%	0	0	0%	0	0	0%
Oil	1	0%	0	0	0%	1	0	0%	3	0	1%	5	0	4%	0	0	0%	4	0	1%	0	0	0%	0	0	0%
Total Wood	406	95%	3637	3	88%	36371	26	94%	252	0	90%	81	0	57%	10911	8	98%	650	0	92%	3637	3	93%	394	0	100%
Total Coal	18	4%	505	0	12%	2161	2	6%	22	0	8%	55	0	39%	272	0	2%	47	0	7%	288	0	7%	0	0	0%
Total	429		4143	3		38534	27		281	0		142	0		11184	8		709	1		3926	3		394	0	

Table 3.24: The rest of the Hawke's Bay Region average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			Benzene		
	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	31.4	9%	314	0	10%	3142	2	11%	50	0	23%	6	0	5%	943	1	11%	50	0	9%	314	0	10%	30	0	10%
Open fire - coal	0.5	0%	10	0	0%	36	0	0%	2	0	1%	2	0	2%	7	0	0%	1	0	0%	5	0	0%	0	0	0%
Wood burner																										
Pre 1994 wood burner	104.0	31%	1144	1	35%	11442	8	38%	52	0	24%	21	0	17%	3433	2	40%	166	0	30%	1144	1	37%	101	0	33%
1994-1999 wood burner	135.2	41%	946	1	29%	9462	7	32%	68	0	31%	27	0	22%	2838	2	33%	216	0	39%	946	1	31%	131	0	43%
Post 1999 wood burner	25.1	8%	151	0	5%	1508	1	5%	13	0	6%	5	0	4%	452	0	5%	40	0	7%	151	0	5%	24	0	8%
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	0	0%
Multi fuel burner																										
Multi fuel burner - wood	16.0	5%	208	0	6%	2082	1	7%	8	0	4%	3	0	3%	625	0	7%	26	0	5%	208	0	7%	16	0	5%
Multi fuel burner - coal	17.7	5%	496	0	15%	2125	2	7%	21	0	9%	53	0	44%	266	0	3%	46	0	8%	283	0	9%	0	0	0%
Gas	1.7	1%	0	0	0%	0	0	0%	2	0	1%	0	0	0%	0	0	0%	4	0	1%	0	0	0%	0	0	0%
Oil	1.0	0%	0	0	0%	1	0	0%	2	0	1%	4	0	3%	0	0	0%	3	0	1%	0	0	0%	0	0	0%
Total Wood	311.7	94%	2763	2	85%	27635	20	93%	190	0	88%	62	0	51%	8290	6	97%	499	0	90%	2763	2	91%	302	0	100%
Total Coal	18.2	5%	505	0	15%	2161	2	7%	22	0	10%	55	0	46%	272	0	3%	47	0	9%	288	0	9%	0	0	0%
Total	333		3269	2		29797	21		217	0		122	0		8563	6		554	0		3052	2		302	0	

Table 3.25: Monthly variations in contaminant emissions in the rest of the Hawke's Bay Region

	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	Benzene kg/day
January	5	49	0	0	15	1	5	1
February	5	49	0	0	15	1	5	1
March	5	49	0	0	15	1	5	1
April	645	6452	49	15	1936	120	645	72
May	2585	22961	164	103	6512	432	2368	231
June	3207	29177	209	117	8377	540	2990	296
July	3269	29796	215	118	8563	550	3052	302
August	3259	29701	212	117	8534	542	3042	298
September	1111	11107	77	25	3332	202	1111	122
October	309	3086	26	7	926	57	309	34
November	93	932	11	2	280	16	93	10
December	73	725	10	2	218	12	73	7
Total (kg/ year)	446455	4108785	29835	15536	1186387	75839	419729	42091

3.4 Daily variations in emissions from domestic home heating

Emissions estimates for domestic home heating in the Hawke's Bay Region were allocated to different time of day categories based on data from the time of day breakdown for Hamilton City. Of the areas where suitable information was available, Hamilton was considered to provide the most likely representation for the urban areas of the Hawke's Bay. Other areas considered were Auckland, Taupo and Tokoroa. Table 3.26 shows the proportion of each contaminant estimated to occur within each time of day period for Hamilton. These percentages were applied to the domestic heating emissions for each study area to give the time of day emission estimates also shown in Table 3.26.

Table 3.26: Daily variations in contaminant emissions from domestic home heating

	Suspended Particulate				Carbon monoxide				Nitrogen oxides				Sulphur oxides			
	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Hamilton distribution	8%	12%	65%	15%	8%	12%	65%	14%	7%	10%	65%	18%	6%	9%	62%	23%
Napier	166	253	1361	317	1656	2493	13422	2963	11	17	107	29	4	5	38	14
Havelock North	43	65	351	82	409	615	3312	731	3	4	24	7	1	2	11	4
Hastings	93	142	763	178	920	1385	7454	1646	6	9	57	16	2	3	22	8
Flaxmere	36	56	299	70	371	559	3010	664	2	4	22	6	1	1	7	3
Wairoa, Waipawa and Waipukurau	47	72	387	90	481	723	3894	860	3	4	27	7	1	1	9	3
Rest of Region	259	395	2121	495	2404	3618	19475	4300	15	23	141	38	7	11	75	28

	Volatile organic compounds				Carbon dioxide				Benzene				$PM_{2.5}$			
	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Hamilton distribution	8%	12%	66%	14%	8%	12%	64%	16%	8%	12%	65%	14%	8%	12%	65%	15%
Napier	491	739	4019	870	32	45	249	63	18	27	143	31	165	250	1348	303
Havelock North	118	178	970	210	7	10	58	15	4	6	32	7	41	62	336	76
Hastings	271	408	2221	481	17	24	134	34	10	15	78	17	92	139	750	169
Flaxmere	111	167	907	196	7	10	55	14	4	6	33	7	37	56	300	68
Wairoa, Waipawa and Waipukurau	143	216	1174	254	9	12	67	17	5	8	40	9	48	72	389	87
Rest of Region	687	1034	5625	1218	45	64	355	89	25	37	198	42	244	369	1991	448

4 Transport

Transportation emissions included in the inventory are motor vehicle tailpipe emissions, motor vehicle brake and tyre wear emissions, aviation emissions and marine emissions. Emissions from the latter two sources feature only within the Napier study area.

4.1 Methodology

4.1.1 Motor vehicle emissions

Assessing emissions from motor vehicles involves collecting data on vehicle kilometres travelled (VKT) under different levels of congestion, and the application of emission factors to these data. For the areas of Napier, Hastings, Flaxmere and Havelock North these data were obtained from the road network model developed and operated by Gabbites Porter for the Regional Land Transport Study. For Wairoa, Waipawa, Waipukurau and the rest of the Region, estimates of PM_{10} from the draft National Pollution Inventory (NPI) were used. As the latter method was found to significantly over predict PM_{10} emissions relative to the road network modelling approach for Napier, Hastings, Flaxmere and Havelock North, the NPI data for Wairoa, Waipawa, Waipukurau and the rest of the Region were adjusted based on the ratio of the NPI approach to the road network modelling approach for Napier.

The emission factors used to estimate motor vehicle emissions for PM_{10}, CO, NOx and VOC were taken from the New Zealand Traffic Emission Rates (NZTER) database based on a vehicle fleet profile derived from motor vehicle registrations for the Hawke's Bay Region (Table 4.1). 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/traffic conditions. Emission rates for SOx and CO_2 are not included in the NZTER database and were selected based on emission rates derived by the Fuel and Energy Group for the national vehicle fleet profile.

Benzene emission factors were derived based on a weight fraction of motor vehicle VOC emissions from the Australian National Pollutant Inventory. These were 6.58% for petrol vehicles, 1.01% for diesel vehicles and 0.943% for LPG vehicles. These data were apportioned using the Hawke's Bay Region vehicle fleet profile. Because of differences in the composition of New Zealand and Australian petrol, these data should be treated as rough estimates that provide an indication of order of magnitude only.

The emission factors for $PM_{2.5}$ were based on estimates of PM_{10} emissions using data from the British Columbia Lower Fraser Valley adjusted for the Hawke's Bay Region vehicle fleet profile. This indicated that around 57% of the PM_{10} tailpipe emissions would be in the $PM_{2.5}$ size fraction in the Hawke's Bay area. In addition to tailpipe emissions, PM_{10} from the wearing of brakes and tyres were also included in the emissions assessments. Emission factors for PM_{10} and $PM_{2.5}$ from these sources were also derived from the British Columbia Lower Fraser Valley data adjusted for the Hawke's Bay Region vehicle fleet profile. However, the extent to which these conversions based on overseas data are applicable to New Zealand vehicle emissions is uncertain. Consequently emission estimates for $PM_{2.5}$ from motor vehicles and PM_{10} from the wearing of tyre and brakes should be treated as indicative only.

Table 4.1: Vehicle registrations in the Hawke's Bay Region (December 2004)

	Petrol	Diesel	LPG	Other	Total
Cars	72,641	5,901	22	9	78,573
LCV	5,335	8,815	6	2	14,158
Bus	119	472			591
Heavy truck	1,419	2343			3,762
Motorcycle	1,683				1,683
Total	81,197	17,531	28	11	98,767
Total percentage	82%	18%	<1%	<1%	

For the purpose of assessing emissions from motor vehicles, VKTs are typically differentiated into three different driving conditions called Levels Of Service (LOS) and a fourth category representing emissions under cold running conditions. The LOS categories include free flow conditions (LOS category A-B), interrupted flow conditions (LOS category C-D) and congested flow conditions (LOS category E-F). The number of VKTs occurring under different LOS is usually determined on a road network model by the number of vehicles on a particular road relative to the capacity of the road. Table 4.2 shows the estimated number of VKTs under different LOS categories for Napier, Hastings, Flaxmere and Havelock North. The majority of the VKTs occur under free flowing (A-B) conditions with only a small proportion of the VKTs occurring under congested (E-F) conditions in Napier only.

Table 4.2: VKT by LOS and time of day in Napier, Hastings, Flaxmere and Havelock North

	Total VKT	VKT Level of Service			Time of day			
		A-B	C-D	E-F	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Napier	878,629	796499	80522	1608	207552	368397	257268	45411
Havelock North	142,046	128735	13311	0	33963	57670	43300	7112
Hastings	472,747	418205	54542	0	112450	196545	139451	24300
Flaxmere	88,816	88816	0	0	21772	36251	26420	4373

The emission factors for each contaminant under the different degrees of congestion are shown in Table 4.3. These are based on the assumption that 20% of the VKTs occur under cold start conditions.

Table 4.3: Emission factors for the Hawke's Bay Region based on a suburban driving regime

Driving Conditions	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	SOx g/VKT	PM_{10} g/VKT	$PM_{2.5}$ g/VKT	Benzene g/VKT
Congested – **E-F**	16.36	475.85	2.36	1.74	0.281	0.16	0.100	0.1316
Interrupted – **C-D**	13.10	406.10	1.86	1.65	0.235	0.12	0.071	0.1038
Free flow - **A-B**	10.69	365.44	1.73	1.55	0.215	0.10	0.063	0.0968

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) = A-B Emission Rate (g/VKT) * VKT (A-B) + C-D Emission Rate (g/VKT) * VKT (C-D) + E-F Emission Rate (g/VKT) * VKT (E-F)

Estimates of emissions for contaminants other than PM_{10} for Wairoa, Waipawa, Waipukurau and the rest of the Region were based on the ratio of PM_{10} to other contaminants for free flow (A-B) conditions. These were allocated to different time periods based on the time of day allocations for Napier.

4.1.2 Marine

The activity data for estimating emissions from commercial shipping at the Napier Port is the number and types of vessels entering and leaving the Port. Table 4.4 show the number of ships in and out of the Port of Napier during 2004. These data were obtained from the Port of Napier website (www. portofnapier.co.nz). The average KW per ship was estimated based on the gross tonnage of the vessels within each weight category.

Table 4.4: Shipping data for Port of Napier for 2004

Gross Tonnage	Approximate horsepower	Number of ships	Estimated average KW per ship
<1,000	500 - 1,000	14	550
1,000 - 5,000	1,000 - 5,000	82	2200
5,000 - 10,000	5,000 - 10,000	180	5500
10,000 - 20,000	10,000 - 20,000	18	11000
20,000 - 40,000	20,000 - 30,000	359	29500
40,000 - 60,000	30,000 - 50,000	49	40400

Emissions were estimated based on the emission factors shown in Table 4.5 and the following assumptions:

- Harbour transit times for each journey in and out of approximately 30 minutes for five kilometres[1]. Total transit time for "in" and "out" of one hour (pers comm., Charlie Rycroft, 2005).
- Operating power during harbour transit of 50% (Dravitzki, et. al, 1998).
- The SOx emission rate is based on an average sulphur content of 1%[2].

Table 4.5: Emission factors for shipping (Dravitzki, et. al, 1998)

CO g/KWh	NOx g/KWh	SO_2 g/KWh	PM_{10} g/KWh
1.6	17	4.2	1.5

4.1.3 Aviation

The activity data for estimating air emissions from aviation was the number of take-offs and landings (LTO) cycles for different aircraft types. These data were collected from Nigel Sutton at Hawke's Bay Airport. Table 4.6 outlines the annual LTO cycles by time of day for Hawke's Bay airport.

Table 4.6: Annual take off and landing cycles (LTO) for Hawke's Bay Airport

	LTO	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Piper PA-28 Cherokee	3,631	1,452	1,816	363	
Piper PA-34 Seneca	6,524	2,936	2,610	652	326
Piper PA-42 Cheyenne	212	85	106	21	
Fairchild Metroliner	1,690	676	287	676	51
Saab 340A	12,197	4,879	4,269	3,049	
ATR 72	1,253	501	439	313	
Lockheed PK3 Orion	14	4	6	4	
Cessna Citation Jet	24	5	14	5	
Gulfstream Astra Jet	42	8	25	8	
Gulfsteam V Jet	14	3	8	3	
Boeing 737	2	1	1		
Robinson R44 helicopter	209	52	73	52	31
Bell UHIH Iroquoi helicopter	75	19	26	19	11
Total	25,887	10,621	9,680	5,166	420

Emission factors for aviation emissions were taken from a combination of sources including GVRD (1997), which were based on a combination of Canadian Federal Aviation Administration (FAA) Aircraft Emission Database, the USEPA AP-42 database and Leverton (1993). Table 4.7 outlines the emission rates used for aircraft types used at Hawke's Bay Airport and indicates sources of emission rates for each aircraft type.

[1] 5 kilometres was selected as transit outside of 5 kilometres is unlikely to result in emissions within the Napier study area.
[2] Although marine diesel oil typically has a sulphur content of less than 1%, larger vessels that will typically be using heavy fuel oil (HFO) dominate port activity. The sulphur content of HFO has decreased in many countries over the last decade. In 2003, an EU directive specified a maximum sulphur content of 1% for HFO. Although vessels from some countries visiting the port will have a higher sulphur content, on average 1% is assumed.

Table 4.7: Emission factors for aviation emissions (kg/ LTO)

	CO	NOx	NMVOC	SO_2	CO_2	Total PM	PM_{10}	$PM_{2.5}$
Piper PA[1]	4.1	0.2	3.5	0.0	3,150	0.54	0.3	0.2
Metroliner[2]	2.9	0.2	2.4	0.0	3150	0.54	0.3	0.2
SAAB 340[2]	1.0	0.4	0.1	0.0	3,150	0.54	0.3	0.2
ATR- 72[2]	1.0	0.4	0.1	0.0	3,150	0.54	0.3	0.2
Boeing 737[3]	11.2	9.6	0.6	0.7	3,150	0.54	0.3	0.2
Small Jet[3]	4.4	0.0	0.3	0.0	3,150	0.54	0.3	0.2
Other Jet[3]	24.4	9.2	6.9	0.7	3,150	0.54	0.3	0.2
Helicopter[3]	0.4	0.5	0.5	0.1	3,150	0.54	0.3	0.2

[1] – from USEPA Federal Aviation Administration Aircraft Engine Emission Database for PA – 42 cheyenne.
[2] - emission factors were not available for all New Zealand Aircraft. Emission factors were selected based on conversions used for the Wellington Regional Council inventory (based on Wellington airport staff selection of most similar aircraft and engine types.
[3] as reported in GVRD (1997).

4.2 Transportation emissions

4.2.1 Motor vehicle emissions

Across the whole of the Hawke's Bay Region, motor vehicles are estimated to contribute around 313 kilograms of PM_{10}. Around 108 kilograms (35%) is estimated to occur in Napier and 58 kilograms (18%) in Hastings.

Figure 4.1 shows the breakdown of PM_{10} and $PM_{2.5}$ emissions from motor vehicles by tailpipe emissions and the wearing of brakes and tyres. These proportions are based on the Hawke's Bay Region vehicle fleet and are therefore applicable for all study areas. Based on overseas emission data adjusted for the Hawke's Bay vehicle fleet, approximately 58% of the tailpipe and 34% of the brake and tyre wear PM_{10} emissions are in the finer $PM_{2.5}$ size fraction. If these data are applicable to motor vehicle emissions in New Zealand, about 54% of the PM_{10} emissions from motor vehicles are likely to be in the finer $PM_{2.5}$ size fraction.

