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PREPARED FOR

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Motueka Air Emission Inventory 2023

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EXECUTIVE SUMMARY

In New Zealand the main air contaminants of concern are $PM_{2.5}$ and PM_{10} as concentrations can exceed the Air Quality National Environmental Standards (NES) for PM_{10} and the proposed NES for $PM_{2.5}$ (Ministry for the Environment, 2020) in many locations in New Zealand. In September 2021 the WHO released revised guidelines for $PM_{2.5}$ including annual and 24-hour standards lower than the proposed NES.

Temporary monitoring for PM_{10} was carried out in Motueka during winter 2018 and 2019 at Parklands School and during winter 2020 and 2021 at Ledger Goodman Park. In 2022 monitoring was carried out for $PM_{2.5}$ at Ledger Goodman Park. No breaches of the National Environmental Standards for PM_{10} (50 µg/m^3 24-hour average, one allowable exceedance per year) were measured although in 2020 an exceedance of 50 µg/m^3 (24-hour average) was recorded. Monitoring for $PM_{2.5}$ using a Partisol gravimetric sampler (Thermo 2025i) indicates concentrations regularly breach the WHO (2021) daily guideline for $PM_{2.5}$ of 15 µg/m^3. It is noted that the monitoring sites may not be located where they would measure worst case PM_{10} and $PM_{2.5}$ in Motueka as required by the NES.

In 2023 an emission inventory was carried out to assess quantities and sources of discharges to air in Motueka. The sources included were domestic heating, motor vehicles, outdoor burning (including braziers, pizza ovens and solid fuel barbeques), and industrial and commercial activities. Natural source contributions (for example sea salt and soil) were not included because the methodology to estimate emissions is less robust. The evaluation focuses on particles in the air less than 10 microns (PM_{10}), particles in the air less than 2.5 microns ($PM_{2.5}$), sulphur oxides, nitrogen oxides and carbon monoxide.

A domestic home heating and outdoor burning survey was undertaken within Motueka to determine heating methods and fuels and the prevalence and characteristics of outdoor burning as well as the use of braziers, pizza ovens and wood fired barbeques.

Electricity was found to be the most common method of heating the main living area with 71% of households using this source. Heat pumps were the most common electric heating option with 81% of the electric heating reporting households having these. Wood burners were used by 49% of households and around 29 tonnes of wood was burnt on an average winters night. Around 4% of households use wood fired cookers in Motueka.

Across all sources around 215 kilograms of PM_{10} and 201 kilograms of $PM_{2.5}$ is discharged per day during the winter. Domestic heating was the most significant contributor to annual and daily winter PM_{10} in Motueka contributing 68% and 85% respectively. Industrial activities were the next highest contributor at around 21% of the annual and 9% of the daily winter PM_{10} and 16% and 7% of the $PM_{2.5.}$ Industrial activities were also the main source of the SOx and motor vehicles were the main source of NOx emissions in Motueka in 2023.

1 INTRODUCTION

Emission inventories are used by Governments and Local Government internationally to provide an estimate of the quantities of contaminants from anthropogenic sources that are emitted into the air and the relative contribution of sources to total emissions. The sources that are typically included in emissions inventories in New Zealand are domestic heating, motor vehicles, industrial and commercial activities and outdoor burning although other sources such as shipping, port activities, off road transport, aviation and rail may also be included where appropriate.

In New Zealand the main air contaminants of concern are $PM_{2.5}$ and PM_{10} as concentrations can exceed the Air Quality National Environmental Standards (NES) for PM_{10} and the proposed NES for $PM_{2.5}$ (Ministry for the Environment, 2020) in many locations in New Zealand. In September 2021 the WHO released revised guidelines for $PM_{2.5}$ including annual and 24-hour standards lower than the proposed NES.

Temporary monitoring for PM_{10} was carried out in Motueka during winter 2018 and 2019 at Parklands School and during winter 2020 and 2021 at Ledger Goodman Park. In 2022 monitoring was carried out for $PM_{2.5}$ at Ledger Goodman Park. No breaches of the National Environmental Standards for PM_{10} (50 $\mu g/m^3$ 24-hour average, one allowable exceedance per year) were recorded although in 2020 an exceedance of 50 $\mu g/m^3$ (24-hour average) was recorded. Monitoring for $PM_{2.5}$ using a Partisol gravimetric sampler (Thermo 2025i) indicates concentrations regularly breach the WHO (2021) daily guideline for $PM_{2.5}$ of 15 $\mu g/m^3$ with maximum concentrations around 25 $\mu g/m^3$. It is noted that the monitoring sites may not be located where they would measure worst case PM_{10} and $PM_{2.5}$ in Motueka as required by the NES owing to the prevalence of drainage flow winds from the south west quadrant and the proximity of the monitoring sites to the rural area from that wind direction.

This report provides an estimate of emissions of particles (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrogen oxides and sulphur oxides from domestic heating, transportation, industrial and commercial activities and outdoor burning for Motueka for 2023 and identifies the relative contribution of different sources to contaminant emissions for this area.

2 INVENTORY DESIGN

The key components of inventory design are selection of the study area, selection of sources and the focus/extent of investment in data collection for each, contaminants to be included, the spatial resolution (within the study area what breakdowns might be required), temporal resolution (hourly, daily or annual emissions).

2.1 Key issues

The main air quality issue for most urban areas of New Zealand is particles in the air that are typically associated with solid fuel burning for domestic home heating.

2.2 Selection of contaminants

The scope of the inventory with respect to contaminants is:

- particles (PM_{10})
- fine particles ($PM_{2.5}$)
- carbon monoxide (CO)
- sulphur oxides (SOx)
- nitrogen oxides (NOx)

Emissions of PM_{10}, CO, SOx and NOx are included as these contaminants are NES contaminants because of their potential for adverse health impacts. $PM_{2.5}$ has been included in the inventory because this size fraction has significance in terms health and is included in the proposed revisions to the NES for $PM_{2.5}$.

2.3 Selection of sources

The inventory will include emission estimates from the following sources:

- Industry including small scale industrial and commercial activities.
- Domestic heating
- Motor vehicles
- Outdoor burning

Marine aerosol emissions and other natural dusts are not well characterized using inventory techniques and are not included in the emissions assessment. Other methods such as receptor modelling and source apportionment will provide a more robust approach for these sources.

2.4 Selection of inventory area

The Motueka inventory area is based on the Statistical Area (SA2) categories of Motueka East, Motueka North, and Motueka West (Figure 2.1).

Figure 2.1: Motueka emission inventory area (2023 SA2s - Motueka North, Motueka East and Motueka West)

2.5 Temporal distribution

The inventory is based on emission estimates for 2023. For domestic heating and outdoor burning the method includes a 2023 survey of households. For other sources, estimates are based on 2023 where available. For sources where 2023 data are not available, activity data are based on the most recent year information is available.

The temporal distribution of the inventory information is annual, monthly and daily basis where appropriate. Domestic heating data are presented as average and worst-case wintertime scenarios and by month of the year. Motor vehicle data are based on annualised vehicle movements as seasonal variations are not available.

No differentiation is made for weekday and weekend sources.

3 DOMESTIC HEATING

3.1 Methodology

Domestic heating methods and fuel used by households were collected using a household phone survey carried out by Symphony Research (sample error 5%) during May and June 2023 (Appendix A). based on data provided by Tasman District Council (from Stats NZ, SA2 Motueka North, Motueka East and Motueka West, Census 2018 and Building Consents Issued 2023) is 3195. The area included in the Motueka inventory area comprises 1366 hectares. This includes the urban areas of Motueka and some rural areas to the south-west of Motueka.

