# ALEXANDRA, ARROWTOWN, MOSGIEL AND MILTON AIR EMISSION INVENTORY 2026

PREPARED BY

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# EXECUTIVE SUMMARY

Fine particulate matter ($PM_{2.5}$) is the air contaminant of greatest concern for human health in urban Otago. Although New Zealand's National Environmental Standard for Air Quality (NES-AQ) regulates $PM_{10}$, international evidence firmly establishes $PM_{2.5}$ as the more health-relevant metric, with the World Health Organization's 2021 Global Air Quality Guidelines (WHO, 2021) setting a 24-hour mean guideline value of 15 μg/m$^3$ and an annual mean of 5 μg/m$^3$. Both thresholds are substantially lower than existing NES-AQ limits, underscoring the significance of reducing particulate emissions in the four communities assessed in this report.

This report presents an assessment of anthropogenic emissions to air in Alexandra, Arrowtown, Mosgiel and Milton for 2025/2026. The inventory quantifies emissions from domestic heating, motor vehicles, industrial and commercial activities, and outdoor burning, and assesses how emissions have changed since previous inventories. Contaminants evaluated include $PM_{10}$, $PM_{2.5}$, carbon monoxide (CO), nitrogen oxides ($NO_x$), sulphur oxides ($SO_x$), volatile organic compounds (VOC) and carbon dioxide ($CO_2$).

A household heating survey was undertaken by Symphony Research in June 2026 to determine the proportions of households using different heating methods and fuels. Electricity and wood burners are the most common heating methods across all four areas. In Alexandra, 66% of households use electricity and 58% use wood burners; in Arrowtown, 67% and 54% respectively; in Milton, 51% and 53%; and in Mosgiel, 83% and 39%.

Domestic heating is the dominant source of anthropogenic $PM_{10}$ and $PM_{2.5}$ in all four areas. On an average winter's day, domestic heating contributes 87% of $PM_{10}$ in Alexandra, 85% in Arrowtown, and 92% in Mosgiel and Milton. The contributions to $PM_{2.5}$ are similar. Outdoor burning and motor vehicles each typically contribute less than 10%. Motor vehicles are the primary source of $NO_x$ in all areas but are not a significant contributor to $PM_{10}$ and $PM_{2.5}$. Total average daily winter $PM_{10}$ emissions are approximately 153 kg/day in Alexandra, 38 kg/day in Arrowtown, 292 kg/day in Mosgiel, and 96 kg/day in Milton.

Comparison with previous inventories indicates that $PM_{10}$ emissions have continued to decline since 2016 in all four areas. Arrowtown has seen the largest reduction (approximately 62% since 2016), driven primarily by a high uptake of ultra-low emission burners (ULEBs), which now account for over half of wood burners in use. Alexandra has reduced by around 19% since 2016, with Mosgiel and Milton each reducing by approximately 30%. These reductions build on larger decreases observed between 2005/2006 and 2016, which were driven primarily by the replacement of pre-2006 wood burners and the reduction in coal use for domestic heating. The cumulative reductions since 2005/2006 are substantial across all areas and reflect the ongoing effectiveness of burner replacement programmes and regulatory controls on solid fuel appliances.

# 1 INTRODUCTION

Fine particulate matter ($PM_{2.5}$ - particles less than 2.5 microns in diameter) is the air contaminant of greatest concern for human health in urban Otago. Although regulatory frameworks in New Zealand have historically focused on the coarser $PM_{10}$ fraction (particles less than 10 microns in diameter), international evidence now firmly establishes $PM_{2.5}$ as the more health-relevant metric. The World Health Organization's 2021 Global Air Quality Guidelines (WHO, 2021) set a 24-hour mean guideline value of 15 µg/m³ for $PM_{2.5}$ and an annual mean of 5 µg/m³ reflect extensive evidence linking $PM_{2.5}$ exposure to cardiovascular disease, respiratory illness, lung cancer, and premature mortality.

Under New Zealand's National Environmental Standards for Air Quality (NES-AQ), a 24-hour $PM_{10}$ limit of 50 µg/m³ currently applies and this may be exceeded on no more than one occasion per year. Concentrations in excess of this limit have been recorded across a number of Otago towns. Alexandra and Arrowtown, which together with Cromwell and Clyde form Air Zone 1, have historically recorded some of the highest $PM_{10}$ concentrations in the region. Mosgiel and Milton, which form part of Air Zone 2, also regularly experience exceedances during winter months.