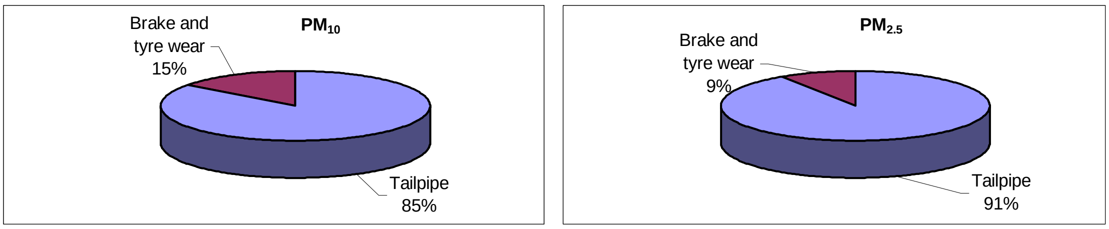

Figure 4.1: Breakdown of PM_{10} and $PM_{2.5}$ emissions from motor vehicles

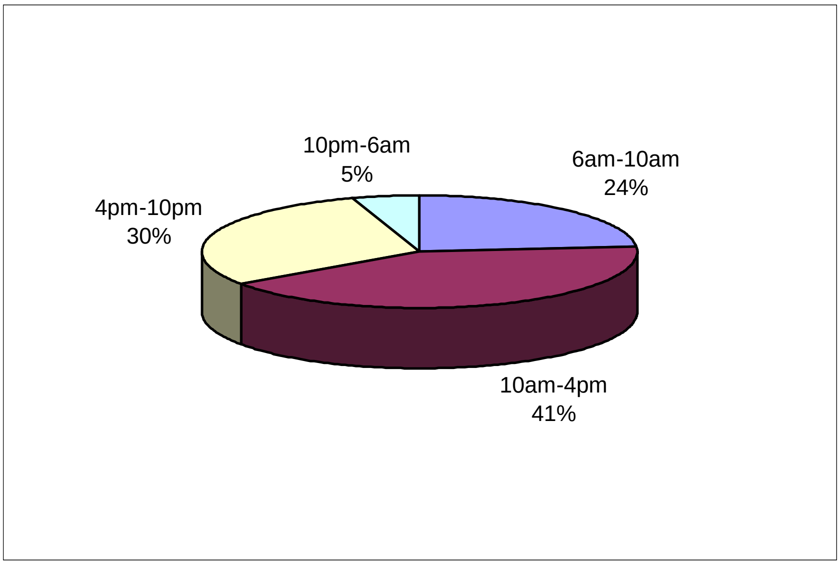

Figure 4.2: PM_{10} emissions in the Hawke's Bay Region by time of day

Figure 4.2 shows variations in total motor vehicle PM_{10} emissions in the Hawke's Bay Region by time of day. The majority of the emissions occur during the daytime (10am-4pm) time period and evening periods with smaller contributions during the morning (24%) and night time (5%) periods.

Tables 4.8 and 4.9 show emissions from motor vehicles in the Hawke's Bay Region by time of day and by weight and grams per hectare respectively.

4.2.2 Marine and aviation emissions

Daily emission estimates from aviation and marine sources are shown in Tables 4.10 and 4.11. Around 21 kilograms per day of PM_{10} is estimated to occur as a result of aircraft emissions during the landing and take-off cycles. In comparison, the amount of PM_{10} from marine sources is estimated to be around 29 kilograms per day. Emissions from both sources are included within the Napier study area.

As no time of day breakdown were available for marine data, emissions were assumed to occur evenly over a 24-hour period.

Table 4.8: Daily emissions from motor vehicles by time of day

	PM_{10}					CO					NOx					SOx				
	6am-10am	10am-4pm	4pm-10pm	10pm-6am	PM_{10} (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	NOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	SOx (kg)
Napier	26	45	32	6	108	2275	4007	2831	486	9599	324	574	402	70	1370	45	80	56	10	191
Havelock North	4	7	5	1	17	370	631	474	76	1551	53	90	68	11	222	7	13	9	2	31
Hastings	14	24	17	3	58	1243	2140	1544	260	5187	176	306	218	38	738	25	43	30	5	103
Flaxmere	3	4	3	1	11	233	388	283	47	950	34	56	41	7	138	5	8	6	1	19
Wairoa	2	4	3	1	10	217	383	270	46	917	31	55	38	7	131	4	8	5	1	18
Waipawa	1	3	2	0	6	130	229	162	28	549	19	33	23	4	78	3	5	3	1	11
Waipukurau	3	5	4	1	13	271	477	337	58	1144	39	68	48	8	163	5	10	7	1	23
Rest of Region	21	37	26	5	89	1,868	3,289	2,324	399	7880	266	471	330	58	1125	37	66	46	8	157
Total	74	130	92	16	313	6,608	11,544	8,225	1,399	27776	941	1,653	1,168	203	3965	131	230	163	28	552

	VOC					CO_2					Benzene					$PM_{2.5}$				
	6am-10am	10am-4pm	4pm-10pm	10pm-6am	VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Benzene (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	$PM_{2.5}$ (kg)
Napier	362	642	450	79	1533	100	280	128	17	525	20	36	25	4	86	14	25	17	3	59
Havelock North	59	101	76	12	248	17	46	22	3	87	3	6	4	1	14	2	4	3	0	9
Hastings	197	342	244	42	826	54	146	69	9	277	11	19	14	2	46	8	13	9	2	32
Flaxmere	38	63	46	8	154	11	32	14	2	59	2	4	3	0	9	1	2	2	0	6
Wairoa	35	61	43	8	146	10	27	12	2	50	2	3	2	0	8	1	2	2	0	6
Waipawa	21	37	26	4	88	6	16	7	1	30	1	2	1	0	5	1	1	1	0	3
Waipukurau	43	76	54	9	183	12	33	15	2	63	2	4	3	1	10	2	3	2	0	7
Rest of Region	298	527	370	65	1258	82	230	105	14	431	17	29	21	4	70	11	20	14	2	48
Total	1,052	1,849	1,308	227	4435	292	810	373	48	1523	59	103	73	13	248	40	71	50	9	170

Table 4.9: Summary of daily motor vehicle emissions

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Napier	3321	108	33	9599	2891	1370	413	191	57
Havelock North	1341	17	13	1551	1156	222	165	31	23
Hastings	1436	58	41	5187	3611	738	514	103	72
Flaxmere	482	11	22	950	1972	138	286	19	40
Wairoa	661	10	16	917	1387	131	198	18	28
Waipawa	783	6	8	549	701	78	100	11	14
Waipukurau	693	13	19	1144	1650	163	236	23	33
Rest of Region	1408079	89	0	7880	6	1125	1	157	0
Total	1416796	313	151	27776	13374	3965	1912	552	266
		VOC		**CO_2**		**Benzene**		**$PM_{2.5}$**	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Napier	3321	1533	462	525	158	86	26	62	19
Havelock North	1341	248	185	87	65	14	10	10	7
Hastings	1436	826	575	277	193	46	32	33	23
Flaxmere	482	154	319	59	123	9	18	6	13
Wairoa	661	146	221	50	76	8	12	6	9
Waipawa	783	88	112	30	38	5	6	4	5
Waipukurau	693	183	264	63	90	10	15	7	11
Rest of Region	1408079	1258	1	431	0	70	0	51	0
Total	1416796	4435	2139	1523	744	248	120	178	86

Table 4.10: Daily emissions from aviation and marine by time of day

	PM_{10}					**CO**					**NOx**					**SOx**				
	6am-10am	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**PM_{10} (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**CO (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**NOx (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**SOx (kg)**
Napier - Aviation	9	8	4	0	21	71	67	27	4	169	9	8	5	0	21	0.0	0.0	0.0	0.0	0.1
Napier - Marine	5	7	7	10	29	5	8	8	10	31	54	81	81	108	324	13	20	20	27	80

	VOC					CO_2					$PM_{2.5}$									
	6am-10am	10am-4pm	4pm-10pm	10pm-6am	VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	$PM_{2.5}$ (kg)					
Napier - Aviation	49	47	16	3	115	91	83	44	3	221	6	5	3	0	14					
Napier – Marine[1]																				

[1] No emission estimates were available for VOC, CO2 or $PM_{2.5}$ from shipping

Table 4.11: Summary of aviation and marine emissions

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Napier - Aviation	3321	21	6	169	51	21	6	0.1	0.0
Napier - Marine	3321	29	9	31	9	324	98	80	24
		VOC		**CO_2**		**$PM_{2.5}$**			
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**		
Napier - Aviation	3321	115	35	221	67	14	4		
Napier - Marine									

5 Industrial and Commercial

5.1 Methodology

Industrial and commercial activities discharging to air in the Hawke's Bay Region were identified primarily through the Regional Council databases. The latter source was comprehensive in that information was held on combustion activities with heat outputs as low as 100kW. Additional sources included in the inventory were schools, which were identified from the Ministry of Education's school database.

The selection of industries for inclusion in the inventory was based on potential for PM_{10} emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge only volatile gases (VOC) were not included in the assessment. Woolscouring and dag processing activities were also excluded from the inventory, as no reliable emission factors are available for this source.

The methodology used to estimate emissions from these activities involved the collection of data relating to the process (e.g. boiler) - referred to as activity data - and the application of emission factors to these data. A large proportion of the industrial activities discharging to air involve combustion processes. The activity data required for combustion processes is the quantity of fuel burnt.

The collection of activity data was primarily though a survey of industry in the Region, initially via a survey questionnaire posted to each industry. A copy of the survey questionnaire is shown in Appendix D. A follow up phone call was made to all industries surveyed to aid in improving the initial response rate. Non-respondents were phoned to offer assistance with the form or were asked to provide information over the phone. Data were collected for winter, autumn, spring and summer. Where the consent holder provided no information, the resource consent data was used to estimate emissions. For example, the amount of fuel burnt for combustion activities was based on 90% of the heat capability of the boiler. This is likely to overestimate fuel use and therefore emissions for these activities.

Emissions from a total of 102 industrial/commercial and school discharges were included in the assessment. The most common types of activities included combustion activities and abrasive blasting. Landfills were not included in the inventory as the inventory does not include an assessment of greenhouse gas emissions. A comprehensive emissions inventory for greenhouse gases carried out by NIWA details emissions for the Hawke's Bay Region (NIWA, 2001).

The combustion emissions were estimated using emission factor data as indicated in equation 5.1.

Equation 5.1 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

In the absence of site-specific information on emission discharges, emission factors were used to estimate the quantity of emissions discharged (Table 5.1). The coal fired boiler emission factors for PM_{10} are based on Coal Research Limited emission factors. Emission factors for $PM_{2.5}$ are based on AP42 particle size distribution factors, as are emission factors for PM_{10} from wood fired boilers and diesels and CO, NOx, SOx and benzene factors for all sources. Emission factors for natural gas, VOCs and CO_2 for combustion are based on NIWA 1996. Process emission factors e.g., for abrasive blasting and other non-combustion sources are from AP-42.

Table 5.1: Emission factors for industrial discharges

	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	Benzene g/kg
Coal boiler (underfeed stoker)	3.1	1.9	5.5	4.8	13.5	0.1	2400	0.00065
Diesel boiler	0.47	0.11	0.67	3.24	10.5	0.2	3194	0.022
Wood fired boiler	3.2	2.7	6.8	0.8	0.0	0.1	1069	0.97
Coal boiler (chain grate)	1.8	0.7	3.0	3.8	18.0	0.1	2400	0.00065
Waste oil	1.4	1.3	0.7	2.7	0.0	0.1	3105	0.021
Abrasive Blasting	0.69							
Sandblasting	13	1.3						
Lime manufacturing	28	3.3	.74		2.7		1604	
Lime quarrying	0.014							
Incineration	1.5145 kg/hr		1.48	1.09	1.78			
Crematorium	0.035			0.1			78	
	kg/m3	kg/m3	kg/m3	kg/m3	kg/m3	kg/m3	kg/m3	kg/m3
Natural gas	0.0001	0.0001	0.0006	0.0013	0.0000	0.0001	2.0100	0.0021

5.2 Industrial and commercial emissions

Table 5.2 shows daily estimates of industrial and commercial emissions for each study area during the winter months.

The largest amount of PM_{10} emissions in any single study area occurs within the rest of the Region area, which produces around 117 kilograms of PM_{10} per day. This excludes emissions from the Whirinaki Power Station, a potentially significant contributor, as the station is only used as a back up in the case of power shortages, transmission problems or when other generators are restricted or not available. The main source of PM_{10} emissions from industrial activities in most areas was combustion of coal, wood or diesel.

Figure 5.: Illustration of dust impacts of sandblasting a bridge in the Hawke's Bay Region (photo supplied by Bryce Lawrence, HBRC)

Table 5.2: Summary of industrial/ commercial emissions (winter daily)

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Napier	3321	57	17	115	35	28	8	32	10
Hastings	1341	39	29	92	69	122	91	177	132
Flaxmere	1436	7	5	4	3	3	2	7	5
Havelock North	482	5	9	9	18	5	11	14	29
Wairoa, Waipawa and Waipukarau	2137	32	15	45	21	46	21	196	92
Rest of the Region	1408079	273	0	1283	1	217	0	922	1
		VOC		**CO_2**		**Benzene**		**$PM_{2.5}$**	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Napier	3321	3	1	27	8	5	2	46	14
Hastings	1341	7	5	138	103	113	85	27	20
Flaxmere	1436	0	0	1	1	0	0	3	2
Havelock North	482	0	0	3	6	0	0	3	6
Wairoa, Waipawa and Waipukarau	2137	1	0	28	13	0	0	15	7
Rest of the Region	1408079	27	0	248	0	15	0	113	0

Table 5.3: Industrial/commercial emissions by time of day (winter daily)

	Suspended Particulate – PM_{10}					Suspended Particulate - $PM_{2.5}$					Carbon monoxide					Nitrogen oxides				
	6am-10am	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**PM_{10} (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**$PM_{2.5}$ (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**CO (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**NOx (kg)**
Napier	15	15	12	16	57	11	12	10	13	46	29	28	24	33	115	11	8	4	5	28
Hastings	16	9	6	8	39	11	6	4	6	27	34	20	16	21	92	31	29	26	35	122
Flaxmere	3	2	1	2	7	2	1	0	1	3	3	1	0	0	4	2	0	0	0	3
Havelock North	4	1	0	0	5	2	1	0	0	3	7	1	0	0	9	4	1	0	0	5
Wairoa, Waipawa and	12	9	7	4	32	7	4	3	1	15	19	12	9	5	45	16	13	11	6	46

Waipukarau																				
Rest of the Region	63	75	61	74	273	30	32	23	27	113	244	323	311	403	1283	56	57	49	55	217

	Sulphur oxides					**Volatile organic compounds**					**Carbon dioxide**					**Benzene**				
	6am-10am	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**SOx (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**VOC (kg)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**CO_2 (t)**	**6am-10am**	**10am-4pm**	**4pm-10pm**	**10pm-6am**	**Benzene (kg)**
Napier	21	6	2	3	32	1	1	1	1	3	8	6	5	7	27	1	1	1	2	5
Hastings	59	39	32	44	177	1	2	2	2	7	29	34	32	43	138	19	28	28	38	113
Flaxmere	6	1	0	0	7	0	0	0	0	0	1	0	0	29	1	0	0	0	0	0
Havelock North	11	2	0	0	14	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0
Wairoa, Waipawa and Waipukarau	58	57	53	27	196	0	0	0	0	1	9	8	7	4	28	0	0	0	0	0
Rest of the Region	199	228	214	279	922	5	7	7	9	27	52	63	59	74	248	3	4	4	5	15

6 Outdoor burning

Outdoor burning includes any backyard burning of household or garden/orchard wastes in a drum, incinerator or open air. Emissions from outdoor burning can contribute to concentrations of PM_{10} and other air contaminants. In some urban areas of New Zealand outdoor burning is prohibited because of the adverse health and nuisance effects associated with these emissions. Presently there are no regulations restricting outdoor burning in the Hawke's Bay Region. Figure 6.1 shows the localised impact of smoke from outdoor rubbish burning in a Hawke's Bay location.

Figure 6.1: Smoke from the burning of green material at a site in the Hawke's Bay region (photo supplied by Bryce Lawrence, HBRC)

6.1 Methodology

In this report, outdoor burning is separated into domestic household and garden waste, and outdoor burning of pruning from orchards and vineyards. Domestic data, collected via the household survey used primarily for domestic heating. are detailed in Appendix B. The activity data collected for this purpose was the frequency of burns and an estimate of the amount of material combusted per burn. This was used to estimate the daily material burnt in each study area based on the assumption that the burning is spread evenly throughout the week (Table 6.1). In reality it is probable that a greater proportion of burning occurs during the weekend, particularly in the urban areas. The proportion of green waste (60%) versus household rubbish burnt (40%) was based on data collected in Otago.

Table 6.1 shows a much greater amount of material is burnt in the rural areas per household on average than in the urban areas.