Home heating methods were classified as; electricity, open fires, wood burners, pellet fires, multi fuel burners, gas burners and oil burners. Wood fired cooker use was also included in the survey. Emissions from cookers were estimated based on fuel consumption data provided and using the emission factors for older (pre 2006) wood burners.

Emission factors were applied to these data to provide an estimate of emissions for each study area. The emission factors used to estimate emissions from domestic heating are shown in Table 3.1. The basis for these is detailed in Appendix B.

Table 3.1: Emission factors for domestic heating methods.

	PM_{10} g/kg	$PM_{2.5}$ g/kg	CO g/kg	NOx g/kg	SO_2 g/kg
Open fire - wood	7.5	7.5	55	1.2	0.2
Open fire - coal	21	18	70	4	8
Pre 2006 burners	10	10	140	0.5	0.2
Post 2006 burners	4.5	4.5	45	0.5	0.2
Pellet burners	2	2	20	0.5	0.2
Multi-fuel[1] - wood	10	10	140	0.5	0.2
Multi-fuel[1] – coal	19	17	110	1.6	8
Gas	0.03	0.03	0.18	1.3	7.56E-09
Oil	0.3	0.22	0.6	2.2	3.8

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

The average weight for a log of wood is one of the assumptions required for this inventory to convert householder's estimates of fuel use in logs per evening to a mass measurement required for estimating emissions. This was converted into average daily fuel consumption based on an average log weight of 1.6 kg per piece of wood and integrating seasonal and weekly usage rates. The value of 1.6 kg/log was selected as the mid-point of the range found from different New Zealand evaluations (Wilton & Bluett, 2012, Wilton, Smith, Dey, & Webley, 2006, Metcalfe, Sridhar, & Wickham, 2013). The log weight recommended for this work (1.6 kg/ piece) is the midpoint and average of the range of values.

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

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

Where:

CE = contaminant emission

EF = emission factor

FB = fuel burnt

The main assumptions underlying the emissions calculations are as follows:

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

3.2 Home heating methods and fuels

Trends in household heating methods/fuels in Motueka from 2006 to 2018 from census data are shown in Figure 3.1. This shows a reduction in the number of households using coal as their main fuel for home heating from 2006 to 2018 and an increase in households using wood. Overall, there is a 2% reduction in households using solid fuel for home heating over the 2006 to 2018 period.

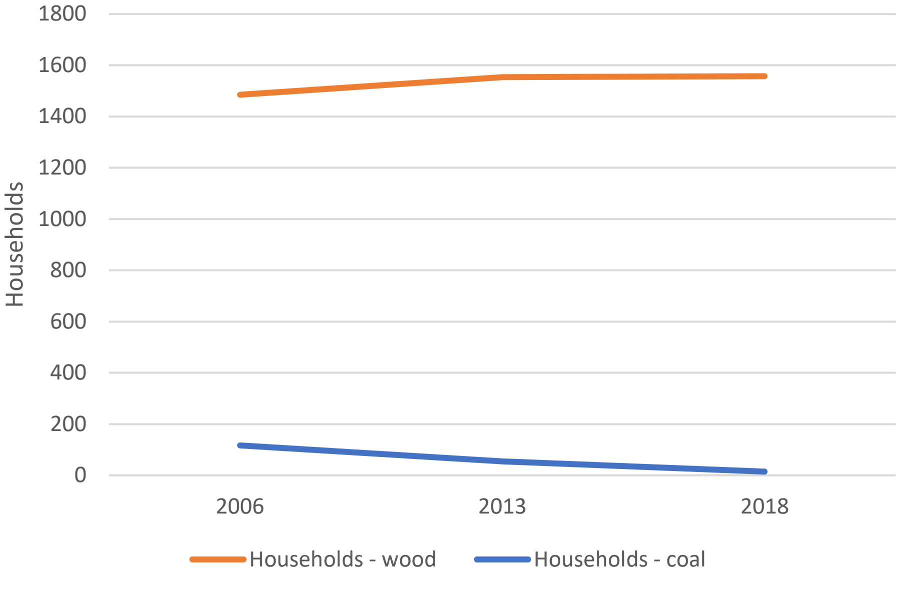

Figure 3.1: Trends in wood or coal use for home heating in Motueka from census data 2006, 2013 and 2018.

The 2023 domestic heating survey for Motueka found in 2023 around 1600 households used wood for home heating and that the most popular form of heating the main living area of homes is electricity with around 71% of households using that method. Around 49% of households use wood burners. The majority of the wood burners are models installed between 2006 and 2016. Open fires and multi fuel burners are used by less than 4% of households. Table 3.2 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 29 tonnes of wood is burnt per typical winter's night in Motueka. Around 63% of the wood used on wood burners in Motueka bought with 37% being self-collected or obtained free of charge.

Figure 3.2 shows the proportion of households using different electrical heating types. This shows around 81% of households using electricity in their main living area use heat pumps.

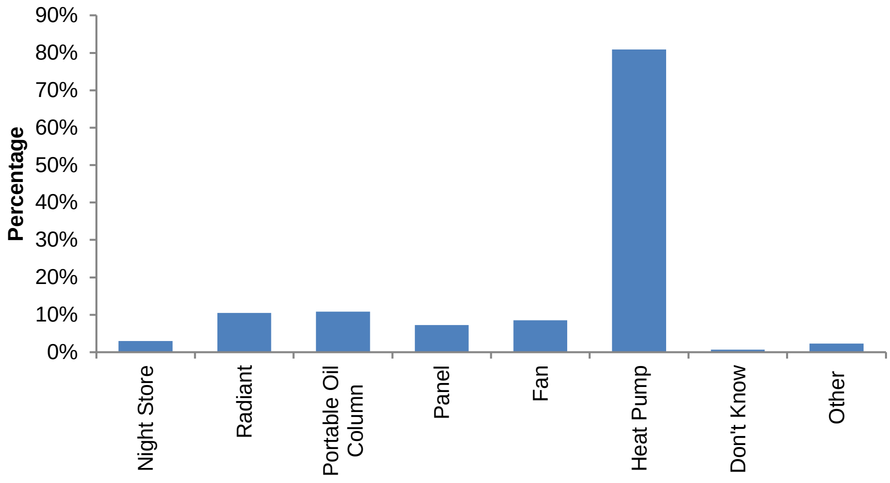

Figure 3.2: Electric heating options for Motueka households (main living area).

Table 3.2: Home heating methods and fuels in Motueka.

	Heating methods		Fuel Use	
	%	Households	t/day	%
Electricity	71%	2,269		
Total Gas	4%	112	0	0%
Flued gas	3%	95		
Unflued gas	1%	17		
Oil	0%	15	0.0	0%
Open fire	1%	30		
Open fire - wood	1%	30	0.2	1%
Open fire - coal	0%	0	0	0%
Total Wood burner	49%	1,575	26	89%
Pre 2006 wood burner	14%	435	7	24%
2006-2018 wood burner	29%	931	15	52%
Post-2018 wood burner	7%	209	3	12%
Multi-fuel burners	2%	52		
Multi-fuel burners-wood	2%	52	2	6%
Multi-fuel burners-coal	0%	0	0	0%
Pellet burners	0%	15	0.1	0%
Wood fired cooker	4%	119	1.1	
Total wood	56%	1,792	29	100%
Total coal	0%	0	0	0%
Total		3,195	29	100%

3.3 Domestic heating emissions

Around 184 kilograms of PM_{10} is discharged on a typical winter's day from domestic home heating and cooking across Motueka.