Otago Regional Council's most recent Annual Air Quality Report (ORC, 2026) indicated 16 exceedances of the NES-AQ $PM_{10}$ standard across the region during winter 2025, down from 28 exceedances in 2024. Exceedances were recorded in Alexandra (4), Arrowtown (10) and Mosgiel (2). Particulate matter from home heating remains the primary air quality issue in Otago, particularly during colder winter conditions when smoke can become trapped close to the ground. During 2025, $PM_{2.5}$ monitoring was carried out in eight locations across the region, including Arrowtown, Mosgiel and Milton, providing an increasingly detailed picture of fine particle concentrations alongside the longer-established $PM_{10}$ network.

A previous emission inventory was carried out for Alexandra, Arrowtown, Mosgiel and Milton during 2016. That inventory identified domestic home heating as the main source of anthropogenic $PM_{10}$ and $PM_{2.5}$ in all four towns, accounting for approximately 99% of daily winter $PM_{10}$ and $PM_{2.5}$ emissions in Alexandra, Arrowtown and Mosgiel, and 83% ($PM_{10}$) and 85% ($PM_{2.5}$) in Milton — with industry representing the other significant contributor in Milton. Motor vehicle emissions were minimal, at around 1% of daily winter $PM_{10}$ in all areas. Electricity and wood burners were found to be the most common heating methods across all four towns, with heat pumps accounting for the majority of electric heating.

The purpose of the present emission inventory is to evaluate emissions to air for 2026 for Alexandra, Arrowtown, Mosgiel and Milton; to quantify the relative contribution of different source types; and to assess the extent of any change over the last ten years. The contaminants evaluated include $PM_{10}$, $PM_{2.5}$, carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), volatile organic compounds (VOC), carbon dioxide ($CO_2$). The source categories included are domestic heating, motor vehicles, and industrial and commercial activities. Natural source contributions (such as sea salt and windblown soil) are excluded due to less robust quantification methodologies, and outdoor burning is not included as this activity is not permitted in these urban areas.

# 2 INVENTORY DESIGN

This emission inventory focuses on $PM_{10}$ emissions as $PM_{10}$ has been identified as the main contaminant of concern in urban New Zealand. It is unlikely that concentrations of other contaminants are likely to exceed national environmental standards (NES).

## 2.1 Selection of sources

Estimates of emissions from the domestic heating, motor vehicles and industry are included in the emissions inventory. Outdoor burning emissions is highly restricted in these urban areas although properties on the urban fringe may be able burn. The source has been included in the inventory to assess the extent of burning being carried out whether on the urban fringes or in conflict with the regulations. Additionally, the use of braziers, pizza ovens and wood fired BBQ has been assessed. The report also discusses particulate emissions from a number of other minor sources.

## 2.2 Selection of contaminants

The inventory included an assessment of emissions of suspended particles ($PM_{10}$), fine particles ($PM_{2.5}$) carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC) and carbon dioxide ($CO_2$).

Emissions of $PM_{2.5}$, $PM_{10}$, CO, SOx and NOx are included as these contaminants are NES contaminants because of their potential for adverse health impacts. Carbon dioxide has been typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas $CO_2$ emissions. However, these data are now generally collected nationally and for a broader range of greenhouse gases. Estimates of $CO_2$ have been retained in the inventory but readers should be directed to national statistics (e.g., www.climatechange.govt.nz.) should detailed data on this source be required. Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. It is unlikely that ozone formation from emissions within Alexandra, Arrowtown, Mosgiel or Milton would cause ozone problems. In this report, VOC emissions have been estimated for existing sources but data on emissions from VOC specific sources (e.g., spray painting) has not been included. It is likely that the inventory does not capture a number of sources of VOCs.

## 2.3 Selection of areas

As the towns form only parts of a larger airshed the inventory areas have been selected based on the Statistics New Zealand SA2 boundaries that cover urban areas within each town. These are listed below and compared with the census area units (CAU) used for the previous inventory. Appendix A compares the SA2 and CAU boundaries for Arrowtown, Milton and Mosgiel.