Table 6.1: Quantity of material burnt on outdoor rubbish fires per day

	Winter t/day	Spring t/day	Summer t/day	Autumn t/day	Winter kg/hh	Spring kg/hh	Summer kg/hh	Autumn kg/hh
Napier	9	7	5	6	0.5	0.3	0.2	0.3
Havelock North	7	7	7	6	1.6	1.7	1.7	1.6
Hastings	6	17	22	5	0.5	1.5	2.1	0.5
Flaxmere	2	2	2	2	0.7	0.8	0.6	0.7
Wairoa, Waipawa, Waipukurau	4	3	2	3	1.2	0.9	0.7	0.8
Rest of Region	41	34	28	35	3.5	2.9	2.3	2.9

The amount of burning carried out on orchards and vineyards was estimated based on discussions with orchardists and vineyard managers in the Region and other contacts in the viticulture industry. This industry indicated a large proportion (around 99%) of the prunings were mulched for most crop types. The exception was stone fruit of which around 20% was raked and burnt due to issues such as brown rot. Information supplied by Ken Robertson at Fruitfed indicated around 1063 hectares of land were used for summer fruits in the Region, around 4326 hectares for vineyards (John Barker, pers comm.) and around 7000 for pipfruit.

The quantity of prunings per year was estimated at about 2 tonnes per hectare of vineyard. This was based on a ratio of prunings to yield of around 1:5-10 and an estimated average yield across a range of varieties of 10 tonnes per hectare (David Richardson, pers comm., 2005). Assuming 95% was mulched this indicates around 200-400 tonnes of vineyard prunings may be burnt per year. As no data were sourced on the amount of pruning for stonefruit and pipfruit, it was assumed to be a similar amount per hectare as for vineyards. Outdoor burning of orchard and vineyard waste was assumed to occur within the rest of the Region study area.

Estimates of emissions from orchard burning did not include an assessment of emissions from the burning of rootball/ stumps and branches as a part of orchard replacement practices. This process occurs every 15-20 years (pers comm. Andrew Curtis, 2005).

Emissions were calculated using the emission factors in Table 6.2. The garden rubbish emission rates were used for orchard and vineyard prunings. The 60:40 combination of green waste to household rubbish factors given in Table 6.2 as the "domestic burning" emission rate was used for domestic outdoor burning.

Table 6.2: Outdoor burning emission factors

	$PM_{2.5}$ g/kg	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg	Benzene g/kg
Garden rubbish	8	8	42	3	0.5	4	1470	0.0
Household rubbish	17	19	42	3	0.5	4.278	1470	1.2
Domestic burning	11.7	12.5	42.0	3.0	0.5	4.3	1470	0.5

6.2 Emissions from outdoor burning

Outdoor burning emission estimates for the Hawke's Bay Region are shown in Table 6.3. Around 110 kg and 70 kg of PM_{10} are estimated to occur per winter's day within Napier and Hastings respectively. Of this, the majority (94%) is within the finer, $PM_{2.5}$ size fraction. Around 28 kilograms of PM_{10} per day is estimated to occur as a result of burning orchard and vineyard pruning. This is based on the maximum estimated amount burnt per year. The quantity of emissions is less than the estimated PM_{10} from domestic burning of garden waste and rubbish (515 kg/ day) in the rest of the Hawke's Bay study area.

It should be noted, however, that there are a number of uncertainties relating to the estimates of emissions from outdoor burning. In addition to uncertainties relating to the average outdoor burning quantities for orchards and vineyards, it is assumed that domestic burning is carried out evenly throughout the week, whereas in reality it is highly probable that a disproportionate amount of burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

Table 6.3: Domestic and horticultural outdoor burning emission estimates

Napier	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 kg/ day	$PM_{2.5}$ t/ day	Benzene kg/ day
Summer (Dec-Feb)	59	199	14	2	20	7	55	2
Autumn (Mar-May)	69	231	17	3	24	8	64	3
Winter (June-Aug)	110	371	26	4	38	13	103	4
Spring (Sept-Nov)	82	274	20	3	28	10	76	3
Hastings								
Summer (Dec-Feb)	280	942	67	11	96	33	262	11
Autumn (Mar-May)	69	230	16	3	24	8	64	3
Winter (June-Aug)	70	236	17	3	24	8	66	3
Spring (Sept-Nov)	207	695	50	8	71	24	194	8
Havelock North								
Summer (Dec-Feb)	82	277	20	3	28	10	77	3
Autumn (Mar-May)	78	262	19	3	27	9	73	3
Winter (June-Aug)	82	274	20	3	28	10	76	3
Spring (Sept-Nov)	85	286	20	3	29	10	80	3
Flaxmere								
Summer (Dec-Feb)	21	70	5	1	7	2	19	1
Autumn (Mar-May)	24	82	6	1	8	3	23	1
Winter (June-Aug)	25	86	6	1	9	3	24	1
Spring (Sept-Nov)	28	94	7	1	10	3	26	1
Wairoa, Waipawa, Waipukurau								
Summer (Dec-Feb)	30	101	7	1	10	4	28	1
Autumn (Mar-May)	35	118	8	1	12	4	33	1
Winter (June-Aug)	54	180	13	2	18	6	50	2
Spring (Sept-Nov)	40	134	10	2	14	5	37	2
Rest of the Region - domestic								
Summer (Dec-Feb)	345	1158	83	14	119	41	322	14

Autumn (Mar-May)	437	1470	105	17	150	51	409	17
Winter (June-Aug)	515	1730	124	21	177	61	482	21
Spring (Sept-Nov)	426	1431	102	17	146	50	399	17
Orchard and vineyard burning								
Summer (Dec-Feb)								
Autumn (Mar-May)	28	149	11	2	14	5	28	0
Winter (June-Aug)	28	149	11	2	14	5	28	0
Spring (Sept-Nov)								

7 Orchard Heaters

Orchard heaters are used by vineyards and orchards in the Hawke's Bay Region to prevent frost damage to fruit and fruit trees. The burners are fuelled with oil and lit at around 4am on selected days during the spring when frosts are predicted. The heat generated by the burners heats the air surrounding the fruit trees and vineyards to prevent frost damage to new spring growth. While a small number of orchards in the Region may use the older style frost pots for frost protection, the return stack style orchard burners (Figure 7.1) are the main oil fired frost protection method in the Region.

Figure 7.1: Illustration of a return stack burner (photo supplied by Chris Simmonds)

7.1 Methodology

The activity data required for orchard heaters is the number of burners used, the hours per day of use and the average fuel-burning rate per burner. Information on the number of burners used in the Region was obtained from Fruitfed Suppliers, who are the main distributor of return stack burners in the Hawke's Bay Region. They estimated a total of 2500 burners for the Region (pers comm., Roger Pearce, May 2005)

The average fuel-burning rate for the return stack burners was estimated at around 1.5 kilograms per hour (pers comm., Chris Simmonds, 2005). The average daily use of the burners was estimated to be from 4am to 8am on around 4 occasions per year on average for vineyards and 10 occasions per year on average for orchards (pers comm., Ken Roberston, Fruitfed, May 2005).

Emission factors for return stack orchard heaters were sourced from the USEPA AP-42 database. This indicated a particulate emission rate of 1.8 kilograms per hour per 1000 burners. The SOx emission rate was based on emission factors for oil combustion of 3.9 kilograms per tonne of fuel burnt, assuming average sulphur content of 0.5%. No data were available on CO emissions, and NOx emissions were assumed to be negligible owing to the relatively low combustion temperatures (USEPA, 1995).

7.2 Emissions from orchard heaters

Table 7.1 shows the estimated PM_{10} and SOx emissions from orchard heaters in the Hawke's Bay Region. Emission estimates are based on the assumption that all return stack heaters will be used on any given day when frost protection is required. It is likely that the data provides an overestimate or worst case estimate of the contribution of return stack burners to emissions in the Region as different crop types are likely to require protection at different times.

It is important to note also that the contribution from orchard heaters occurs on only a limited number of days per year (probably not more than 10 days most years). For the purposes of this evaluation the use of orchard burners is assumed to occur within the spring months.

Table 7.1: Estimated daily PM_{10} and SOx emissions in the Hawke's Bay Region on days when frost protection is used

	Emissions (kg/ day)					Summer	Autumn	Winter	Spring	Annual
	6am - 10am	10am - 4pm	4pm- 10pm	10pm- 6am	Total		kg/ day	kg/ day	kg/ day	kg/ year
PM_{10}	9	0	0	9	18	0	0	0	18	180
SOx	27	0	0	27	54	0	0	0	54	540

* annual total based on the assumption of estimated average usage of 10 days per year

8 Other sources of emissions

The major sources of PM_{10} and other contaminants during the winter months when PM_{10} concentrations are high in Napier and Hastings are likely to result from domestic home heating, outdoor burning, motor vehicles and industry. Under some conditions, e.g., elevated wind speeds, emissions from other sources such as sea spray may also contribute to PM_{10} measurements. This source isn't typically included in emission inventories because of difficulties in quantifying emissions.

Other sources of emissions not included in the inventory include vegetation, which can emit volatile organic compounds (VOCs) and nitrogen oxides (NOx). Concentrations of NO_2 are unlikely to be of concern in the Hawke's Bay Region. Emissions of VOCs are primarily estimated because of their potential contribution to the formation of ozone. It is uncertain whether or not ozone may be an issue in the Hawke's Bay.

Emissions of PM_{10} from wind blown dusts from the erosion of soils and from the tilling of land are also potential contributors. Although unlikely within the urban areas, some contribution from rural areas is possible. Limited emission data available for tilling suggests around 1.26 kg PM_{10} and 0.6 kg $PM_{2.5}$ is produced per hectare tilled (GVRD, 1998). Thus if 10 hectares were being tilled, emissions might be in the order of 12 kilograms of PM_{10} and 6 kg of $PM_{2.5}$.

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 the urban areas of Hawke's Bay Region are likely to be less than 10 kg per day.

Emissions from the use of railways were not included in the inventory but were estimated by the Ministry of Transport in 1998 (MOT, 1999) for the main rail centres. A total of 0.6 tonnes per year of PM_{10} from use of railways was estimated for Napier. This equates to less than 2 kilograms of PM_{10} per day.

9 Total Emissions

9.1 Napier

Around 2.4 tonnes of PM_{10} is discharged into the air over Napier on an average winter's day. This may increase to 4.2 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 87% of the daily total PM_{10} (Figure 9.1). Industry and motor vehicle emissions contribute 2% and 4% respectively, with outdoor burning, aviation and marine contributing 5%, 1% and 1%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.2. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 31% of the CO and 71% of the NOx.

Tables 9.1 and 9.2 show daily wintertime contaminant emissions in Napier by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.3. This indicates around 352 tonnes of PM_{10} per year are emitted in Napier. Table 9.4 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for home heating.

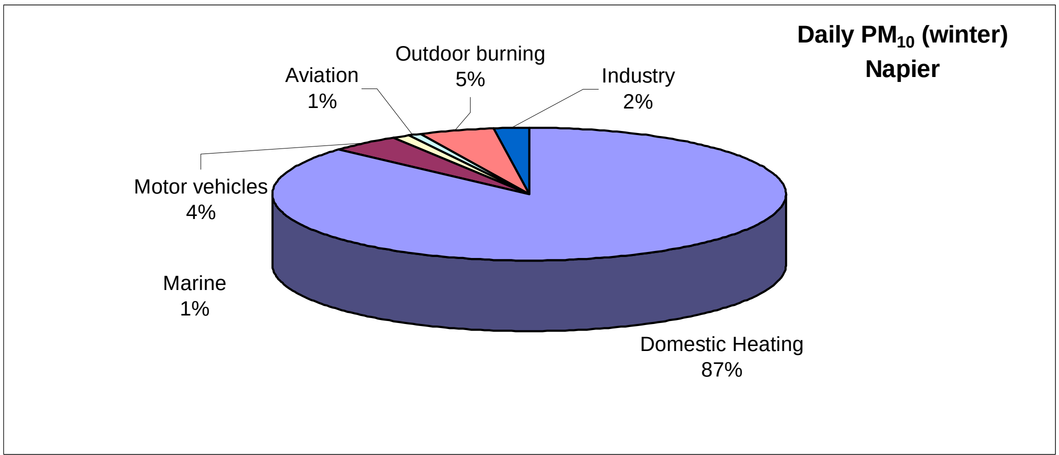

Figure 9.1: Relative contribution of different sources to average daily winter PM_{10} emissions in Napier

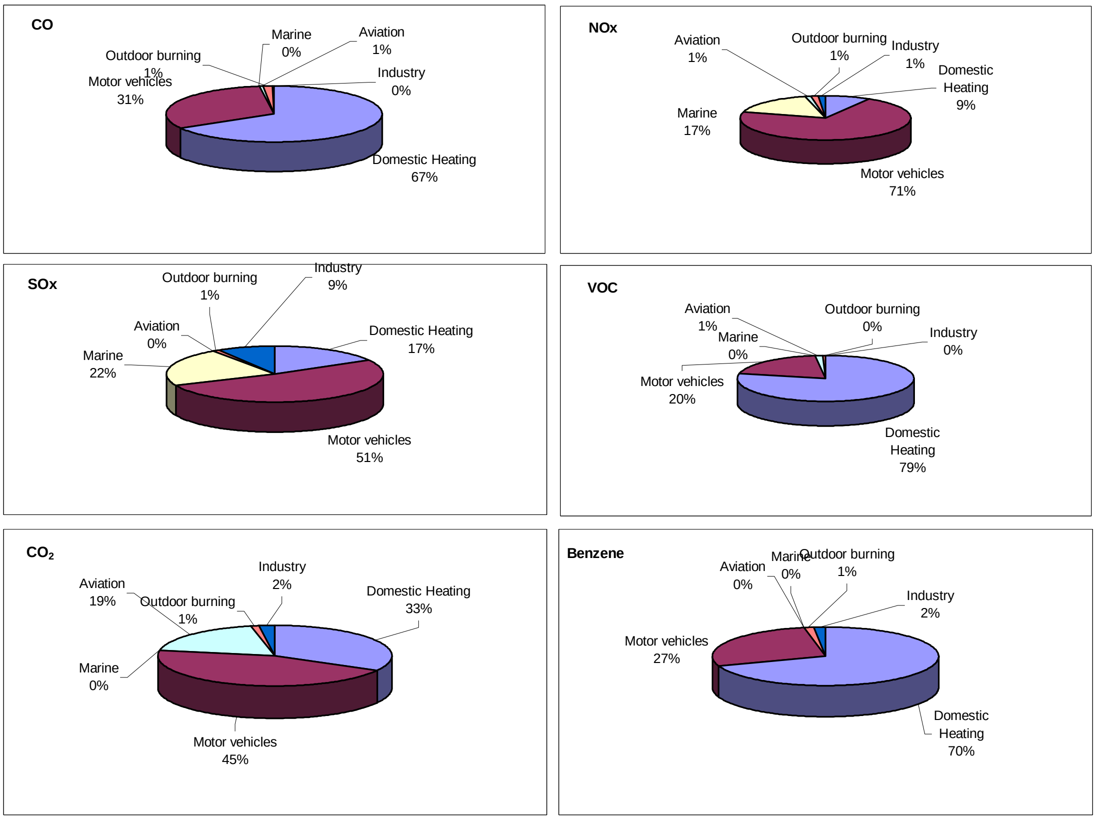

Figure 9.2: Relative contribution of sources to contaminant emissions in Napier

Table 9.1: Total daily emissions by time of day for Napier (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	166	253	1361	317	2098	165	250	1348	303	2066	1656	2493	13422	2963	20535	11	17	107	29	165
Motor vehicles	26	45	32	6	108	15	26	18	3	62	2275	4007	2831	486	9599	324	574	402	70	1370
Marine	5	7	7	10	29						5	8	8	10	31	54	81	81	108	324
Aviation	9	8	4	0	21	6	5	3	0	14	71	67	27	4	169	9	8	5	0	21
Outdoor burning	28	83			110	26	77			103	93	278			371	7	20			26
Industry	15	15	12	16	57	11	12	10	13	46	29	28	24	33	115	11	8	4	5	28
Total	248	411	1416	348	2423	223	370	1378	319	2291	4130	6882	16312	3496	30820	416	708	598	213	1935

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	4	5	38	14	61	491	739	4019	870	6119	32	45	249	63	389	18	27	143	31	219
Motor vehicles	45	80	56	10	191	362	642	450	79	1533	100	280	128	17	525	20	36	25	4	86
Marine	13	20	20	27	80															
Aviation	1	3			4	9	28			38	3	10			13	1	3			4
Outdoor burning	8	11	8	2	29	1	1	1	1	3	8	12	10	7	37	1	1	1	2	5
Industry	21	6	2	3	32	1	1	1	1	3	8	6	5	7	27	1	1	1	2	5
Total	84	114	116	53	368	912	1457	4486	953	7808	234	424	427	90	1175	41	67	170	37	314

Table 9.2: Summary of total Napier emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	2098	632	86%	20535	6184	67%	165	50	8%	61	18	17%	6119	1843	78%	389	117	33%	219	66	70%	2066	622	90%
Motor vehicles	108	33	4%	9599	2891	31%	1370	413	70%	191	57	52%	1533	462	20%	525	158	44%	86	26	27%	62	19	3%
Marine	29	9	1%	31	9	0%	324	98	17%	80	24	22%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Aviation	21	6	1%	169	51	1%	21	6	1%	0	0	0%	115	35	1%	221	67	19%	0	0	0%	14	4	1%
Outdoor burning	110	33	5%	371	112	1%	26	8	1%	4	1	1%	38	11	0%	13	4	1%	4	1	1%	103	31	4%
Industry	57	17	2%	115	34	0%	28	8	1%	32	9	9%	3	1	0%	27	8	2%	5	2	2%	46	14	2%
Total	2423	730	1	30820	9281	1	1935	583	1	368	111	1	7808	2351	1	1175	354	1	314	95	1	2291	690	1