Figure 3.3 shows that 39% of the PM_{10} emissions are from pre-2006 wood burners and a similar proportion 38% from burners installed between 2006 and 2018. The NES design criteria for wood burners was mandatory for new installations on properties less than 2 hectares from September 2005. Burners less than five years old contribute around 6% of the daily winter PM_{10}. This category included households reporting to use ultra-low emission burners (9% of households using wood burners).

Tables 3.3 and 3.4 show the estimates of emissions for different heating methods under average and worst-case scenarios respectively. Emissions are shown in kilograms per day (kg/day) and in grams per hectare (g/ha). Days when households may not be using specific home heating methods are accounted for in the daily winter average emissions[1]. Under the worst-case scenario that all households are using a burner on any given night around 217 kilograms of PM_{10} is likely to be emitted.

The seasonal variation in contaminant emissions is shown in Table 3.5. Figure 3.4 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during May, June, July and August.

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

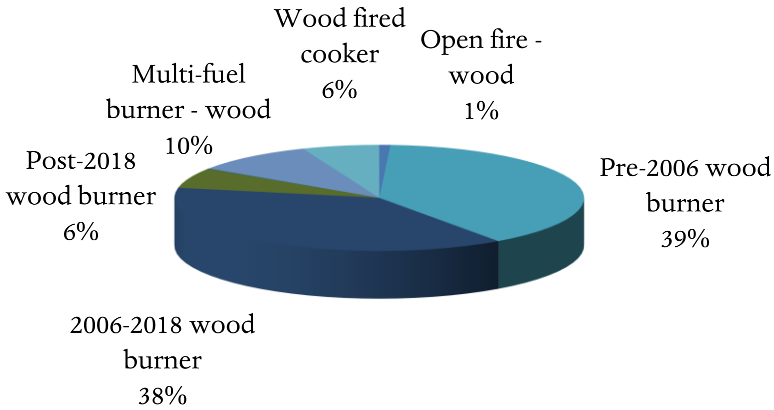

Figure 3.3: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Motueka.

Table 3.3: Motueka winter daily domestic heating emissions by appliance type (winter average for July).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																	
Open fire - wood	0.2	1%	2	1	1%	12	9	1%	0	0	2%	0	0	1%	2	1	1%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood burner	26.3																
Pre 2006 wood burner	7.2	25%	72	53	39%	1010	739	45%	4	3	24%	1	1	24%	72	53	39%
2006-2018 wood burner	15.5	55%	70	51	38%	696	509	31%	8	6	52%	3	2	52%	70	51	38%
Post 2018 wood burner	3.5	12%	11	8	6%	113	83	5%	2	1	12%	1	1	12%	11	8	6%
Pellet Burner	0.1	0%	0.2	0	0%	2	2	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																	
Multi fuel– wood	1.8	6%	18	13	10%	246	180	11%	1	1	6%	0	0	6%	18	13	10%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood fired cooker	1.12	4%	11	8	6%	157	115	7%	1	0	4%	0	0	4%	11	8	6%
Gas	0.1	0%	0.00	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Oil	0.0	0%	0.00	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%
Total Wood	28.2	100%	184	134	100%	2236	1637	100%	15	11	99%	6	4	99%	184	134	100%
Total Coal	0.0	0%	0.00	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total	28		184	134		2236	1637		15	11		6	4		184	134	

Table 3.4: Motueka winter daily domestic heating emissions by appliance type (worst case).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																	
Open fire - wood	0.4	1%	3	2	1%	22	16	1%	0	0	3%	0	0	1%	3	2	1%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood burner	29.9																
Pre 2006 wood burner	8.3	24%	83	60	38%	1155	846	44%	4	3	23%	2	1	24%	83	60	38%
2006-2018 wood burner	17.7	51%	80	58	37%	796	583	30%	9	6	50%	4	3	51%	80	58	37%
Post 2018 wood burner	4.0	12%	13	9	6%	129	95	5%	2	1	11%	1	1	12%	13	9	6%
Pellet Burner	0.1	0%	0	0	0%	2	2	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																	
Multi fuel– wood	2.0	6%	20	14	9%	274	201	10%	1	1	6%	0	0	6%	20	14	9%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Wood fired cooker	1.9	6%	19	14	9%	268	196	10%	1	1	5%	0	0	6%	19	14	9%
Gas	0.1	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%
Total Wood	34	100%	217	159	100%	2647	1937	100%	17	13	99%	7	5	99%	217	159	100%
Total Coal	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total	34		217	159		2647	1937		18	13		7	5		217	159	

Table 3.5: Total annual and monthly variations in contaminant emissions from domestic heating in Motueka.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	$PM_{2.5}$ kg/day
January	5	65	1	2	5
February	5	65	1	2	5
March	5	66	1	2	5
April	14	179	2	2	14
May	138	1669	13	8	138
June	175	2118	16	9	175
July	184	2237	17	10	184
August	172	2086	16	10	171
September	41	508	5	4	41
October	15	183	2	2	15
November	2	24	2	2	2
December	1	7	0	0	1
	PM_{10} tonnes/year	CO tonnes/year	NOx tonnes/year	SOx tonnes/year	$PM_{2.5}$ tonnes/year
Total domestic heating	23	282	2	2	23

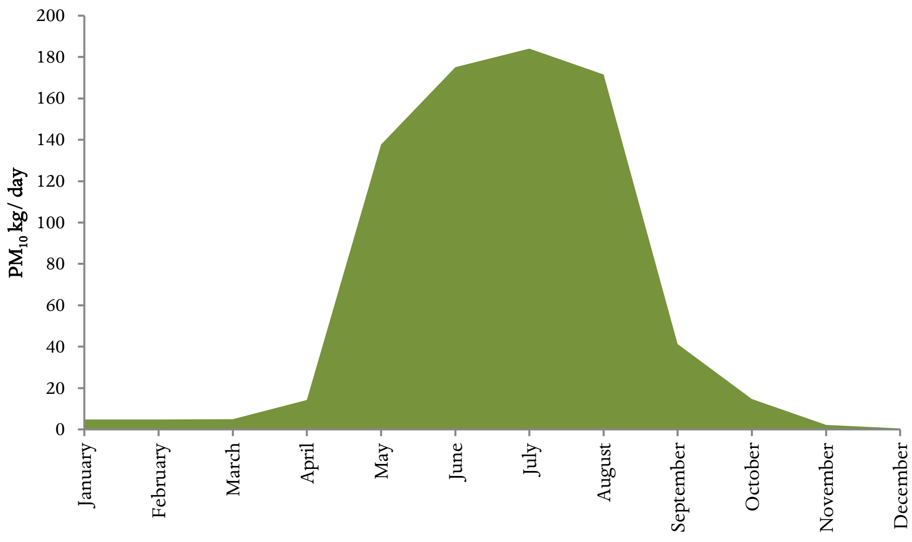

Figure 3.4: Monthly variations in PM_{10} emissions from domestic heating in Motueka.

3.4 Other domestic sources of emissions

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. Wilton, (2019) provides an assessment of potential emissions from small domestic appliances such as lawn mowers, chain saws and leaf blowers that which indicates a range of 0.0012 to 0.05 g/household/day for PM_{10}. This indicates less than half a kilogram of PM_{10} per day in Motueka. Because of the negligible quantities from these sources, they have not been included in the subsequent emission estimates.