- Alexandra: Alexandra North and Alexandra South – previously Alexandra CAU (maps exactly)
- Arrowtown: Arrowtown SA2 less SA1s of 7036811 and 7036812– previously Arrowtown CAU (maps exactly)
- Mosgiel: Bush Road, Mosgiel East, Mosgiel Central, Seddon Park, East Taieri – previously Mosgiel East and Mosgiel South CAUs
- Milton: Milton SA2 less SA1 7029068 – previously Milton CAU – maps closely with a little additional rural area included in the 2026 area.

## 2.4 Temporal distribution

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

No differentiation was made for weekday and weekend sources. Limited time-of-day breakdowns were obtained for the data.

# 3 DOMESTIC HEATING

## 3.1 Methodology

Domestic heating methods and fuel use used by households in the four inventory areas was collected using a household survey carried out by Symphony Research during June 2026 (Appendix B). Table 3.1 shows the number of households based on 2023 census data adjusted for population changes to 2026[1] based on average growth per year. For Alexandra and Mosgiel home heating surveys were carried out to establish heating methods as well as appliance age distributions and average fuel use. For Arrowtown and Milton 2023 census data (adjusted for changes in dwellings) were used quantify heating methods and survey data were used for appliance age distributions and average fuel use. The method variability occurs because of the lower sample sizes for the smaller towns.

**Table 3.1: Summary household, area and survey data.**

| | Dwellings in inventory area | Sample size | Area (ha) | Sample error |
|---|---|---|---|---|
| Alexandra | 2546 | 330 | 976 | 5% |
| Arrowtown | 996 | 82 | 230 | 10% |
| Milton | 842 | 100 | 238 | 9% |
| Mosgiel | 5996 | 350 | 731 | 5% |

Home heating methods were classified as; electricity, open fires, wood burners around 20 years or older (pre 2006), wood burners five to 20 years old (2006-2020), wood burners less than five years old (post 2020), ultra low emission burners (ULEB), pellet fires, multi fuel burners, gas burners and oil burners. The post 2006 wood burner categories would contain wood burners meeting the National Environmental Standard (NES) design criteria which was introduced in 2004 and effective from September 2005. In Alexandra and Arrowtown the post 2020 wood burner categories should be predominantly ULEB burners.

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

[1] https://regions.infometrics.co.nz/milton-rural-north-clutha-cd/population/growth
https://regions.infometrics.co.nz/new-zealand/population/small-areas
https://regions.infometrics.co.nz/alexandra-urban-2026/population/growth
https://regions.infometrics.co.nz/otago-region/population/small-areas

**Table 3.2: Emission factors for domestic heating methods.**

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

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

The average daily wood use on wood burners for each of the towns was calculated by dividing the annual fuel consumption (provided as an estimate of $m^3$ (or cords) per year) by the number of days per year the household indicated they burnt. For open fires and multi fuel burners wood use was estimated based on the reported daily pieces of wood used and a kilogram to log ratio of 1.6. 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 used for this work (1.6 kg/ piece) is the midpoint and average of the range of values.

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

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

Where:

CE = contaminant emission

EF = emission factor

FB = fuel burnt

The main assumptions underlying the emissions calculations are as follows:

- The average density of wood of 400 kg/$m^3$.
- The average weight of a bucket of coal is 9 kilograms.

## 3.2 Home heating methods Alexandra

Electricity and wood burners were the main heating methods in Alexandra with 74% and 48% of households respectively using these methods to heat their main living area (Table 3.3) during 2026. This compares with 66% and 58% respectively for 2016 indicating a slight reduction in wood burner use as a percentage of the population. Survey data showed that almost all of the post 2020 wood burners were ULEB. Table 3.3 also shows that households relied on more than one method of heating their main living area during the winter months.

Around 27 tonnes of wood was burnt per typical winter's night in Alexandra.