Table 9.3: Total Napier annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	246	2413	19	7	720	46	26	243
Motor vehicle	40	3513	502	70	561	192	31	23
Marine	10	11	118	29				
Aviation	8	62	8	0	42	81		5
Outdoor burning	29	27	98	1	10	3	1	27
Industry	19	39	8	7	1	9	2	16
Total	352	6066	753	114	1334	331	60	314

Table 9.4: Seasonal variations in daily emissions in Napier

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	108	59	50	0	9599	55	101	0	1370	199	19
February	0	108	59	50	0	9599	55	101	0	1370	199	19
March	0	108	69	49	0	9599	64	100	0	1370	231	19
April	326	108	69	49	2967	9599	64	100	27	1370	231	19
May	1178	108	69	49	11660	9599	64	100	88	1370	231	19
June	1985	108	110	57	19449	9599	103	115	153	1370	371	28
July	2098	108	110	57	20535	9599	103	115	163	1370	371	28
August	1564	108	110	57	15301	9599	103	115	126	1370	371	28
September	780	108	82	55	7795	9599	76	112	54	1370	274	22
October	95	108	82	55	951	9599	76	112	6	1370	274	22
November	16	108	82	55	157	9599	76	112	1	1370	274	22
December	0	108	59	50	0	9599	55	101	0	1370	199	19
	SOx kg/day				**VOC kg/day**				**CO_2 t/day**			
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**
January	0	191	2	7	0	1533	20	2	0	525	7	22
February	0	191	2	7	0	1533	20	2	0	525	7	22
March	0	191	3	25	0	1533	24	2	0	525	8	23
April	18	191	3	25	869	1533	24	2	62	525	8	23
May	30	191	3	25	3485	1533	24	2	226	525	8	23
June	55	191	4	32	5796	1533	38	3	369	525	13	27
July	59	191	4	32	6119	1533	38	3	386	525	13	27
August	46	191	4	32	4563	1533	38	3	299	525	13	27

September	17	191	3	12	2338	1533	28	3	141	525	10	24
October	2	191	3	12	285	1533	28	3	18	525	10	24
November	0	191	3	12	47	1533	28	3	3	525	10	24
December	0	191	2	7	0	1533	20	2	0	525	7	22
	Benzene kg/day				**$PM_{2.5}$** kg/day							
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**				
January	0	86	2	5	0	62	55	46				
February	0	86	2	5	0	62	55	46				
March	0	86	3	6	0	62	64	45				
April	32	86	3	6	306	62	64	45				
May	129	86	3	6	1169	62	64	45				
June	208	86	4	5	1956	62	103	41				
July	219	86	4	5	2066	62	103	41				
August	168	86	4	5	1540	62	103	41				
September	82	86	3	5	780	62	76	41				
October	10	86	3	5	95	62	76	41				
November	2	86	3	5	16	62	76	41				
December	0	86	2	5	0	62	55	46				

9.2 Hastings

Around 1.3 tonnes of PM_{10} is discharged into the air over Hastings on an average winter's day. This may increase to 1.5 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 88% of the daily total PM_{10} (Figure 9.3). Industry and motor vehicle emissions contribute 3% and 4% respectively, with outdoor burning contributing 5%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.4. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 31% of the CO and 76% of the NOx.

Tables 9.5 and 9.6 show daily wintertime contaminants emissions in Hastings by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.7. This indicates around 257 tonnes of PM_{10} per year are emitted in Hastings. Table 9.8 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

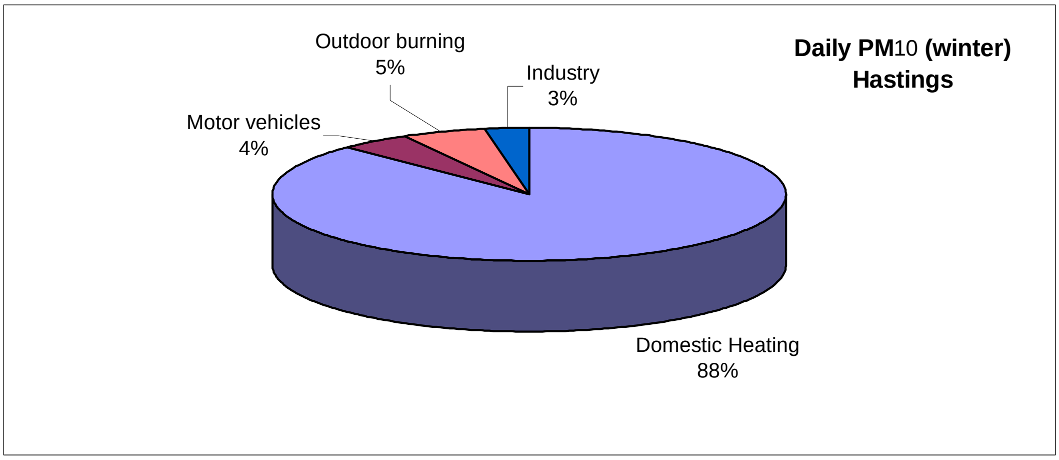

Figure 9.3: Relative contribution of different sources to average daily winter PM_{10} emissions in Hastings

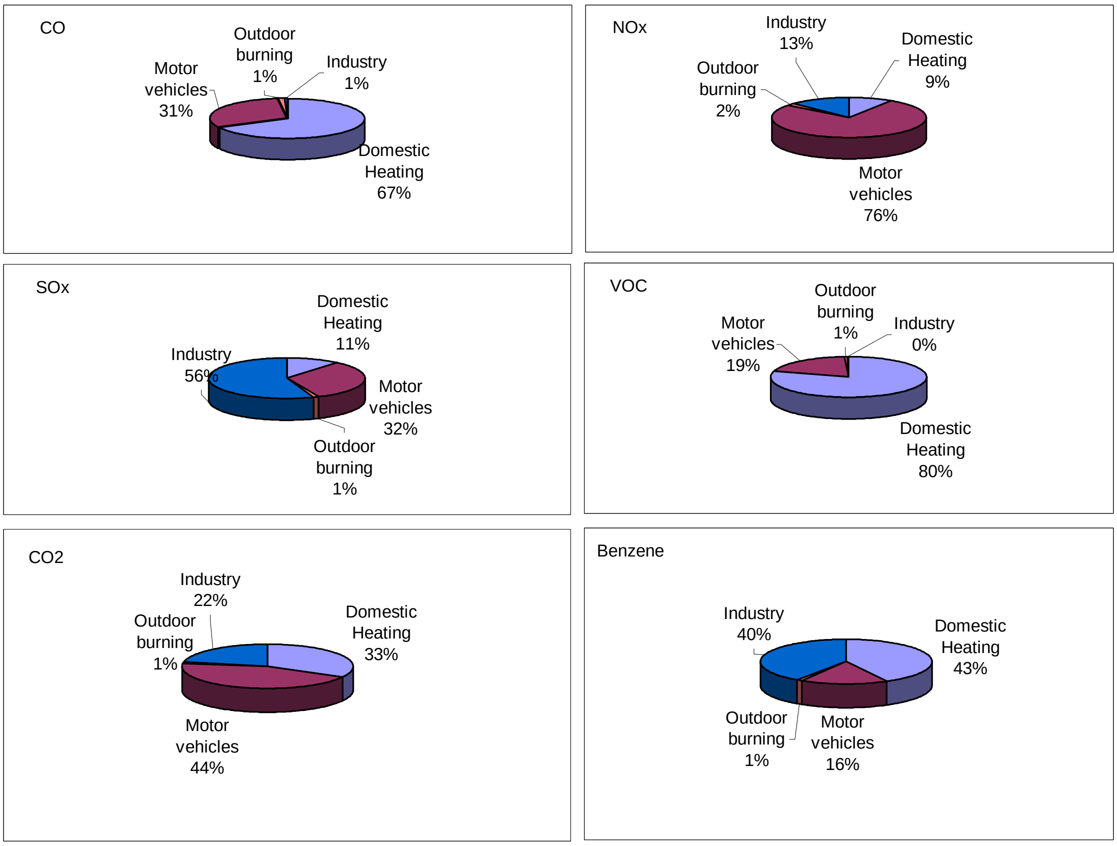

Figure 9.4: Relative contribution of sources to contaminant emissions in Hastings

Table 9.5: Total daily emissions by time of day for Hastings (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	93	142	764	178	1177	92	139	750	169	1150	920	1385	7454	1646	11405	6	9	57	16	88
Motor vehicles	14	24	17	3	58	8	14	10	2	33	1243	2140	1544	260	5187	176	306	218	38	738
Outdoor burning	18	53			70	16	49			66	59	177			236	4	13			17
Industry	16	9	6	8	39	11	6	4	6	27	34	20	16	21	92	31	29	26	35	122
Total	141	227	787	189	1344	128	208	764	176	1276	2255	3722	9014	1927	16920	218	357	302	88	965

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	2	3	22	8	35	271	408	2221	481	3382	17	24	135	34	210	10	15	78	17	119
Motor vehicles	25	43	30	5	103	197	342	244	42	826	54	146	69	9	277	11	19	14	2	46
Outdoor burning	1	2			3	6	18			24	2	6			8	1	2			3
Industry	59	39	32	44	177	1	2	2	2	7	29	34	32	43	138	19	28	28	38	113
Total	86	87	84	57	317	475	770	2467	525	4238	102	210	235	86	633	41	64	120	57	281

Table 9.6: Summary of total Hastings emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	1177	819	88%	11405	7941	67%	88	61	9%	35	24	11%	3382	2354	80%	210	146	33%	119	83	42%	1150	801	90%
Motor vehicles	58	41	4%	5187	3611	31%	738	514	76%	103	72	32%	826	575	19%	277	193	44%	46	32	16%	33	23	3%
Outdoor burning	70	49	5%	236	164	1%	17	12	2%	3	2	1%	24	17	1%	8	6	1%	3	2	1%	66	46	5%
Industry	39	27	3%	92	63	1%	122	85	13%	177	122	56%	7	5	0%	138	96	22%	113	79	40%	27	19	2%
Total	1344	936	1	16920	11780	1	965	672	1	317	220	1	4238	2951	1	633	441	1	281	196	1	1276	888	1

Table 9.7: Total Hastings annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	167	1635	13	5	487	30	17	165
Motor vehicle	21	1898	270	38	302	101	17	12
Outdoor burning	57	53	192	2	20	7	2	53
Industry	11	28	41	43	2	50	43	8
Total	257	3615	516	87	811	188	80	238

Table 9.8: Seasonal variations in daily emissions in Hastings

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	58	280	25	0	5187	262	72	0	738	942	124
February	0	58	280	25	0	5187	262	72	0	738	942	124
March	0	58	69	24	0	5187	64	64	0	738	230	107
April	336	58	69	24	3363	5187	64	64	29	738	230	107
May	942	58	69	24	9293	5187	64	64	75	738	230	107
June	1098	58	70	39	10612	5187	66	92	84	738	236	122
July	1177	58	70	39	11404	5187	66	92	88	738	236	122
August	1088	58	70	39	10520	5187	66	92	83	738	236	122
September	695	58	207	34	6949	5187	194	81	46	738	695	99
October	122	58	207	34	1223	5187	194	81	8	738	695	99
November	6	58	207	34	59	5187	194	81	1	738	695	99
December	0	58	280	25	0	5187	262	72	0	738	942	124
	SOx kg/day				VOC kg/day				CO_2 t/day			

	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	103	11	132	0	826	96	8	0	277	33	159
February	0	103	11	132	0	826	96	8	0	277	33	159
March	0	103	3	18	0	826	24	6	0	277	8	133
April	7	103	3	18	1009	826	24	6	62	277	8	133
May	25	103	3	18	2779	826	24	6	172	277	8	133
June	32	103	3	177	3144	826	24	7	197	277	8	138
July	34	103	3	177	3381	826	24	7	209	277	8	138
August	32	103	3	177	3116	826	24	7	195	277	8	138
September	16	103	8	141	2085	826	71	6	127	277	24	116
October	3	103	8	141	367	826	71	6	23	277	24	116
November	0	103	8	141	18	826	71	6	1	277	24	116
December	0	103	11	132	0	826	96	8	0	277	33	159
	Benzene kg/day				**$PM_{2.5}$** kg/day							
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**				
January	0	46	11	145	0	33	262	27				
February	0	46	11	145	0	33	262	27				
March	0	46	3	118	0	33	64	24				
April	36	46	3	118	336	33	64	24				
May	99	46	3	118	933	33	64	24				
June	112	46	3	113	1071	33	66	18				
July	119	46	3	113	1150	33	66	18				
August	111	46	3	113	1062	33	66	18				
September	76	46	8	95	695	33	194	16				

October	14	46	8	95	122	33	194	16				
November	1	46	8	95	6	33	194	16				
December	0	46	11	145	0	33	262	27				

9.3 Flaxmere

Around 0.5 tonnes of PM_{10} is discharged into the air over Flaxmere on an average winter's day. This may increase to 0.76 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 92% of the daily total PM_{10} (Figure 9.5). Industry and motor vehicle emissions contribute 1% and 2% respectively, with outdoor burning contributing 5%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.6. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 17% of the CO and 77% of the NOx.

Tables 9.9 and 9.10 show daily wintertime contaminants emissions in Flaxmere by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.11. This indicates around 79 tonnes of PM_{10} per year are emitted in Flaxmere. Table 9.12 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

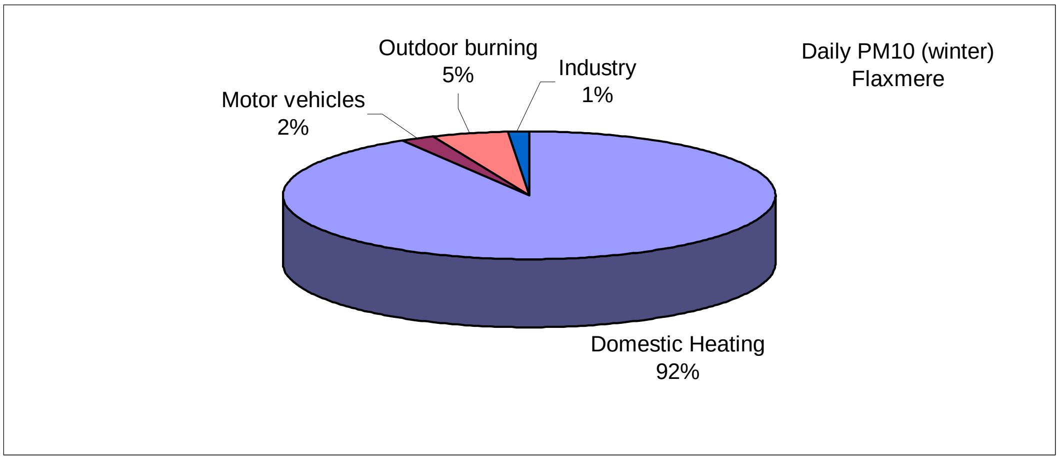

Figure 9.5: Relative contribution of different sources to average daily winter PM_{10} emissions in Flaxmere

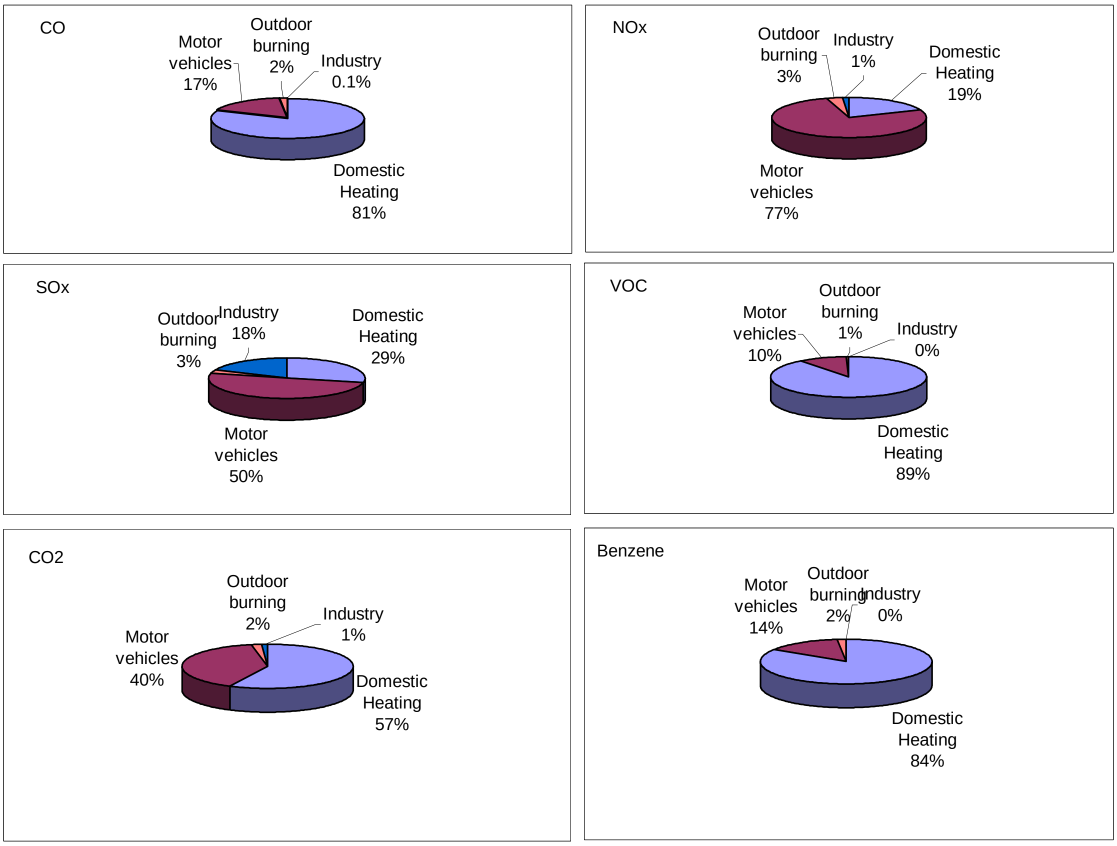

Figure 9.6: Relative contribution of sources to contaminant emissions in Flaxmere