4 MOTOR VEHICLES

4.1 Methodology

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

Emission factors for motor vehicles are determined using the Vehicle Emission Prediction Model (VEPM 6.0) developed by Auckland Council. Emission factors for PM_{10}, $PM_{2.5}$, CO and NOx for this study have been based on VEPM 6.0. Default settings were used for all variables except for the temperature data and the vehicle fleet profile which was based on Tasman vehicle registration data for the year ending December 2022 (Table 4.1). Temperature data were based on an average winter temperature for Motueka of 6.5 degrees. Resulting emission factors are shown in Table 4.2.

Emission factors for SOx were estimated for diesel vehicles based on the sulphur content of the fuel (10ppm) and the assumption of 100% conversion to SOx. The g/km emission factor was estimated using VEPM 6.0 using the fuel consumption per VKT for the parameters described above.

The number of vehicle kilometres travelled (VKT) for each area were estimated using the New Zealand Transport Authority VKT data (Table 4.3) for Motueka. The NZTA data are available only at the District level. The year 2021 VKT estimate for Tasman District was 623 million VKT and is the most recent year that data are available. Spatially distributed VKT data from NZTA from 2013 found around 6% of the Districts VKT occurred in Motueka. These data were used to estimate the 2023 VKT for Motueka (6% of 2021 VKT for Tasman).

In addition to estimates of tailpipe emissions and brake and tyre emissions using VEPM an estimate of the non-tailpipe emissions (including brake and tyre wear and re-suspended road dusts) was made using the European Environment Agency (EEA) air pollutant emission inventory guidebook (2016) combined with the fleet profile data. The emission factors from this method are shown in Table 4.4. It is noted that emission factors for fugitive sources such as resuspended dusts can have a high level of uncertainty.

Table 4.1: Vehicle registrations for Tasman for the year ending December 2022.

Motueka	Petrol	Diesel	Hybrid	Plug in Hybrid	Electric	LPG	Other	Total
Cars	357	60	133	64	104	0	0	718
LCV	18	359	0	0	0	0	0	377
Bus	0	0	0	0	0	0	0	0
HCV		143			1			144
Miscellaneous	55	54	0	0	19	1	0	129
Motorcycle	139							139
Total	569	616	133	64	124	1	0	1,507

Table 4.2: Emission factors for Tasman vehicle fleet (2023).

2023	CO g/VKT	PM_{10} g/VKT	PM brake & tyre g/VKT	NOx g/VKT	NO_2 g/VKT	$PM_{2.5}$ g/VKT	$PM_{2.5}$ brake & tyre g/VKT
Tasman	0.8	0.027	0.024	0.840	0.195	0.022	0.012

Table 4.3: VKT daily and annual (NZTA, 2021).

	Total VKT per day	Annual VKT
Motueka	102438	37390011

Emissions were calculated by multiplying the appropriate average emission factor by the VKT:

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

Table 4.4: Road dust total suspended particulate (TSP) emissions (EEA, 2016).

	TSP g/KVT
Two wheeled vehicles	0.001
Passenger car	0.008
Light duty trucks	0.004
Heavy duty trucks	0.007
Weighted vehicle fleet factor	0.020
PM_{10} size fraction	0.010
$PM_{2.5}$ size fraction	0.005

4.2 Motor vehicle emissions

Around six kilograms per day of PM_{10} are estimated to be emitted from motor vehicles daily in Motueka.

Around 45% of the PM_{10} and 60% of the $PM_{2.5}$ from motor vehicles is estimated to occur as a result of the tailpipe emissions with the remainder estimated from brake and tyre wear and road dust (Figure 4.1). Tables 4.5 and 4.6 show the daily and annual estimates of emissions from motor vehicles in Motueka.

Table 4.5: Summary of daily motor vehicle emissions (kg/day)

	PM_{10}		CO		NOx		SOx		$PM_{2.5}$	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Tailpipe	2.8	2.0	82	60	86	63	0.1	0.08	2.8	2.0
Brake and tyre	2.4	1.8							1.3	1.0
Road dust	1.0	0.7							0.6	0.4
Total	6.2	4.6	82	60	86	63	0.1	0.08	4.6	3.4

Table 4.6: Summary of annual motor vehicle emissions (tonnes/year)

	PM_{10}		CO		NOx		SOx		$PM_{2.5}$	
	tonnes	kg/ha	tonnes	kg/ha	tonnes	kg/ha	tonnes	kg/ha	tonnes	kg/ha
Tailpipe	1.0	0.7	30	22	31	23	0.0	0.03	1.0	0.7
Brake and tyre	0.9	0.6							0.5	0.3
Road dust	0.4	0.3							0.2	0.1
Total	2.3	1.7	30	22	31	23	0.0	0.03	1.7	1.2

Figure 4.1: Motor vehicle PM_{10} (left) and $PM_{2.5}$ (right) emissions by source.

5 INDUSTRIAL AND COMMERCIAL ACTIVITIES

5.1 Methodology

Industrial and commercial activities to be included in the inventory were identified by searching a range of databases and through the Council's resource consent database.

Information on activities with resource consents for discharges to air in Motueka were provided by the Tasman District Council. Additionally, schools in were contacted to assess if solid fuels or diesel were used for school heating.

The general approach was to identify activities discharging to air and collect site specific information relevant to the discharge type (activity data) as well as information on seasonal variability and hours of operation where relevant.

For industries for which relatively recent site-specific emissions data were available from compliance testing or the resource consent application, emissions were estimated based on equation 5.1.

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

Where site specific emissions data were not available, emissions were estimated using activity data and emission factor information, as indicated in Equation 5.2. Activity data from industry includes information such as the quantities of fuel used, or in the case of non-combustion activities, materials used or produced. Activity data was collected by direct contact with industry, using data from the resource consents or compliance monitoring or a combination of these methods.

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

The emission factors used to estimate the quantity of emissions discharged are shown in Table 5.1. Site specific information was available for a number of sources. The emissions factors used are from the USEPA AP42 database[2] (USEPA, 2023) with the exception of the cremation factors which are from EEA, (2016) and coal and wood combustion factors which are from (Wilton & Baynes, 2010). In addition, AP 42 database was used to assess the proportion of PM_{10} emissions that were likely to be $PM_{2.5}$ for a range of sources. Fugitive dust emissions from industrial and commercial activities were generally not included in the inventory assessment because of difficulties in quantifying the emissions.

Table 5.1: Emission factors for industrial discharges.

AP 42 Chapter	AP 42 Source Category Code	Discharge Type	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	$PM_{2.5}$ g/kg
11.12	SCC 3-05-011-04,-21,23	Aggregate loading unloading for concrete production	0.0017				0.0005
EEA 2016	5.c.1.v Table 3.1	Crematoria	0.0347	0.14	0.824	0.113	0.0347
	Wilton and Baynes (2009) for PM and AP 42 for others	Wood boiler	1.6	6.8	0.8	0.04	1.4

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

AP42 Chpt 3	SO_2 by % in fuel	Light Fuel Oil Boiler	1.3	0.67	6.3	40.0	0.8

5.2 Industrial and commercial emissions

Table 5.2 shows the estimated emissions to air from industrial and commercial activities in Motueka. The two main industrial activities contributing to the emissions were Genia (timber products) and Talley's (seafood processing). Around seven tonnes of PM_{10} and five tonnes of $PM_{2.5}$ is estimated to be discharged to air per year in Motueka. The average daily amount during winter is 19 kg/day and 14 kg/day for PM_{10} and $PM_{2.5}$ respectively (Table 5.2).

Table 5.2: Industrial and commercial daily and annual emissions in Motueka.

	PM_{10}		CO		NOx		SOx		$PM_{2.5}$	
Daily	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Industrial & commercial activities	19	14	41	30	53	39	308	226	14	10
	PM_{10}		CO		NOx		SOx		$PM_{2.5}$	
Annual	t/year	kg/ha	t/year	kg/ha	t/year	kg/ha	t/year	kg/ha	t/year	kg/ha
Industrial & commercial activities	7	5	15	11	20	14	115	84	5	4

6 OUTDOOR BURNING EMISSIONS

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

The Tasman Resource Management Plan (TRMP) does not allow open burning of garden waste or burning in the outdoors in incinerators in the Fire Ban area of Motueka. Exemptions from this exist for:

- Fireworks.
- Small fires used for food cooking purposes such as barbecues, hangis, and small camp fires that are no bigger than $1m^2$ at the base.
- Candles, lamps or similar small-scale burners or tools.
- Outdoor fireplaces, including braziers or fires for ahi ka purposes.
- Celebratory fires in Open Space Zone or Recreation Zone.
- Any forge or kiln.
- Burning during the months of October to April on properties larger than $5000m^2$ with a resource consent.

The Fire Ban area of Motueka is shown in Figure 6.1. The 'Fire Sensitive Area' adjacent to the Fire Ban area (brown shading) defines the spatial catchment for seasonal restrictions over winter (June to August inclusive). The Fire Sensitive Area requirements replicates the Fire Ban requirements, but also allows for the permissive wintertime burning controls for disease management under the TRMP.

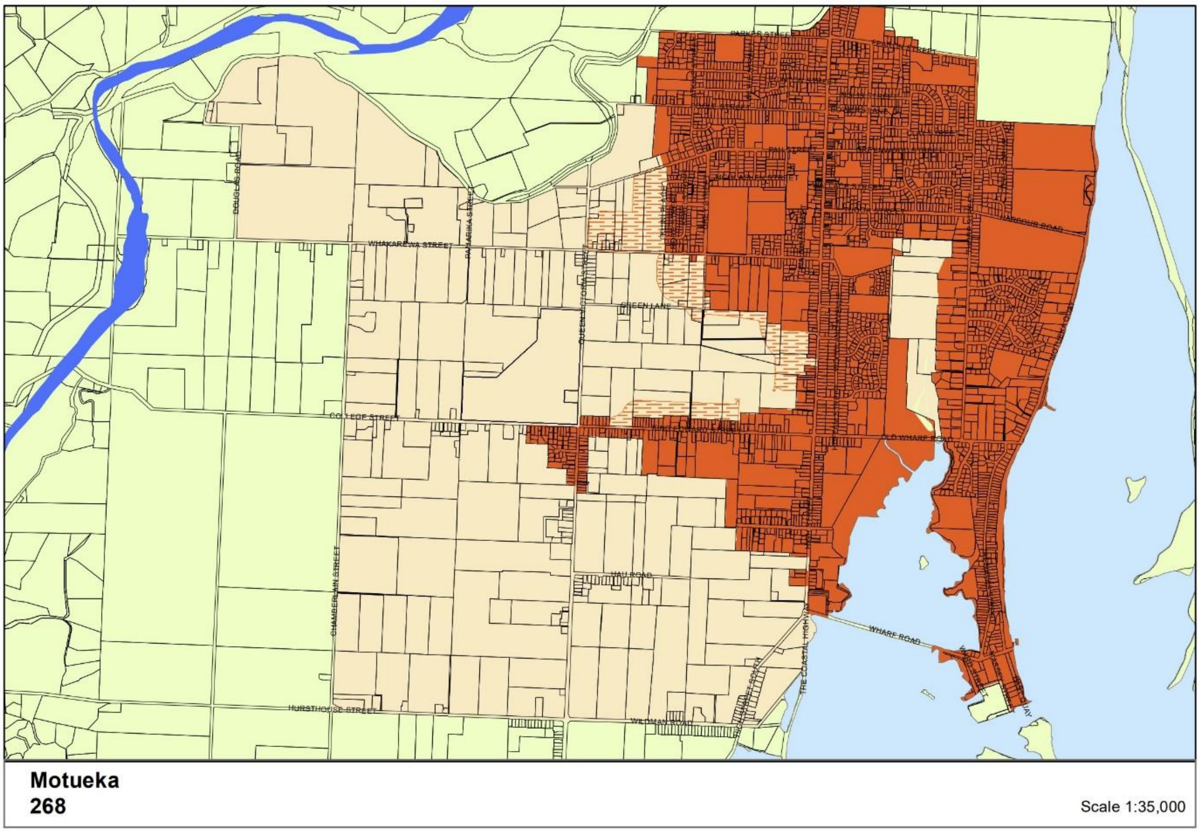

Figure 6-1: TRMP Motueka Fire Ban (red shading) and Fire Sensitive Area (brown shading)

An additional source of burning in the outdoors that can contribute to air pollution is the use of braziers, pizza ovens and wood fired barbeques. This source is also evaluated in this section.

6.1 Methodology

Outdoor burning emissions for Motueka were estimated for all seasons based on data collected during the 2023 domestic home heating survey. This included questions relating to the burning of garden waste in the outdoors as well as the frequency of and quantities of materials burnt in braziers, wood fired barbeques and pizza ovens.

Emissions from the burning of garden waste were calculated based on the assumption of an average weight of material per burn of 159 kilograms per cubic metre of material[3] and using the emission factors in Table 6.1 with an average fire size of 1.6 m^3 (size based on survey responses). The AP42 emission factor database includes estimates for a wide range of materials including different tree species, weeds, leaves, vines and other agricultural material. The factors selected are based on a combination of refuse (AP42 table 2.5.1), weeds and prunings (AP42 table 2.5.5). Emission factors for SOx are based on residential wood burning in the absence of emission factors for these contaminants within the AP42 database for outdoor burning. AP42 emission factors were selected in preference to European Environment Agency air pollution emission inventory guidebook (EEA, 2016) tier one assessment emission factors as the latter are based on tree slash for two species and tree pruning for two species only. Emission factors for burning of wood on braziers, pizza ovens and barbeques also used the emission factors in Table 6.1.

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

Source AP 42	PM_{10} g/kg	$PM_{2.5}$ g/kg	CO g/kg	NOx g/kg	SOx g/kg
Tables 2.5- 1 and 2.5-5	8	8	42	3	0.5

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

6.2 Outdoor burning emissions

Table 6.2 shows that around four kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Motueka. This does not include the impact from outdoor burning from outside of the inventory study area. Survey responses for Motueka indicated a greater prevalence of outdoor burning during the winter months than other seasons of the year.

It should be noted that there are a number of uncertainties relating to the calculations. In particular it is assumed that burning is carried out evenly throughout each season, whereas in reality it is highly probable that a disproportionate amount of burning is carried out on days more suitable for burning. Thus, on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment. Outdoor burning emissions include a higher degree of uncertainty relative to domestic heating, motor vehicles and industry owing to uncertainties in the distribution of burning and potential variabilities in material density.