Table 9.9: Total daily emissions by time of day for Flaxmere (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	36	56	299	70	461	37	56	300	68	460	371	559	3010	664	4605	2	4	22	6	34
Motor vehicles	3	4	3	1	11	2	3	2	0	6	233	388	283	47	950	34	56	41	7	138
Outdoor burning	6	19			25	6	18			24	21	64			86	2	5			6
Industry	3	2	1	2	7	2	1	0	1	3	3	1	0	0	4	2	0	0	0	3
Total	48	81	303	72	504	46	77	303	69	494	629	1012	3292	711	5644	40	65	63	13	180

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	1	1	7	3	11	111	167	907	196	1381	7	10	55	14	85	4	6	33	7	51
Motor vehicles	5	8	6	1	19	38	63	46	8	154	11	32	14	2	59	2	4	3	0	9
Outdoor burning	0	1			1	2	7			9	1	2			3	0	1			1
Industry	6	1	0	0	7	0	0	0	0	0	1	0	0	29	1	0	0	0	0	0
Total	11	11	12	4	38	151	236	953	204	1544	20	45	69	44	149	7	10	36	8	60

Table 9.10: Summary of total Flaxmere emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	461	956	91%	4605	9560	82%	34	70	19%	11	23	29%	1381	2868	89%	85	177	57%	51	105	84%	460	956	93%
Motor vehicles	11	22	2%	950	1972	17%	138	286	77%	19	40	50%	154	319	10%	59	123	40%	9	18	14%	6	13	1%
Outdoor burning	25	53	5%	86	178	2%	6	13	3%	1	2	3%	9	18	1%	3	6	2%	1	2	2%	24	50	5%
Industry	7	14	1%	4	9	0%	3	5	1%	7	14	18%	0	0	0%	1	62	1%	0	0	0%	3	7	1%
Total	504	1046	1	5644	11718	1	180	374	1	38	79	1	1544	3206	1	149	368	1	60	125	1	494	1026	1

Table 9.11: Total Flaxmere annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	64	637	5	1	191	12	7	64
Motor vehicle	4	348	50	7	56	22	3	2
Outdoor burning	9	8	30	0	3	1	0	8
Industry	2	1	0	1	0	0	0	1
Total	79	994	86	10	251	35	11	75

Table 9.12: Seasonal variations in daily emissions in Flaxmere

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	11	21	5	0	950	19	0	0	138	70	0
February	0	11	21	5	0	950	19	0	0	138	70	0
March	0	11	24	5	0	950	23	0	0	138	82	0
April	120	11	24	5	1197	950	23	0	7	138	82	0
May	333	11	24	5	3325	950	23	0	25	138	82	0
June	478	11	25	7	4784	950	24	4	35	138	86	3
July	460	11	25	7	4605	950	24	4	33	138	86	3
August	376	11	25	7	3764	950	24	4	28	138	86	3
September	246	11	28	6	2461	950	26	3	16	138	94	1
October	45	11	28	6	455	950	26	3	3	138	94	1
November	24	11	28	6	240	950	26	3	1	138	94	1
December	0	11	21	5	0	950	19	0	0	138	70	0
	SOx kg/day				VOC kg/day				CO_2 t/day			

	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	19	1	0	0	154	7	0	0	59	2	0
February	0	19	1	0	0	154	7	0	0	59	2	0
March	0	19	1	0	0	154	8	0	0	59	3	0
April	3	19	1	0	359	154	8	0	23	59	3	0
May	8	19	1	0	998	154	8	0	63	59	3	0
June	11	19	1	7	1435	154	9	0	89	59	3	1
July	10	19	1	7	1381	154	9	0	85	59	3	1
August	8	19	1	7	1129	154	9	0	69	59	3	1
September	6	19	1	2	738	154	10	0	46	59	3	1
October	1	19	1	2	136	154	10	0	9	59	3	1
November	1	19	1	2	72	154	10	0	5	59	3	1
December	0	19	1	0	0	154	7	0	0	59	2	0
	Benzene kg/day				**$PM_{2.5}$** kg/day							
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry				
January	0	9	1	0	0	6	19	3				
February	0	9	1	0	0	6	19	3				
March	0	9	1	0	0	6	23	3				
April	14	9	1	0	120	6	23	3				
May	37	9	1	0	333	6	23	3				
June	53	9	1	0	478	6	24	2				
July	51	9	1	0	460	6	24	2				
August	41	9	1	0	376	6	24	2				
September	28	9	1	0	246	6	26	2				

October	5	9	1	0	45	6	26	2				
November	3	9	1	0	24	6	26	2				
December	0	9	1	0	0	6	19	3				

9.4 Hastings/Flaxmere

Around 1.8 tonnes of PM_{10} is discharged into the air over Hastings/ Flaxmere on an average winter's day. This increases to around 2.3 tonnes if all households use existing solid fuel burners on any given night. The main source of the PM_{10} is domestic home heating which contributes around 89% of the daily total PM_{10} (Figure 9.7). Industry and motor vehicle emissions contribute 2% and 4% respectively, with outdoor burning contributing 5%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.8. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 27% of the CO and 76% of the NOx.

Tables 9.13 and 9.14 show daily wintertime contaminants emissions in Hastings/Flaxmere by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.15. This indicates around 335 tonnes of PM_{10} per year are emitted in Hastings/Flaxmere. Table 9.16 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

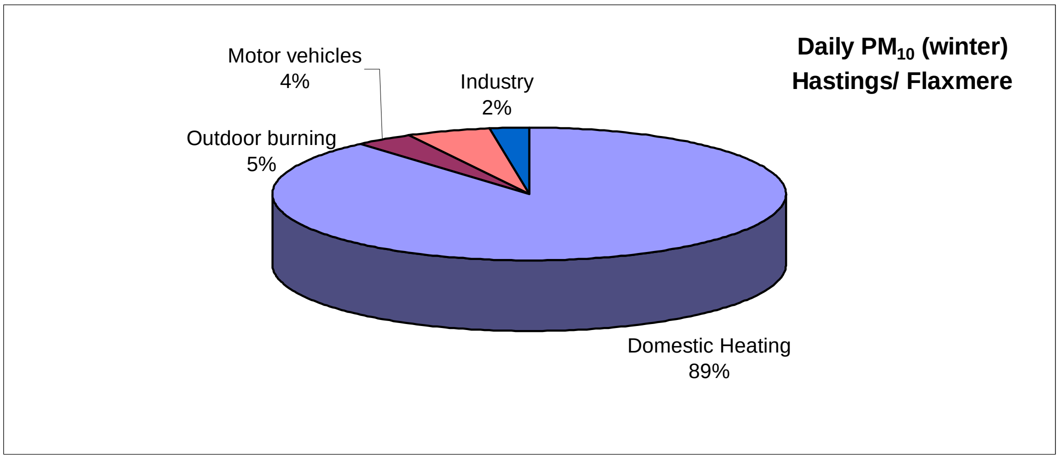

Figure 9.7: Relative contribution of different sources to average daily winter PM_{10} emissions in Hastings/Flaxmere

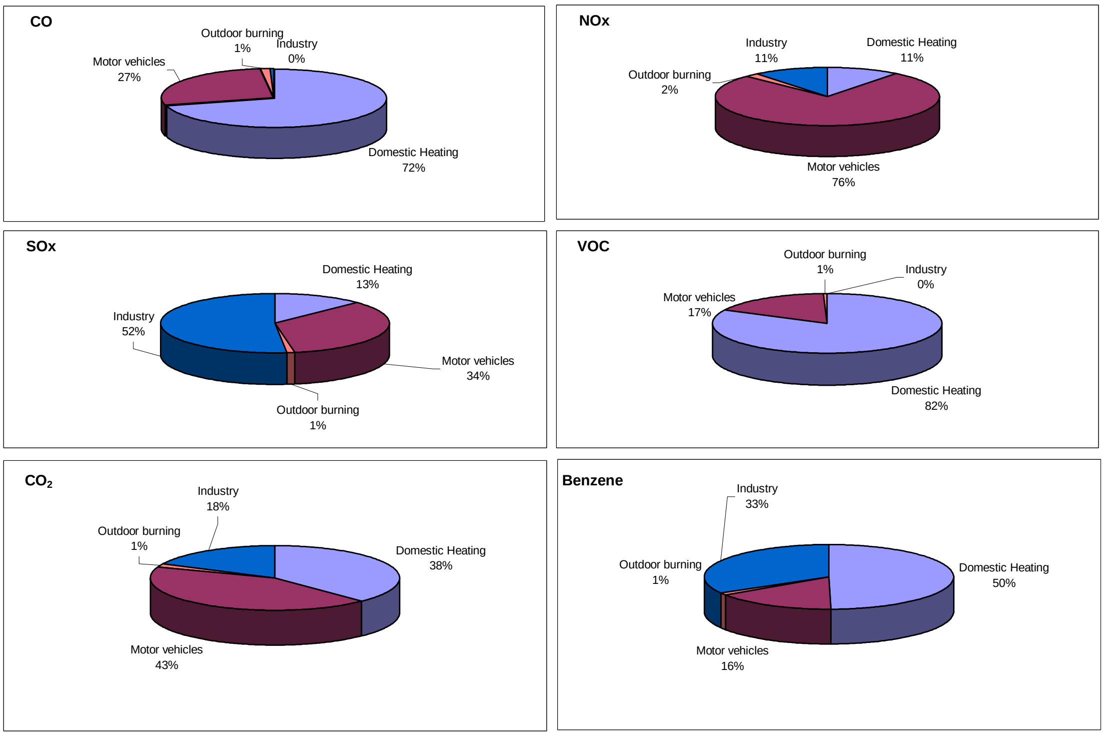

Figure 9.8: Relative contribution of sources to contaminant emissions in Hastings/ Flaxmere

Table 9.13: Total daily emissions by time of day for Hastings/Flaxmere (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	130	198	1062	248	1637	129	195	1051	236	1611	1291	1944	10464	2310	16010	8	13	79	21	122
Motor vehicles	17	29	20	3	69	9	16	12	2	39	1476	2528	1826	307	6137	210	362	259	44	876
Outdoor burning	24	72			96	22	67			90	80	241			321	6	17			23
Industry	19	10	7	10	46	13	7	5	6	30	37	21	16	22	96	34	30	26	35	125
Total	189	308	1090	261	1848	173	285	1067	244	1770	2885	4734	12306	2638	22564	258	422	364	101	1145

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	3	4	28	11	46	382	575	3129	677	4763	24	34	189	48	295	14	21	111	24	170
Motor vehicles	29	50	36	6	122	235	405	290	50	980	65	178	83	10	336	13	23	16	3	55
Outdoor burning	1	3			4	8	25			33	3	8			11	1	3			4
Industry	65	41	32	44	184	1	2	2	2	7	30	34	32	72	140	19	28	28	38	113
Total	98	98	97	61	355	626	1007	3420	729	5782	122	255	304	130	782	47	75	156	64	342

Table 9.14: Summary of total Hastings/Flaxmere emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	1637	854	89%	16010	8347	71%	122	63	11%	46	24	13%	4763	2483	82%	295	154	38%	170	88	50%	1611	840	91%
Motor vehicles	69	36	4%	6137	3200	27%	876	457	76%	122	64	34%	980	511	17%	336	175	43%	55	29	16%	39	21	2%
Outdoor burning	96	50	5%	321	168	1%	23	12	2%	4	2	1%	33	17	1%	11	6	1%	4	2	1%	90	47	5%
Industry	46	24	2%	96	50	0%	125	65	11%	184	95	52%	7	3	0%	140	88	18%	113	59	33%	30	16	2%
Total	1848	963	1	22564	11764	1	1145	597	1	355	184	1	5782	3015	1	782	423	1	342	178	1	1770	923	1

Table 9.15: Total Hastings/Flaxmere annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	231	2272	17	6	678	42	24	228
Motor vehicle	25	2246	321	45	359	123	20	14
Outdoor burning	66	62	222	3	23	8	3	62
Industry	13	29	42	44	2	50	43	9
Total	335	4609	601	97	1061	223	90	313

Table 9.16: Seasonal variations in daily emissions in Hastings/Flaxmere

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	69	301	30	0	6137	282	72	0	876	1012	124
February	0	69	301	30	0	6137	282	72	0	876	1012	124
March	0	69	93	28	0	6137	87	64	0	876	312	107
April	456	69	93	28	4563	6137	87	64	37	876	312	107
May	1274	69	93	28	12611	6137	87	64	101	876	312	107
June	1577	69	96	46	15403	6137	90	96	118	876	321	125
July	1637	69	96	46	16008	6137	90	96	121	876	321	125
August	1463	69	96	46	14270	6137	90	96	111	876	321	125
September	940	69	235	40	9404	6137	220	84	62	876	789	100
October	168	69	235	40	1677	6137	220	84	11	876	789	100
November	30	69	235	40	304	6137	220	84	2	876	789	100
December	0	69	301	30	0	6137	282	72	0	876	1012	124
	SOx kg/day				VOC kg/day				CO_2 t/day			

	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	122	12	132	0	980	104	8	0	336	35	159
February	0	122	12	132	0	980	104	8	0	336	35	159
March	0	122	4	18	0	980	32	6	0	336	11	133
April	10	122	4	18	1369	980	32	6	85	336	11	133
May	33	122	4	18	3774	980	32	6	235	336	11	133
June	43	122	4	184	4581	980	33	7	285	336	11	140
July	44	122	4	184	4763	980	33	7	293	336	11	140
August	41	122	4	184	4241	980	33	7	263	336	11	140
September	21	122	9	143	2821	980	81	6	173	336	28	117
October	4	122	9	143	503	980	81	6	32	336	28	117
November	1	122	9	143	91	980	81	6	5	336	28	117
December	0	122	12	132	0	980	104	8	0	336	35	159
	Benzene kg/day				PM2.5 kg/day							
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**				
January	0	55	12	145	0	39	282	30				
February	0	55	12	145	0	39	282	30				
March	0	55	4	118	0	39	87	28				
April	50	55	4	118	456	39	87	28				
May	137	55	4	118	1265	39	87	28				
June	164	55	4	113	1550	39	90	20				
July	170	55	4	113	1611	39	90	20				
August	152	55	4	113	1437	39	90	20				
September	104	55	9	95	940	39	220	18				

October	19	55	9	95	168	39	220	18				
November	3	55	9	95	30	39	220	18				
December	0	55	12	145	0	39	282	30				

9.5 Havelock North

Just less than 0.65 tonnes of PM_{10} is discharged into the air over Havelock North on an average winter's day. This may increase to just less than 0.85 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 83% of the daily total PM_{10} (Figure 9.9). Industry and motor vehicle emissions contribute 1% and 3% respectively, with outdoor burning, contributing the second highest contribution at 13%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.10. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 22% of the CO and 78% of the NOx.

Tables 9.17 and 9.18 show daily wintertime contaminants emissions in Havelock North by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.19. This indicates around 119 tonnes of PM_{10} per year are emitted in Havelock North. Table 9.20 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

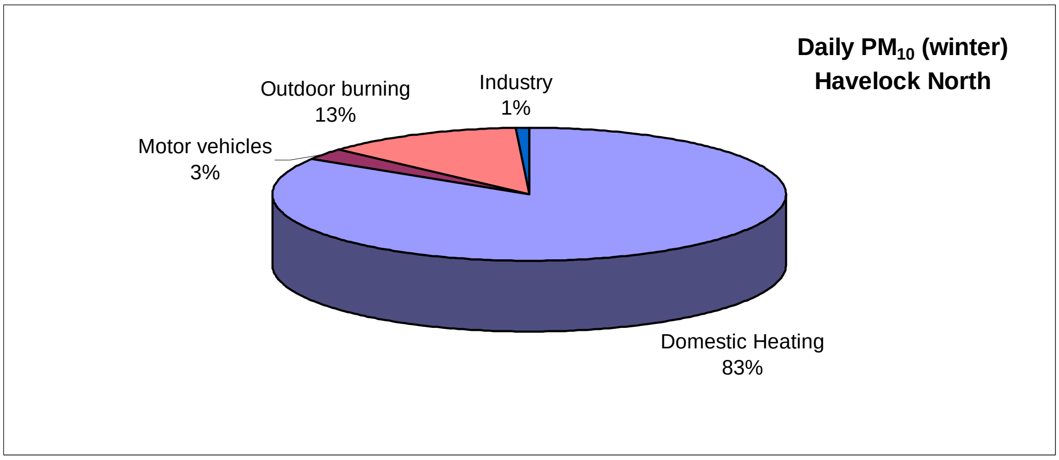

Figure 9.9: Relative contribution of different sources to average daily winter PM_{10} emissions in Havelock North

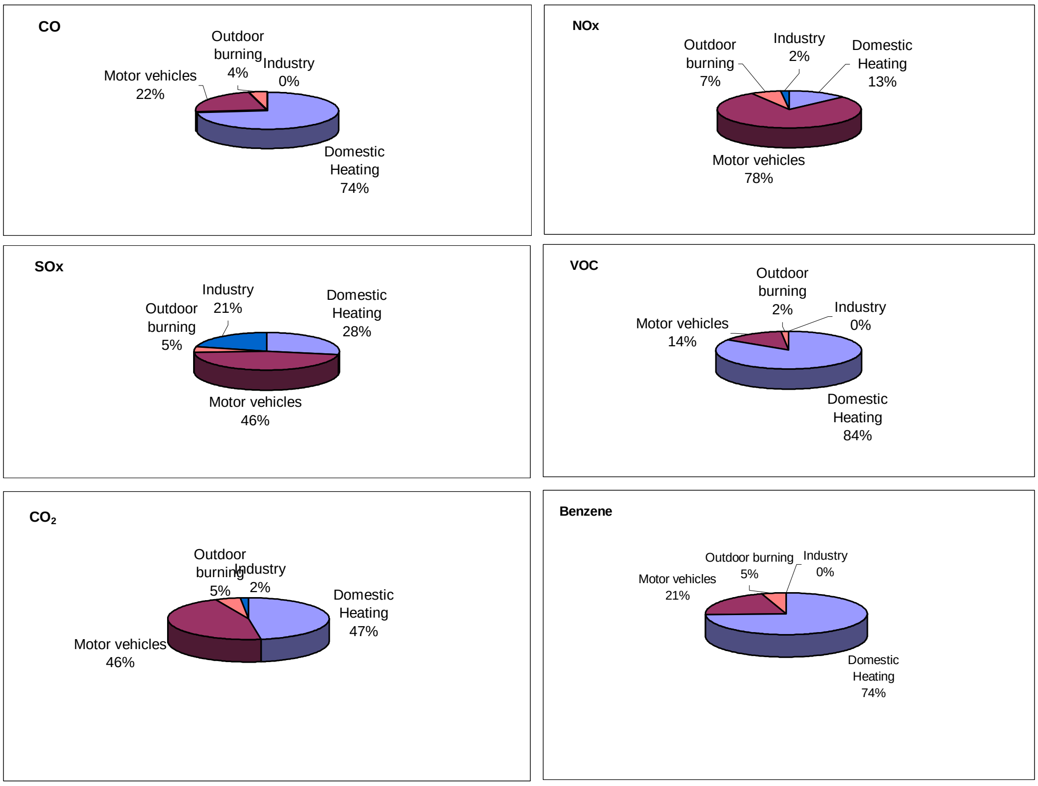

Figure 9.10: Relative contribution of sources to contaminant emissions in Havelock North

Table 9.17: Total daily emissions by time of day for Havelock North (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	43	65	351	82	541	41	62	336	76	515	409	615	3312	731	5068	3	4	24	7	38
Motor vehicles	4	7	5	1	17	2	4	3	0	10	370	631	474	76	1551	53	90	68	11	222
Outdoor burning	20	61			82	19	57			76	68	205			274	5	15			20
Industry	4	1	0	0	5	2	1	0	0	3	7	1	0	0	9	4	1	0	0	5
Total	71	134	356	83	645	65	124	339	76	605	854	1453	3787	808	6901	65	109	92	18	284

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	1	2	11	4	18	118	178	970	210	1477	7	10	58	15	90	4	6	32	7	50
Motor vehicles	7	13	9	2	31	59	101	76	12	248	17	46	22	3	87	3	6	4	1	14
Outdoor burning	1	2			3	7	21			28	2	7			10	1	2			3
Industry	11	2	0	0	14	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0
Total	20	19	21	6	67	185	300	1046	222	1753	29	64	80	17	190	8	14	37	8	67

Table 9.18: Summary of total Havelock North emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	541	403	68%	5068	3778	73%	38	28	13%	18	14	23%	1477	1101	84%	90	67	45%	50	37	74%	515	384	83%
Motor vehicles	17	13	2%	1551	1156	22%	222	165	78%	31	23	38%	248	185	14%	87	65	44%	14	10	21%	10	7	2%
Outdoor burning	82	61	10%	274	204	4%	20	15	7%	3	2	4%	28	21	2%	10	7	5%	3	2	5%	76	57	12%
Industry	5	3	1%	9	6	0%	5	4	2%	14	10	21%	0	0	0%	3	2	2%	0	0	0%	3	2	1%
Total	645	480	1	6901	5145	1	284	212	1	67	49	1	1753	1307	1	190	142	1	67	50	1	605	451	1

Table 9.19: Total Havelock North annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	82	770	5	3	224	14	8	78
Motor vehicle	6	568	81	11	91	32	5	4
Outdoor burning	30	28	101	1	10	4	1	28
Industry	1	1	1	2	0	0	0	1
Total	119	1368	188	17	325	49	14	111

Table 9.20: Seasonal variations in daily emissions in Havelock North

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	17	82	0	0	1551	77	0	0	222	277	0
February	0	17	82	0	0	1551	77	0	0	222	277	0
March	1	17	78	0	7	1551	73	0	0	222	262	0
April	270	17	78	0	2451	1551	73	0	17	222	262	0
May	409	17	78	0	3819	1551	73	0	26	222	262	0
June	509	17	82	5	4774	1551	76	9	35	222	274	5
July	541	17	82	5	5068	1551	76	9	37	222	274	5
August	446	17	82	5	4150	1551	76	9	28	222	274	5
September	364	17	85	3	3384	1551	80	7	23	222	286	2
October	117	17	85	3	1174	1551	80	7	8	222	286	2
November	24	17	85	3	239	1551	80	7	1	222	286	2
December	15	17	82	0	145	1551	77	0	1	222	277	0

	SOx kg/day				VOC kg/day				CO_2 t/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	31	3	0	0	248	28	0	0	87	10	0
February	0	31	3	0	0	248	28	0	0	87	10	0
March	0	31	3	0	2	248	27	0	0	87	9	0
April	10	31	3	0	703	248	27	0	43	87	9	0
May	13	31	3	0	1110	248	27	0	68	87	9	0
June	16	31	3	14	1392	248	28	0	84	87	10	3
July	17	31	3	14	1477	248	28	0	89	87	10	3
August	15	31	3	14	1205	248	28	0	73	87	10	3
September	12	31	3	3	983	248	29	0	59	87	10	1
October	2	31	3	3	352	248	29	0	20	87	10	1
November	1	31	3	3	72	248	29	0	4	87	10	1
December	0	31	3	0	44	248	28	0	3	87	10	0
	Benzene kg/day				**$PM_{2.5}$ kg/day**							
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**				
January	0	14	3	0	0	10	77	3				
February	0	14	3	0	0	10	77	3				
March	0	14	3	0	1	10	73	3				
April	23	14	3	0	251	10	73	3				
May	38	14	3	0	389	10	73	3				
June	47	14	3	0	485	10	76	0				
July	50	14	3	0	515	10	76	0				
August	40	14	3	0	423	10	76	0				

September	33	14	3	0	345	10	80	0				
October	12	14	3	0	117	10	80	0				
November	3	14	3	0	24	10	80	0				
December	2	14	3	0	15	10	77	3				

9.6 Wairoa, Waipawa and Waipukurau

Around 0.7 tonnes of PM_{10} is discharged into the air over Wairoa, Waipawa and Waipukurau on an average winter's day. This may increase to 0.9 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 84% of the daily total PM_{10} (Figure 9.11). Industry and motor vehicle emissions contribute 4% each, with outdoor burning contributing 8%.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.12. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 6% of the CO and 34% of the NOx. Industry contributes 30% of the NOx in Wairoa, Waipawa and Waipukurau.

Tables 9.21 and 9.22 show daily wintertime contaminants emissions in Wairoa, Waipawa and Waipukurau by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.23. This indicates around 126 tonnes of PM_{10} per year are emitted in Wairoa, Waipawa and Waipukurau. Table 9.24 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

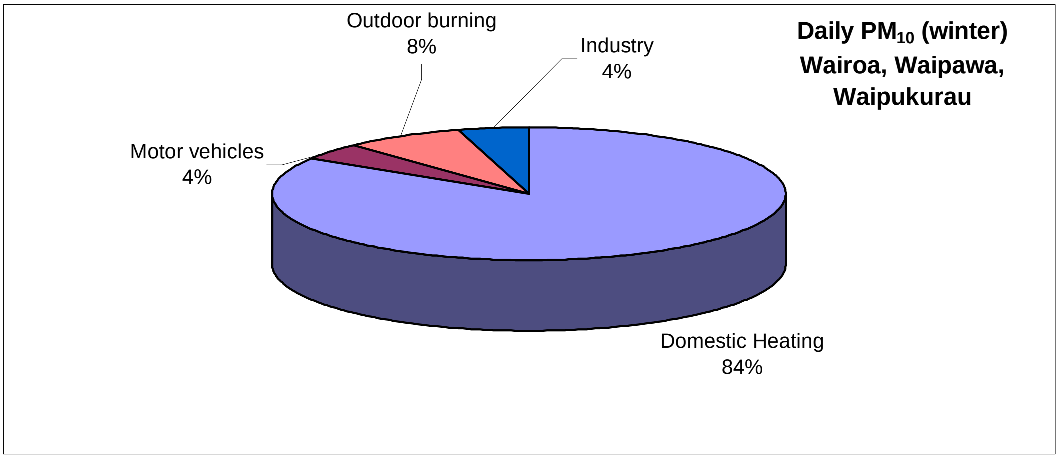

Figure 9.11: Relative contribution of different sources to average daily winter PM_{10} emissions in Wairoa, Waipawa and Waipukurau

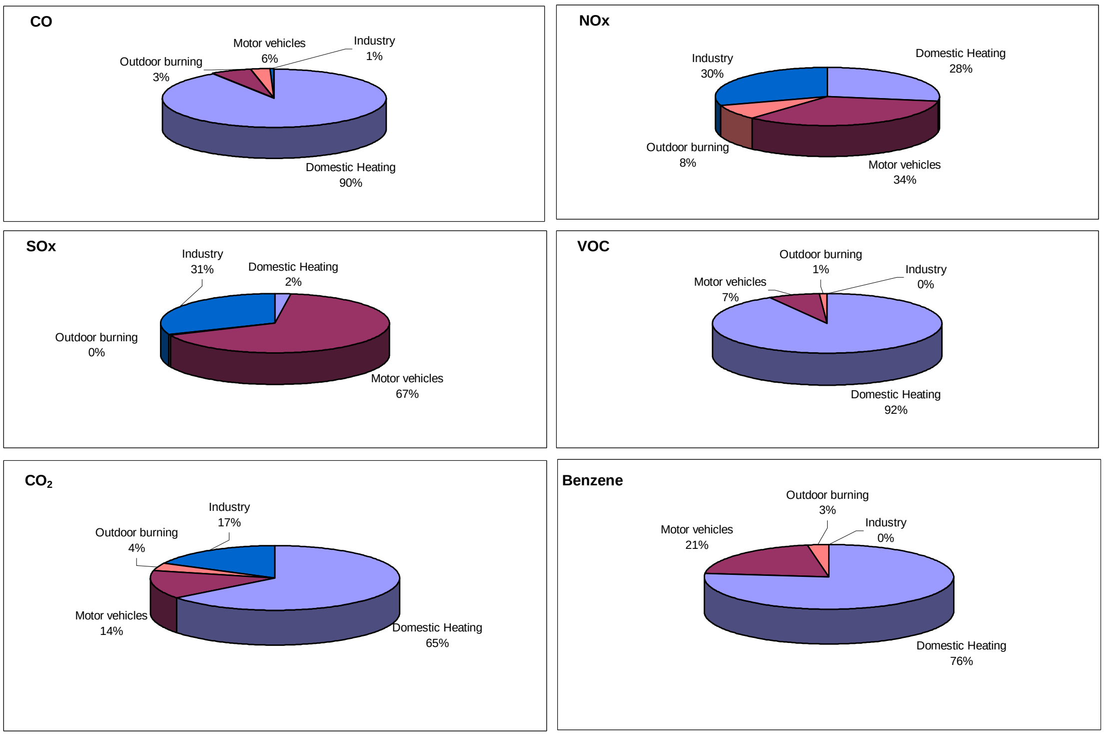

Figure 9.12: Relative contribution of sources to contaminant emissions in Wairoa, Waipawa and Waipukurau

Table 9.21: Total daily emissions by time of day for Wairoa, Waipawa and Waipukurau (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NOx (kg)
Domestic Heating	47	72	387	90	596	48	72	389	87	596	481	723	3894	860	5958	3	4	27	7	42
Motor vehicles	7	12	9	2	29	4	7	5	1	17	88	156	109	19	372	12	22	15	3	52
Outdoor burning	13	40			54	13	38			50	45	135			180	3	10			13
Industry	12	9	7	4	32	7	4	3	1	15	19	12	9	5	45	16	13	11	6	46
Total	80	133	402	95	711	71	120	396	90	677	633	1026	4012	884	6556	34	49	54	16	152

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	1	1	9	3	14	143	216	1174	254	1787	9	12	67	17	105	5	8	40	9	62
Motor vehicles	99	174	122	21	417	27	76	35	5	143	6	10	7	1	23	4	7	5	1	17
Outdoor burning	1	2			2	5	14			18	2	5			6	1	2			2
Industry	58	57	53	27	196	0	0	0	0	1	9	8	7	4	28	0	0	0	0	0
Total	157	235	184	52	629	176	306	1209	259	1949	25	35	81	22	163	10	16	45	10	81

Table 9.22: Summary of total Wairoa, Waipawa and Waipukurau emissions (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic heating	596	279	84%	5958	2788	91%	42	20	28%	14	6	2%	1787	837	92%	105	49	64%	62	29	77%	596	279	88%
Motor vehicles	29	14	4%	372	174	6%	52	24	34%	417	195	66%	143	67	7%	23	11	14%	17	8	21%	17	8	2%
Outdoor burning	54	25	8%	180	84	3%	13	6	8%	2	1	0%	18	9	1%	6	3	4%	2	1	3%	50	23	7%
Industry	32	15	4%	45	21	1%	46	21	30%	196	91	31%	1	0	0%	28	13	17%	0	0	0%	15	7	2%
Total	711	333	1	6556	3068	1	152	71	1	629	294	1	1949	912	1	163	76	1	81	38	1	677	317	1

Table 9.23: Total Wairoa, Waipawa and Waipukurau annual emissions

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	91	916	7	2	274	17	10	91
Motor vehicle	11	136	19	153	52	9	6	6
Outdoor burning	15	14	49	1	5	2	1	14
Industry	10	16	17	59	0	11	0	4
Total	126	1081	92	214	332	38	16	115

Table 9.24: Seasonal variations in daily emissions in Wairoa, Waipawa and Waipukurau

	PM_{10} kg/day				CO kg/day				NOx kg/day			
	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	29	30	23	0	372	28	43	0	52	101	54
February	0	29	30	23	0	372	28	43	0	52	101	54
March	26	29	35	23	261	372	33	42	2	52	118	53
April	261	29	35	23	2612	372	33	42	19	52	118	53
May	525	29	35	23	5254	372	33	42	36	52	118	53
June	593	29	54	32	5932	372	50	45	41	52	180	46
July	596	29	54	32	5958	372	50	45	42	52	180	46
August	513	29	54	32	5129	372	50	45	36	52	180	46
September	323	29	40	29	3231	372	37	42	23	52	134	39
October	125	29	40	29	1248	372	37	42	10	52	134	39
November	33	29	40	29	334	372	37	42	4	52	134	39
December	16	29	30	23	162	372	28	43	3	52	101	54
	SOx kg/day				VOC kg/day				CO_2 t/day			

	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry	Domestic heating	Transport	Outdoor burning	Industry
January	0	417	1	258	0	143	10	1	0	23	4	34
February	0	417	1	258	0	143	10	1	0	23	4	34
March	1	417	1	14	78	143	12	1	5	23	4	34
April	6	417	1	14	783	143	12	1	47	23	4	34
May	11	417	1	14	1576	143	12	1	91	23	4	34
June	13	417	2	196	1780	143	18	1	104	23	6	28
July	13	417	2	196	1787	143	18	1	104	23	6	28
August	11	417	2	196	1539	143	18	1	89	23	6	28
September	7	417	2	176	969	143	14	1	59	23	5	25
October	3	417	2	176	374	143	14	1	23	23	5	25
November	1	417	2	176	100	143	14	1	6	23	5	25
December	0	417	1	258	49	143	10	1	3	23	4	34
	Benzene kg/day				**$PM_{2.5}$** kg/day							
	Domestic heating	**Transport**	**Outdoor burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Industry**				
January	0	17	1	0	0	17	28	15				
February	0	17	1	0	0	17	28	15				
March	3	17	1	0	26	17	33	14				
April	28	17	1	0	261	17	33	14				
May	54	17	1	0	525	17	33	14				
June	62	17	2	0	593	17	50	8				
July	62	17	2	0	596	17	50	8				
August	53	17	2	0	513	17	50	8				
September	35	17	2	0	323	17	37	8				

October	13	17	2	0	125	17	37	8				
November	3	17	2	0	33	17	37	8				
December	2	17	1	0	16	17	28	15				

9.7 The rest of the Region

Around 4.2 tonnes of PM_{10} is discharged into the air over the rest of the Region on an average winter's day. This may increase to around 5 tonnes if all households using solid fuel burning heat their homes on any given night. The main source of the PM_{10} is domestic home heating which contributes around 78% of the daily total PM_{10} (Figure 9.13). Industry and motor vehicle emissions contribute 7% and 2% respectively, with outdoor burning, and orchard and vineyard burning contributing 12% and 1% respectively. The three greatest industrial sources of PM_{10} within the Rest of the Region are a lime production facility located in Poukawa, a wood fired boiler located in Eskdale and a coal-fired boiler located in Awatoto. These are estimated to contribute around 50%, 23% and 7% of the PM_{10} emissions in this study area respectively. These sources are all relatively close to urban areas and may contribute to urban PM_{10} concentrations.