Table 6.2: Outdoor burning (garden waste) emission estimates for Motueka.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	$PM_{2.5}$ kg/day
Summer (Dec-Feb)	1	7	1	0	1
Autumn (Mar-May)	2	11	1	0	2
Winter (June-Aug)	4	21	2	0	4
Spring (Sept-Nov)	2	9	1	0	2
	PM_{10} tonnes/ year	CO tonnes/ year	NOx tonnes/ year	SOx tonnes/ year	$PM_{2.5}$ tonnes/ year
Annual emissions	1	4	0.3	0.1	1

6.3 Brazier, pizza oven and wood fired barbeque emissions

Around two kilograms of PM_{10} and $PM_{2.5}$ from braziers, pizza ovens and outdoor barbeques could be expected per day during the winter months from these sources Motueka. In summer this increases to around three kilograms (Table 6.3).

Table 6.3: Brazier, pizza oven and wood fired barbeque emission estimates for Motueka.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	$PM_{2.5}$ kg/day
Summer (Dec-Feb)	3	16	1	0	3
Autumn (Mar-May)	2	12	1	0	2
Winter (June-Aug)	2	10	1	0	2
Spring (Sept-Nov)	2	13	1	0	2
	PM_{10} tonnes/ year	CO tonnes/ year	NOx tonnes/ year	SOx tonnes/ year	$PM_{2.5}$ tonnes/ year
Annual emissions	1	5	0	0	1

6.4 Total emissions from outdoor burning

Table 6.4 shows the combined outdoor garden waste burning and burning of wood in braziers, pizza ovens and wood fired barbeques in Motueka for 2023 by season and per year. Around six kilograms per day and around two tonnes per year of PM_{10} and $PM_{2.5}$ are estimated from burning in the outdoors.

Table 6.4: Total outdoor burning emission estimates for Motueka.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	$PM_{2.5}$ kg/day
Summer (Dec-Feb)	5	24	2	0	5
Autumn (Mar-May)	4	23	2	0	4
Winter (June-Aug)	6	31	2	0	6
Spring (Sept-Nov)	4	22	2	0	4
	PM_{10} tonnes/ year	CO tonnes/ year	NOx tonnes/ year	SOx tonnes/ year	$PM_{2.5}$ tonnes/ year
Annual emissions	2	9	1	0	2

7 TOTAL EMISSIONS FOR MOTUEKA

The total PM_{10} and $PM_{2.5}$ emissions per year for Motueka for 2023 was 34 and 32 tonnes respectively. The Around 215 kilograms of PM_{10} and 209 kilograms of $PM_{2.5}$ are emitted per day during winter. Domestic heating was the dominant source of daily winter and annual PM_{10} (Figure 7.1). Industry is the next largest contributor at 9% of the daily winter PM_{10} and 21% of the annual PM_{10} and 7% and 16% of the $PM_{2.5}$ (Figure 7.2).

Motor vehicles and outdoor burning contribute 6% and 5% of the annual PM_{10} and 5% and 6% of the annual $PM_{2.5}$. These sources are minor contributors to the daily PM_{10} and $PM_{2.5}$ emissions.

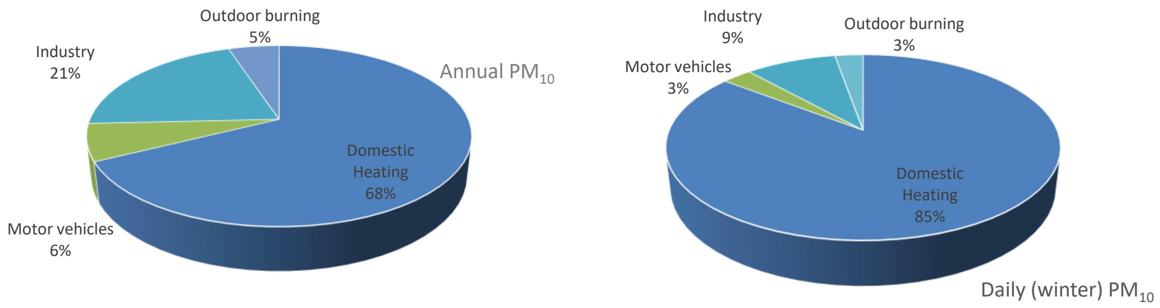

Figure 7.1: Relative contribution of sources to annual PM_{10} and daily winter PM_{10} emissions in Motueka.

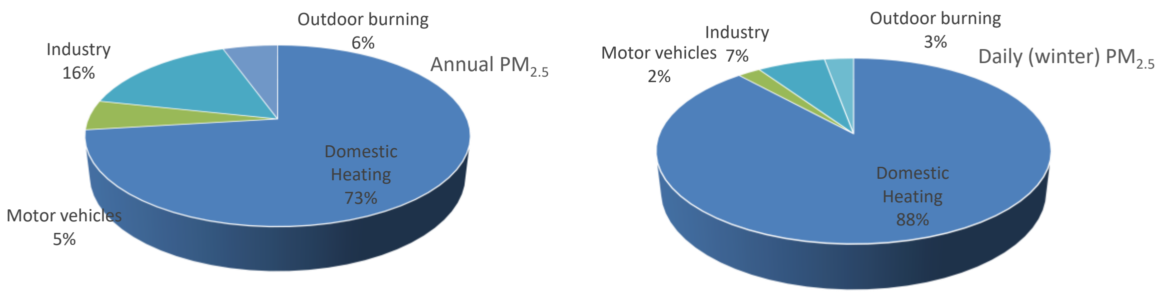

Figure 7.2: Relative contribution of sources to annual $PM_{2.5}$ and daily winter $PM_{2.5}$ in Motueka.

Around 336 tonnes per year of CO and 54 tonnes per year of NOx are emitted in Motueka. Figures 7.3 and 7.4 show domestic heating is also the main source of CO and motor vehicles are the main source of NOx emissions in Motueka. Industry is the main source of SOx (Figure 7.5).

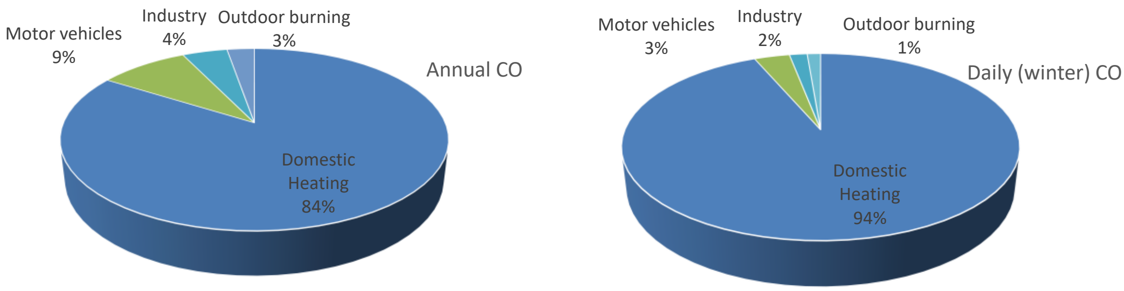

Figure 7.3: Relative contribution of sources to daily winter and annual average CO, emissions in Motueka

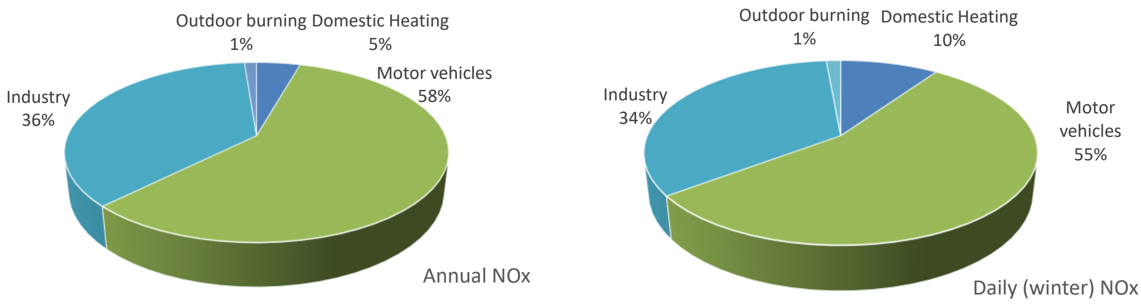

Figure 7.4: Relative contribution of sources to annual (left) and daily winter (right) NOx emissions in Motueka.

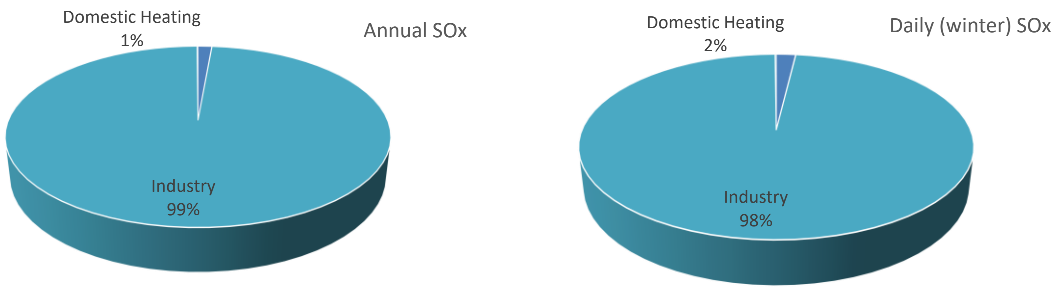

Figure 7.5: Relative contribution of sources to daily winter and annual average SOx, emissions in Motueka

Seasonal variations in PM_{10} emissions are shown in Table 7.3. This suggests the main sources of summer time anthropogenic PM_{10} is industry. Seasonal variations in emissions of other contaminants are shown in Tables 7.4 to 7.7

Table 7.1: Annual average emissions in Motueka by source and contaminant (tonnes/year)

	PM_{10} tonnes/year	CO tonnes/year	Nox tonnes/year	Sox tonnes/year	$PM_{2.5}$ tonnes/year
Domestic Heating	23.2	282	2	2	23
Motor vehicles	2.3	30	31	0	2
Industry	7.1	15	20	115	5
Outdoor burning	1.7	9	1	0	2
Total	34	336	54	116	32

Table 7.2: Daily (winter) average emissions in Motueka by source and contaminant (kg/day)

	PM_{10} kg/day	CO kg/day	Nox kg/day	Sox kg/day	$PM_{2.5}$ kg/day
Domestic Heating	184	2237	17	10	184
Motor vehicles	6	82	86	0	5
Industry	19	41	53	308	14
Outdoor burning	6	31	2	0	6
Total	215	2391	158	319	209

Table 7.3: Monthly variations in PM_{10} emissions in Motueka by source (kg/day)

	Domestic Heating kg/day	Motor vehicles kg/day	Industry kg/day	Outdoor burning kg/day	Total kg/day
January	5	6	19	5	55
February	5	6	21	5	57
March	5	6	19	4	55
April	14	6	20	4	65
May	138	6	19	4	188
June	175	6	20	6	227
July	184	6	19	6	235
August	172	6	19	6	223
September	41	6	20	4	92
October	15	6	19	4	64
November	2	6	20	4	52
December	1	6	19	5	51

Table 7.4: Monthly variations in CO emissions in Motueka by source (kg/day)

	Domestic Heating kg/day	Motor vehicles kg/day	Industry kg/day	Outdoor burning kg/day	Total kg/day
January	65	82	40	24	210
February	65	82	44	24	214
March	66	82	40	23	211
April	179	82	42	23	326
May	1669	82	40	23	1815
June	2118	82	43	31	2274
July	2237	82	41	31	2391
August	2086	82	41	31	2240
September	508	82	42	22	654
October	183	82	40	22	328
November	24	82	42	22	170
December	7	82	40	24	152

Table 7.5: Monthly variations in NOx emissions in Motueka by source (kg/day)

	Domestic Heating kg/day	Motor vehicles kg/day	Industry kg/day	Outdoor burning kg/day	Total kg/day
January	1	86	53	2	142
February	1	86	58	2	147
March	1	86	53	2	142
April	2	86	54	2	144
May	13	86	53	2	154
June	16	86	55	2	159
July	17	86	53	2	158
August	16	86	53	2	157
September	5	86	54	2	147
October	2	86	53	2	142
November	2	86	54	2	144
December	0	86	53	2	140

Table 7.6: Monthly variations in SOx emissions in Motueka by source (kg/day)

	Domestic Heating kg/day	Motor vehicles kg/day	Industry kg/day	Outdoor burning kg/day	Total kg/day
January	2	0.1	308	0.3	310
February	2	0.1	341	0.3	343
March	2	0.1	308	0.3	310
April	2	0.1	319	0.3	321
May	8	0.1	308	0.3	317
June	9	0.1	319	0.4	328
July	10	0.1	308	0.4	319
August	10	0.1	308	0.4	318
September	4	0.1	319	0.3	323
October	2	0.1	308	0.3	311
November	2	0.1	319	0.3	321
December	0	0.1	308	0.3	309

Table 7.7: Monthly variations in $PM_{2.5}$ emissions in Motueka by source (kg/day)

	Domestic Heating kg/day	Motor vehicles kg/day	Industry kg/day	Outdoor burning kg/day	Total kg/day
January	5	5	14	5	34
February	5	5	15	5	35
March	5	5	14	4	34
April	14	5	14	4	43
May	138	5	14	4	166
June	175	5	14	6	206
July	184	5	14	6	214
August	171	5	14	6	202
September	41	5	14	4	70
October	15	5	14	4	43
November	2	5	14	4	31
December	1	5	14	5	29

REFERENCES

Bluett, J., Smith, J., Wilton, E., & Mallet, T. (2009, September 8). *Real world emission testing of domestic wood burners*. 19th International Clean Air and Environment Conference, Perth.

EEA. (2016). *Air pollutant emission inventory guidebook—2016*. European Environment Agency Report 21/2016.

Ehrlich, N., & Kalkoff, W. (2007). *Determining PM-emission fractions (PM10, PM2.5, PM1.0) from small-scale combustion units and domestic stoves using different types of fuels including bio fuels like wood pellets and energy grain*. DustConf. http://www.dustconf.com/CLIENT/DUSTCONF/UPLOAD/S4/EHRLICH_.PDF

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

Ministry for the Environment. (2020). *Proposed amendments to the National Environmental Standards for Air Quality, particulate matter and mercury emissions*. Ministry for Environment.

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

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

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

.

USEPA. (2023). *USEPA AP42 Emissions Database'*. http://www.epa.gov/ttn/chief/ap42/

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

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

Wilton, E. (2019). *Tauranga Air Emission Inventory—2018*. Bay of Plenty Regional Council. https://www.boprc.govt.nz/environment/air/air-pollution/

Wilton, E., & Baynes, M. (2010). *Improving PM10 Emission Factors from Industrial Boilers in New Zealand—Stage 2*. Report prepared for the Foundation of Research, Science and Technology.