The relative contribution of different sources to other contaminant emissions is shown in Figure 9.14. This indicates domestic heating is also the main source of carbon monoxide, VOCs and benzene. Motor vehicles contribute around 19% of the CO and 66% of the NOx.

Tables 9.25 and 9.26 show daily wintertime contaminants emissions in the rest of the Region by time of day and grams per hectare respectively. For domestic heating these are based on average household appliance use during July. The annual estimates of contaminant emissions by source are shown in Table 9.27. This indicates around 760 tonnes of PM_{10} per year are emitted in the rest of the Region. Table 9.28 shows seasonal variations in daily contaminant emissions. The greatest quantity of emissions occurs during the winter months because of the use of solid fuel burning for domestic home heating.

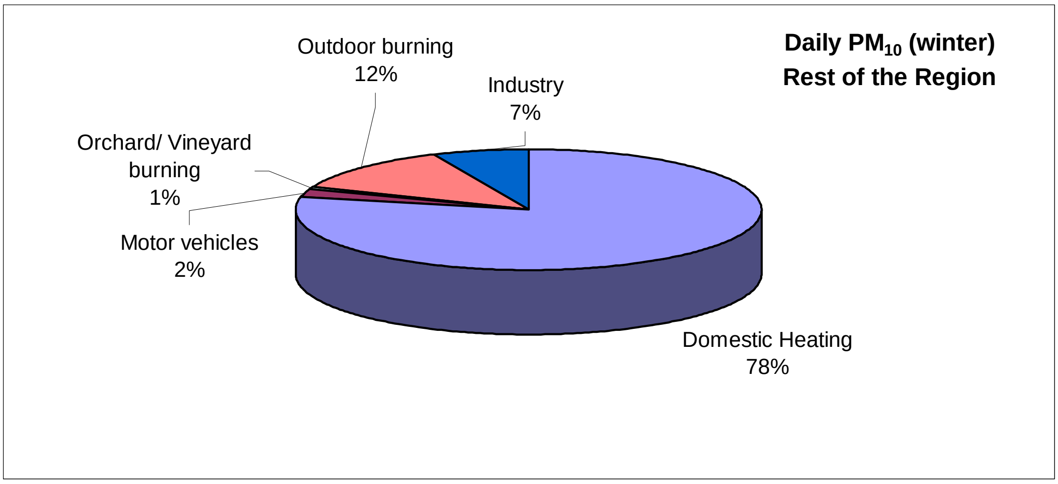

Figure 9.13: Relative contribution of different sources to average daily winter PM_{10} emissions in the rest of the Region

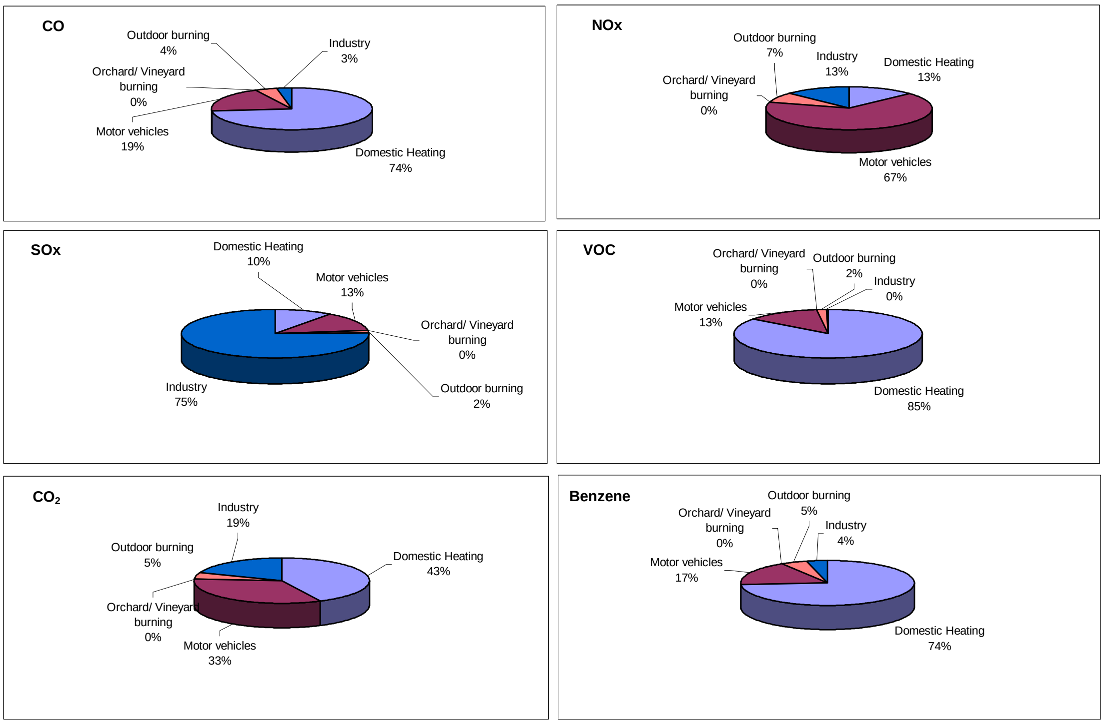

Figure 9.14: Relative contribution of sources to contaminant emissions in the rest of the Region

Table 9.25: Total daily emissions by time of day for the rest of the Region (winter average)

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM_{10} kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total $PM_{2.5}$ kg	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm -6am	Total NOx (kg)
Domestic Heating	259	395	2121	495	3269	244	369	1991	448	3052	2404	3618	19475	4300	29797	15	23	141	38	217
Motor vehicles	21	37	26	5	89	12	21	15	3	51	1868	3289	2324	399	7880	266	471	330	58	1125
Orchard/ Vineyard burning	7	21			28	7	21			28	37	112			149	3	8			11
Outdoor burning	129	388			517	121	363			484	434	1302			1736	31	93			124
Industry	63	75	61	74	273	30	32	23	27	113	244	323	311	403	1283	56	57	49	55	217
Total	479	915	2208	573	4175	415	806	2029	477	3727	4987	8644	22111	5101	40844	371	652	520	151	1694

Total emissions (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SOx (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO_2 (t)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total Benzene (kg)
Domestic Heating	7	11	75	28	122	687	1034	5625	1218	8563	45	64	355	89	554	25	37	198	42	302
Motor vehicles	37	66	46	8	157	298	527	370	65	1258	82	230	105	14	431	17	29	21	4	70
Orchard Heaters																				
Outdoor burning	5	16			21	44	133			178	15	46			61	5	16			21
Industry	199	228	214	279	922	5	7	7	9	27	52	63	59	74	248	3	4	4	5	15
Total	249	321	336	315	1223	1037	1711	6001	1291	10041	196	406	520	177	1299	50	86	222	51	409

Table 9.26: Summary of total emissions for the rest of the Region (winter average)

	PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			$PM_{2.5}$		
	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Domestic Heating	3269	2	78%	29797	21	73%	217	0	13%	122	0	10%	8563	6	85%	554	0	43%	302	0	74%	3052	2	82%
Motor vehicles	89	0	2%	7880	6	19%	1125	1	66%	157	0	13%	1258	1	13%	431	0	33%	70	0	17%	51	0	1%
Orchard/ Vineyard burning	28	0	1%	149	0	0%	11	0	1%	2	0	0%	14	0	0%	5	0	0%	0	0	0%	28	0	1%
Outdoor burning	517	0	12%	1736	1	4%	124	0	7%	21	0	2%	178	0	2%	61	0	5%	21	0	5%	484	0	13%
Industry	273	0	7%	1283	1	3%	217	0	13%	922	1	75%	27	0	0%	248	0	19%	15	0	4%	113	0	3%
Total	4175	3	1	40844	29	1	1694	1	1	1223	1	1	10041	7	1	1299	1	1	409	0	1	3727	3	1

Table 9.27: Total annual emissions for the rest of the Region

	PM_{10}	CO	NOx	SOx	VOC	CO_2	Benzene	$PM_{2.5}$
	t	t	t	t	t	t	t	t
Domestic heating	467	6166	30	16	1371	77	42	440
Motor vehicle	32	2884	412	57	461	158	26	19
Orchard/ Vineyard burning	8	62	8	0	42	81		5
Outdoor burning	158	148	532	6	54	19	6	148
Orchard Heaters	0.2			1				
Industry	95	461	73	256	10	87	6	38
Total	760	9721	1054	336	1938	421	80	650

Table 9.28: Seasonal variations in daily emissions in the rest of the Region

	PM_{10} - kg/ day					CO – kg/ day					NOx – kg/ day				
	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry
January	5	89	346	0	251	49	7880	324	0	1243	0	1125	1162	0	192
February	5	89	346	0	251	49	7880	324	0	1243	0	1125	1162	0	192
March	5	89	439	878	250	49	7880	411	4612	1241	0	1125	1475	329	192
April	645	89	439	850	250	6452	7880	411	4463	1241	49	1333125	1475	319	192
May	2585	89	439	878	250	22961	7880	411	4612	1241	164	1125	1475	329	192
June	3207	89	517	850	273	29177	7880	484	4463	1283	209	1125	1736	319	217
July	3269	89	517	878	273	29796	7880	484	4612	1283	215	1125	1736	329	217
August	3259	89	517	878	273	29701	7880	484	4612	1283	212	1125	1736	329	217
September	1111	89	427	0	266	11107	7880	400	0	1273	77	1125	1436	0	198
October	309	89	427	0	266	3086	7880	400	0	1273	26	1125	1436	0	198
November	93	89	427	0	266	932	7880	400	0	1273	11	1125	1436	0	198
December	73	89	346	0	251	725	7880	324	0	1243	10	1125	1162	0	192

	SOx - kg/ day					VOC – kg/ day					CO2 – t/ day				
	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry	Domestic heating	Transport	Outdoor burning	Orchard/ Vineyard burning	Industry
January	0	157	14	0	685	15	1258	119	0	26	1	431	41	0	233
February	0	157	14	0	685	15	1258	119	0	26	1	431	41	0	233
March	0	157	18	55	312	15	1258	151	439	27	1	431	52	161	236
April	15	157	18	53	312	1936	1258	151	425	27	120	431	52	156	236
May	103	157	18	55	312	6512	1258	151	439	27	432	431	52	161	236

June	117	157	21	53	922	8377	1258	178	425	27	540	431	61	156	248
July	118	157	21	55	922	8563	1258	178	439	27	550	431	61	161	248
August	117	157	21	55	922	8534	1258	178	439	27	542	431	61	161	248
September	25	157	17	0	878	3332	1258	147	0	27	202	431	50	0	238
October	7	157	17	0	878	926	1258	147	0	27	57	431	50	0	238
November	2	157	17	0	878	280	1258	147	0	27	16	431	50	0	238
December	2	157	14	0	685	218	1258	119	0	26	12	431	41	0	233
	Benzene - kg/ day					**$PM_{2.5}$ – kg/ day**									
	Domestic heating	**Transport**	**Outdoor burning**	**Orchard/ Vineyard burning**	**Industry**	**Domestic heating**	**Transport**	**Outdoor burning**	**Orchard/ Vineyard burning**	**Industry**					
January	1	70	14	0	15	5	51	324	0	113					
February	1	70	14	0	15	5	51	324	0	113					
March	1	70	18	0	19	5	51	411	878	110					
April	72	70	18	0	19	645	51	411	850	110					
May	231	70	18	0	19	2368	51	411	878	110					
June	296	70	21	0	15	2990	51	484	850	98					
July	302	70	21	0	15	3052	51	484	878	98					
August	298	70	21	0	15	3042	51	484	878	98					
September	122	70	17	0	14	1111	51	400	0	97					
October	34	70	17	0	14	309	51	400	0	97					
November	10	70	17	0	14	93	51	400	0	97					
December	7	70	14	0	15	73	51	324	0	113					

9.8 Regional PM_{10} Emission Densities

Estimates of the PM_{10} emission densities by census area unit (CAU) were made based on the results of the 2005 air emission inventory. Population density was used to distribute emissions from each study area to the CAUs in that area. PM_{10} emission densities in kilograms per square kilometre per winter's day are shown in Figure 9.14. As would be expected, the highest emission densities occur in the urban areas of Napier and Hastings.

Figure 9.15 provides a more detailed illustration of the same information for the main urban areas of the Region. This shows some variations in emission density across the urban areas, with slightly lower PM_{10} emission density in central Hastings.

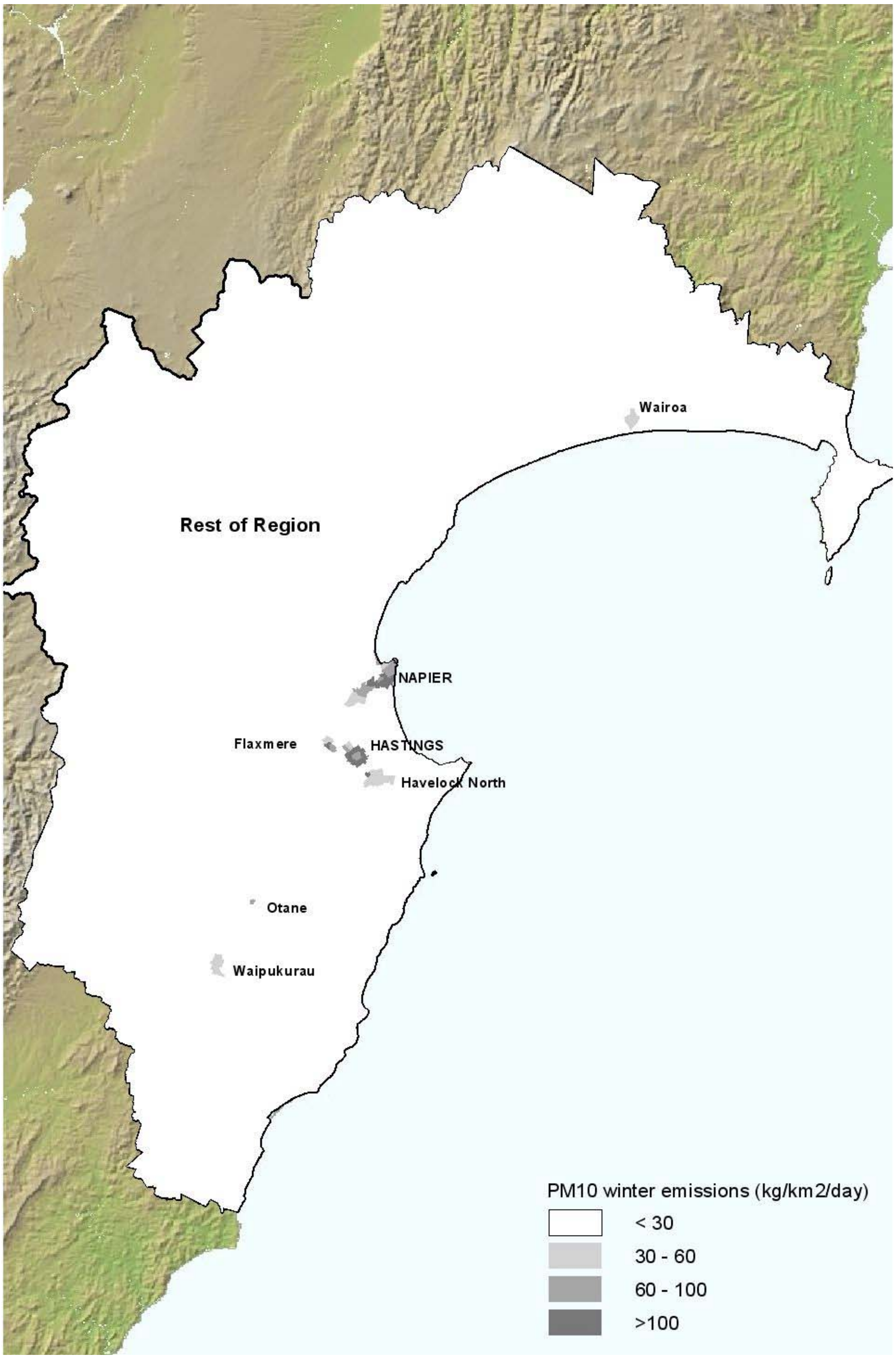

Figure 9.14: PM_{10} emission densities for the Hawke's Bay Region during winter.