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

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

APPENDIX A: HOME HEATING QUESTIONNAIRE

1a.) Do you use any type of electrical heating in your MAIN living area during a typical year?

1b.) What type of electrical heating do you use? Would it be...

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

1c.) Off the top of your head approximately how much would you spend, on average, per month during the winter, on electricity for space heating?

1d.) Do you use any other heating system in your main living area in a typical year? *(*

2a.) Do you use any type of gas heating in your MAIN living area or a gas fired central heating system during a typical year?

2b.) Is it flued or unflued gas heating?

2c.) Which months of the year do you use your gas burner/ heating system?

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

2d.) How many days per week would you use your gas burner/ heating system during?

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

2e.) Do you use mains or bottled gas for home heating?

2f.) Off the top of your head approximately how much would you spend, on average, per month during the winter, on gas for your gas burner/ heating system?

3a.) Do you use a log burner (wood burner) in your MAIN living area during a typical year? This is a fully enclosed burner but does not include multi fuel burner that burns coal or burns coal and wood

3b.) Which months of the year do you use your log burner

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

3c.) How many days per week would you use your log burner during? *(*

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

3d.) During the winter what times of the day do you use your log burner? 6am – 11am

- 11am - 4pm
- 4pm - 10pm
- 10pm - 6am

3e.) Approximately what time during the evening would you put your last load on the fire.

3f.) How old is your log burner?

- 17 years+
- Between 5 and 16 years old
- Less than 5 years old

3f1.) Is your burner an ultra-low emission burner (ULEB)?

3h.) How many pieces of wood do you use per day on an average winters day?

3h2.) How many pieces of wood do you use per day during the other months?

3i.) In a typical year, how much wood would you use per year on your log burner?

3j.) Do you buy wood for your log burner, or do you receive it free of charge?

3k.) What percentage would be bought

3l.) Off the top of your head approximately how much would you spend, on average, per month during the winter, on wood for your log burner?

3m.) If you placed your hand on your burner first thing in the morning (e.g., 6am-7am) after having used it the night before would it be…

- Cold to touch (no feeling of leftover heat)
- Warm to touch (if you held your hands there for a bit it would warm them up)
- Hot to touch (too hot to hold a hand on for more than a few seconds)

4a.) Do you use an enclosed burner which can burn coal as well as wood – i.e., a multi fuel burner in your MAIN living area during a typical year?

4b.) Which months of the year do you use your multi fuel burner?

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

4c.) 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

1

4d.) How old is your multi fuel burner?

- 17 years+

- Between 5 and 16 years old
- Less than 5 years old

4e.) Do you use wood on your multi fuel burner?

4f2.) How many pieces of wood do you use per day on average on a typical winters day

4h.) How many pieces of wood do you use per day during the other months

4i.) In a typical year, how much wood would you use per year on your multi fuel burner?

4j.) Do you use coal on your multi fuel burner?

4l.) How many buckets of coal do you use per day on average on a typical winters day?

4n.) How many buckets of coal do you use per day during the other months

4o.) Do you buy wood for your multi fuel burner, or do you receive it free of charge? *(*

4p.) What percentage would be bought?

5a.) Do you use an open fire in your MAIN living area during a typical year?

5b.) Which months of the year do you use your open fire

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

5c.) How many days per week would you use your open fire during?

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

5d.) Do you use wood on your open fire?

5f.) How many pieces of wood do you use per day on average on a typical winters day?

5h.) How many pieces of wood do you use per day during the other months

5i.) In a typical year, how much wood would you use per year on your open fire?

5j.) Do you use coal on your open fire?

5k.) How many buckets of coal do you use per day during the winter? (

5l.) How many buckets of coal do you use per day during the other months?

5m.) Do you buy wood for your open fire, or do you receive it free of charge?

5n.) What percentage would be bought?

) 5o.) Off the top of your head approximately how much would you spend, on average, per month during the winter, on wood and coal for your open fire?

6a.) Do you use a pellet burner in your MAIN living area or pellet fired central heating system during a typical year?

6b.) Which months of the year do you use your pellet burner

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

6c.) How many days per week would you use your pellet burner during?

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

6d.) How old is your pellet burner?

- 17 years+
- Between 5 and 16 years old
- Less than 5 years old

6f.) How many kilograms of pellets do you use per day on average on a typical winters day?

6h.) How many kgs of pellets do you use per day during the other months

6i.) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?

6j.) Off the top of your head approximately how much would you spend, on average, per month during the winter, on pellets for your pellet burner?

7a.) Do you use any other heating system in your MAIN living area during a typical year?

7b.) What type of heating system do you

8a.) Do you use an indoor wood fuelled cooking appliance during a typical year? (This is an appliance primarily used for cooking and includes an oven and hot plate)

8b.) Which months of the year do you use your wood fuelled cooker?

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

8c.) How many days per week would you use your wood fuelled cooker during?

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

8d.) How old is your wood fuelled cooker?

- 17 years+
- Between 5 and 16 years old
- Less than 5 years old

8e.) In a typical year, how many pieces of wood do you use on an average winter's day on your wood fuelled cooker?

9. Does your home have insulation?

Where do you have insulation in your home?

- Ceiling
- Under floor

- Wall
- Cylinder wrap
- Double glazing
- Other
- None

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

10a.) How many days would you burn waste or garden rubbish outdoors during winter

10b.) How many days would you burn waste or garden rubbish outdoors during Spring?

10c.) How many days would you burn waste or garden rubbish outdoors during Summer?

10d.) How many days would you burn waste or garden rubbish outdoors during Autumn?

10e.) How many cubic metres of garden waste or other material would be burnt per fire on average?

11) Do you use a wood fired bbq, pizza oven, brazier or outdoor fire for outdoor recreation or cooking purposes.

11a) How many days would you use an oven, brazier or outdoor fire during winter?

11b.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor fire during Spring?

11c.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor fire during Summer?

11d.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor fire during Autumn?

11 e) How many pieces of wood would you use on your bbq, pizza oven, brazier or outdoor fire per burn

APPENDIX B: EMISSION FACTORS FOR DOMESTIC HEATING.

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

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

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

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

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

Emission factors for $PM_{2.5}$ are based on 100% of the particulate from wood burning being in the $PM_{2.5}$ size fraction and 88% of the PM_{10} from domestic coal burning. The $PM_{2.5}$ component of PM_{10} is typically expressed as a proportion. The AP42 wood stove and open fire proportion is based on 1998 data and given as 93% of the PM_{10} being $PM_{2.5}$ (http://www.epa.gov/ttnchie1/efdocs/rwc_pm25.pdf). Smithson, (2011) uses a proportion of 97% which is more consistent with current scientific understanding that virtually all the particulate from wood burning in New Zealand is less than 2.5 microns in diameter (Perry Davy, pers comm, 2014). Literature review of the proportion of PM_{10} that was $PM_{2.5}$ returns minimal information for domestic scale wood use. The technical advisory group to the Ministry for the Environment (2014) air quality indicators project on emissions advised their preference for a value of 100% and we have opted for this value for subsequent work because information is indicative of a value nearing 100%. Further investigations into this may be warranted in the future given the focus towards $PM_{2.5}$. A value of 88% from Ehrlich & Kalkoff, (2007) was used for the proportion of PM_{10} in the $PM_{2.5}$ size fraction for small scale coal burning.

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

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