Figure 9.15: Detail of PM_{10} emission density for urban areas of the Heretaunga Plains, Hawke's Bay.

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Appendix A: Study Area - Census Area Units

Napier: Westshore, Ahuriri, Onekawa Central, Onekawa West, Onekawa South, Marewa, Maraenui, Hospital Hill, Bluff Hill, Nelson Park, Mclean Park, Tamatea North, Tamatea South, Greenmeadows, Taradale North, Taradale South and Pirimai

Hastings: Mahora, St Leonards, Frimley, Raureka, Mayfair, Parkvale, Hastings Central, Akina, Camberley and Woolwich

Flaxmere: Kingsley-Chatham, Lochain, Flaxmere East

Havelock North: Anderson Park, Iona, Te Mata

Rest of Region: Tuai, Frasertown, Ruakituri-Morere, Maungataniwha, Inland Water-Lake Waikaremoana, Raupunga, Whakaki, Nuhaka, Mahia, Twyford, Karamu, Whakatu, Clive, Haumoana, Brookvale, Irongate, Longlands South, Tangoio, Eskdale, Sherenden-Puketapu, Omahu, Waiohiki, Pakowhai, Maraekakaho, Bridge, Pa, Poukawa, Pakipaki, Waimarama, Tutira, Puketitiri, Whanawhana, Bay View, Poraiti, Meeanee, Awatoto, Takapau, Tikokino, Otane, Porangahau, Elsthorpe-Flemington, Ngamatea and Taharua.

Appendix B: Home Heating Questionnaire

1. Good morning / afternoon/evening - Is this a home or business number?(- terminate if business)
Hi, I'm _________from DigiPoll and I am calling on behalf of the Hawke's Bay Regional Council
May I please speak to an adult in your household who knows about your home heating systems? We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use to heat your main living area during a typical year. The survey will take about 5 minutes. Is it a good time to talk to you now?

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

2b. Do you use any other heating system in your main living area in a typical year? *(If yes then question 3 otherwise Q9)*

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

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

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

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

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

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

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

(f) What size gas bottle do you use?

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

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

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

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

(b) 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)

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?

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?

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. Do you burn rubbish or garden waste outside in the open or in an incinerator or rubbish bin

How many days would you burn rubbish outdoors during

a) winter (June, July, August)

b) spring (September, October, November)

c) summer (December, January, February)

d) autumn (March, April, May)

How much garden waste or rubbish would you burn each session. We are looking for cubic metres, or number of wheelbarrows full per fire.

10. 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 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.

How many people live at your address?

Do you own your home or rent it?

D5 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 C: Emission factors for domestic heating.

Emission factors for domestic heating were the latest available for use at the time the report was prepared. With the exception of gas, oil and post 1990 wood burners, these 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. The latter 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 22 g/kg was selected for coal burning on an open fire 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 Hessessy (1999). Previous emission factors were around 33 g/kg. An emission factor for PM_{10} for multi fuel burners burning coal of 28 g/kg was selected based on a weighted average of the test results available for different appliance types.

Emission factors for the pre 1994 burners were based on overseas emissions data combined with a limited number of burner tests carried out in New Zealand. Emission factors for the post 1994 wood burner categories were based on data collected in Nelson on burner types in different age categories combined with results from burner tests carried out in New Zealand. Gas and oil emission factors were based on factors derived by Angie Scott (pers comm., 2004) based on more recent testing of these appliances.

Emission factors for benzene and $PM_{2.5}$ were selected based on data from overseas studies. Benzene emission factors for wood burning were based on USEPA AP-42 emission rates for a "conventional burner". The description of this burner suggests that it is appropriate for a pre-baffle burner type and therefore is likely to be most appropriate for the older multi fuel burners and open fires. As no emission factors for a more modern burner were available for benzene, one emission rate based on a "conventional burner" is used for all wood burning. Benzene emissions from a coal burner and light industrial oil burner (AP-42) were used for domestic coal and oil burning, as no data for domestic use were available. Benzene emission factors for the domestic use of gas were based on data from the Australian National Pollutant Inventory. Because of the uncertainties associated with these emission factors, benzene estimations should be treated as indicative only.

Emission factors for $PM_{2.5}$ data for the burning of wood are based on the assumption that 100% of the PM_{10} emissions are $PM_{2.5}$ (USEPA, 1997). For coal burning USEPA AP-42 generalised particle size distributions for the $PM_{2.5}$ component were used. Oil burning emission rates were based on AP-42 data for a utility boiler. No data for LPG gas use was available so it was assumed that 100% of the PM_{10} would be in the finer $PM_{2.5}$ size fraction, based on AP-42 data for natural gas.

Appendix D: Industrial Emission Survey Form

Company Name ____

Resource consent No:__________________

Map reference:__________________

Address:____

Postal Address ____

Person completing Questionnaire ____________________________________

Contact Phone No. _________________Fax No._______________________

Q1. Nature of business: ____
(e.g., textile manufacture, fertiliser production)

Q2a. Please tick box for each type of discharge

- ☐ Coal boiler
- ☐ Diesel boiler
- ☐ LPG boiler
- ☐ LFO boiler
- ☐ Wood burner
- ☐ Incinerator
- ☐ Waste oil burner
- ☐ Diesel generator
- ☐ Foundary
- ☐ Automotive spray painting
- ☐ Architectural spray painting
- ☐ Printing
- ☐ Quarrying
- ☐ Meat smoking
- ☐ Abrasive blasting
- ☐ Fibre glassing
- ☐ Powder coating
- ☐ Adhesive coatings
- ☐ Manufacture rubber products
- ☐ Seed cleaning
- ☐ Seed handling
- ☐ Can coating
- ☐ Other ______*(specify)*

Q2b. For coal combustion please indicate the type of boiler e.g., chain grate, vekos, underfeed stoker, low ram etc. _____________

Q2c. For a diesel generator please specify the heat output:_______

Q3. Attachment one details the type of information required for each discharge type listed in **Q2**. For each discharge from your operation, please estimate the annual amount of materials consumed/ produced etc. as per attachment one. *(tonnes/year, litre/year, kilogram/year, etc.)*

Discharge type e.g., spray painting	Type of control equipment (if applicable) e.g., baghouse filter	Material type e.g., paint consumed	Annual Quantity e.g., 500 litres/year
1.			
2.			
3.			
4.			
5.			
6.			

Q4. Seasonal variation:
If the quantity indicated in **Q3** varies throughout the year, please indicate the percentage of the total that occurs in each of the four periods below *e.g. Sept-Nov 10%, Dec-Feb 10%, Mar-May 30%, Jun-Aug 50%*

Discharge type	Sept - Nov	Dec-Feb	Mar-May	Jun-Aug
1. ________________				
2.				
3.				
4.				
5.				
6.				

Q5. If the emissions from any processes have been measured please outline below and attach emission test data if available.

Discharge type	Compounds measured	Discharge rate	Tested by:
e.g, coal boiler	*particles (TSP)*	*0.2 kg/hour*	*ESR*
1.			
2.			
3.			
4.			
5.			
6.			

Q6. For each discharge type indicated in Q2, please fill in the following form indicating variations in the quantity of material (e.g., paint used) identified in Q3.

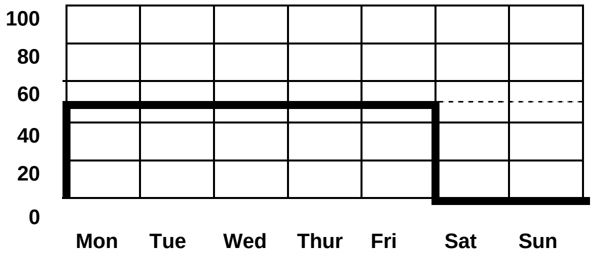
Discharge type____
(e.g., spray painting, *diesel boiler, seed cleaning*)

Q6a. What is the typical daily quantity of material used/ produced (i.e., units used in Q3)

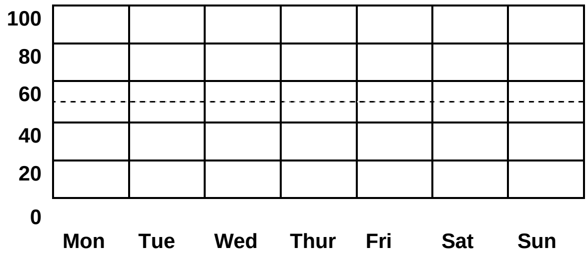
____

If this varies throughout the week please illustrate this variation in the following pictures assuming the value given in Q6a represents 50%. If variations occur, but are not consistent from one week to the next, show a constant use for those periods.

The example shown indicates a constant use Monday to Friday with no weekend usage.



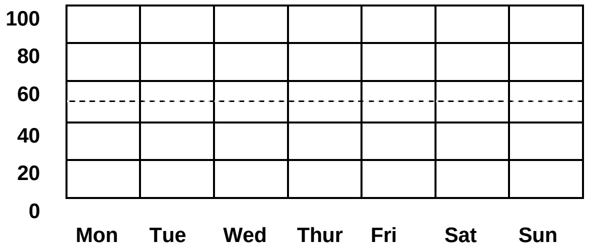
EXAMPLE



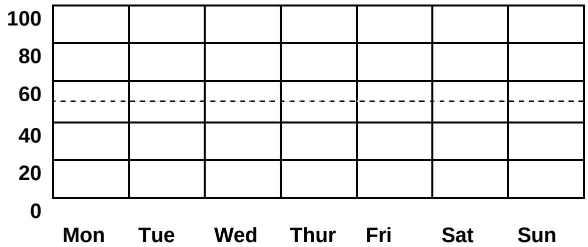
ACTUAL

If this weekly use pattern varies with season please indicate the weekly pattern for each season in the following diagrams.

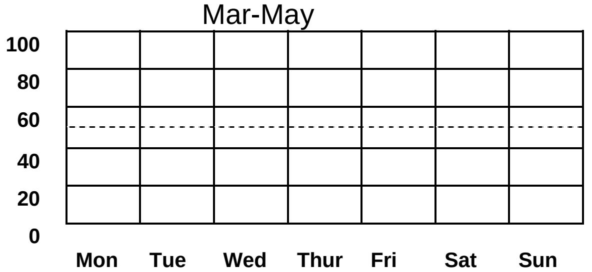
Sept – Nov



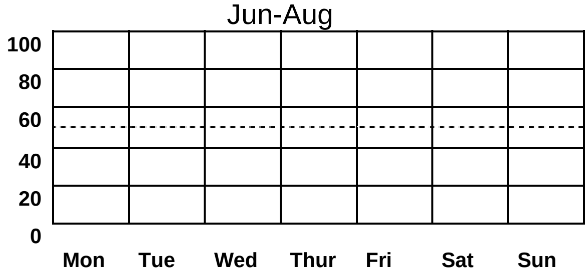
Dec-Feb



Mar-May

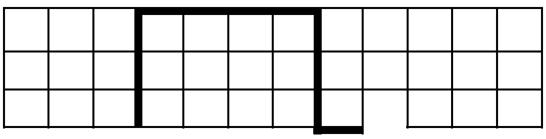


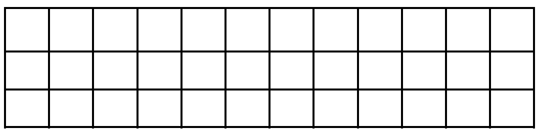
Jun-Aug

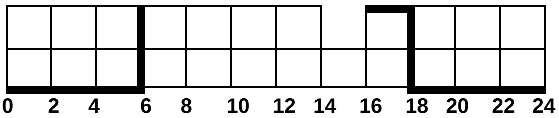


Q6b. Daily variations

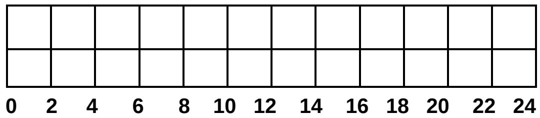
Please estimate the variation throughout the day. The example shown indicates a constant use rate for the hours 6am to 2pm with a reduced use rate from 2pm to 6pm (time is given at the bottom of the diagram in 24 hour clock).







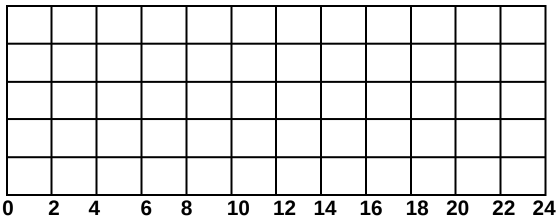
EXAMPLE



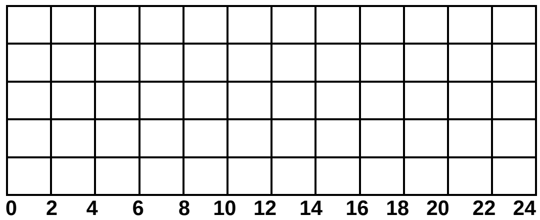
ACTUAL

If this daily use pattern varies with season please indicate the pattern for each season in the following diagrams.

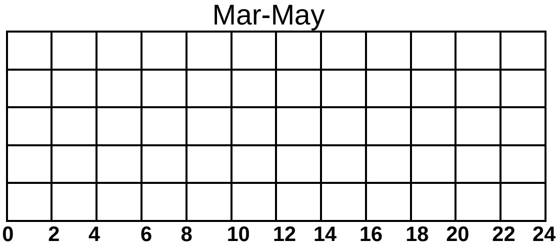
Sept – Nov



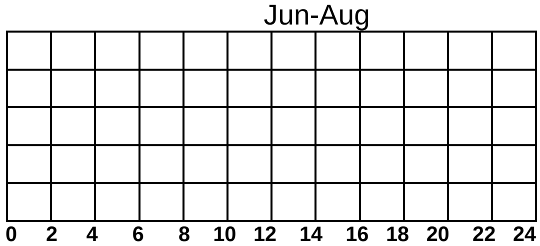
Dec-Feb



Mar-May



Jun-Aug



Industry survey information - attachment one

Discharge type	Type of activity data required	Other data required
Abrasive blasting	Quantity of abrasive material used	Type of material e.g., sand, garnet or metal
Adhesive coatings	Tonnes of adhesive used	Proportion that is solvent
Aggregate handling and storage piles	Tonnes of material transferred	Type of material, mean wind speed
Asphalt plants	Tonnes of product produced	Process type e.g., batch mix or drum mix, type of control equipment e.g., venturi scrubber
Brewing of beer	m^3 of beer produced	
Can coating	Tonnes of solvent used and not recovered	Type of can e.g., two or three piece
Coal fired boiler	Tonnes of coal burnt	Type of boiler e.g., chain grate, vekos, underfeed stoker etc
Diesel boiler	Litres or tonnes of diesel burnt	
Diesel generator	Heat output of the generator (kW or kVa)	
Fibre glassing and polymeric coatings of substrates	Tonnes of coating applied	Solvent content or coating type, and control technology e,g, condenser
Foundary	Tonnes of metal melted	Type of metal, type of furnace, type of control equipment (e.g., baghouse filter)
Incinerators	Quantity of material burnt	Type of material, control equipment
Light fuel oil (LFO) boilers	Litres or tonnes of LFO burnt	
LPG boilers	Tonnes of LPG burnt	
Manufacture of PET	Tonnes of product	Use of spray condensers

(polyethylene Terephthalate)		
Meat smoking	Tonnes of wood used to prepare smoke	Batch or continuous process, control equipment e.g., wet scrubber and de-mister
Pneumatic conveying	Hours conveying occurs and quantity (m^2) of material conveyed	Type of material e.g., wood
Powder coating and other metal coating methods	Area coated	Object being coated i.e., large appliance, metal furniture or miscellaneous, control technology
Printing	Tonnes of ink applied	Type of printing process e.g., web, rotogravure (if available)
Quarrying	Quantity of material processed	Type of material e.g., coal, lime etc, control equipment,
Rubber cement spraying for type retreading	Quantity of material sprayed	Solvent content
Rubber processing	Tonnes of rubber produced	Type of rubber e.g., styrene, spandex etc
Seed cleaning and handling	Tonnes of seed cleaned/ handled	Type of control equipment
Spray painting	Litres of paint applied	Type of activity e.g. automotive, architectural
Textile printing	Tonnes of fabric printed	Proportion of fabric that is printed
Waste oil burners	Litres of tonnes of waste oil burnt	Ash content (note ash content for no. 5 & 6 oils is 15%, waste oil is higher)
Wood fired burners	Tonnes of wood burnt	Type of control equipment, moisture content, fuel type (wood or bark)