**Table 3.3: Home heating methods and fuels in Alexandra.**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | Households | t/day | % |
| Electricity | 74% | 1,890 | | |
| Total Gas | 10% | 255 | 0.2 | 1% |
| Flued gas | 9% | 219 | | |
| Unflued gas | 1% | 35 | | |
| Oil | 9% | 239 | 0.18 | 1% |
| Open fire | 0% | 8 | | |
| Open fire - wood | 0.3% | 8 | 0.1 | 0% |
| Open fire - coal | 0% | 0 | 0 | 0% |
| Total Wood burner | 48% | 1,227 | 26 | 96% |
| Pre 2006 wood burner | 10% | 257 | 5 | 20% |
| 2006-2011 wood burner | 19% | 481 | 10 | 38% |
| 2011-2020 wood burner | 2% | 50 | 1 | 4% |
| Post-2020 wood burner | 0% | 6 | 0.1 | 0% |
| ULEB | 17% | 439 | 9 | 34% |
| Multi-fuel burners | 2% | 46 | | |
| Multi-fuel burners-wood | 1% | 31 | 0 | 1% |
| Multi-fuel burners-coal | 0% | 8 | 0 | 0% |
| Pellet burners | 1% | 23 | 0.2 | 1% |
| Wood fired cooker | 1% | 15 | 0.3 | 1% |
| Total wood | 50% | 1,265 | 27 | 98% |
| Total coal | 0% | 8 | 0 | 0% |
| Total | | 2,546 | 27 | 98% |

## 3.3 Home heating methods Arrowtown

Table 3.4 shows electricity was the main heating method in Arrowtown with 83% of households using this method to heat their main living area. Wood burners were also common with 53% of households using them. Table 3.4 also shows that households relied on more than one method of heating their main living area during the winter months.

Around nine tonnes of wood was burnt per typical winter's night in Arrowtown.

**Table 3.4: Home heating methods and fuels in Arrowtown.**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | Households | t/day | % |
| Electricity | 83% | 826 | | |
| Total Gas | 18% | 182 | 0.2 | 2% |
| Flued gas | 17% | 168 | | |
| Unflued gas | 1% | 14 | | |
| Oil | 15% | 146 | 0.11 | 1% |
| Open fire | 1% | 6 | | |
| Open fire - wood | 1% | 12 | 0 | 0% |
| Open fire - coal | 0% | 0 | 0 | 0% |
| Total Wood burner | 53% | 531 | 9 | 96% |
| Pre 2006 wood burner | 4% | 39 | 1 | 7% |
| 2006-2011 wood burner | 13% | 130 | 2 | 23% |
| 2011-2020 wood burner | 8% | 78 | 1 | 14% |

| | | | | |
|---|---|---|---|---|
| Post 2020 burner (all ULEB) | 0% | 0 | | |
| ULEB | 29% | 285 | 4.8 | 52% |
| Multi-fuel burners | 0% | 0 | | |
| Multi-fuel burners-wood | 0% | 0 | 0 | 0% |
| Multi-fuel burners-coal | 0% | 0 | 0 | 0% |
| Pellet burners | 1% | 12 | 0.1 | 1% |
| Wood fired cooker | 0% | 0% | | |
| Total wood | 55% | 543 | 9 | 97% |
| Total coal | 0% | 0 | 0 | 0% |
| Total | | 996 | 9 | 97% |

## 3.4 Home heating methods Mosgiel

Electricity was the most common heating method in Mosgiel with 89% of households using this method (Table 3.6). Wood burners were used by around 31% of households and multi fuel burners by 5% during 2020. This compares with 83% using electricity, 38% using wood burners and 10% using multifuel burners in 2016. Table 3.6 also shows that households relied on more than one method of heating their main living area during the winter months.

Around 63 tonnes of wood and three tonnes of coal was burnt per typical winter's night in Mosgiel.

**Table 3.5: Home heating methods and fuels in Mosgiel.**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | Households | t/day | % |
| Electricity | 89% | 5,328 | | |
| Total Gas | 5% | 291 | 0.3 | 0.4% |
| Flued gas | 5% | 274 | | |
| Unflued gas | 0% | 17 | | |
| Oil | 1% | 69 | 0.05 | 0.1% |
| Open fire | 1% | 34 | | |
| Open fire - wood | 1% | 34 | 0.2 | 0.3% |
| Open fire - coal | 0% | 17 | 0.1 | 0.1% |
| Total Wood burner | 31% | 1,833 | 52 | 78% |
| Pre 2006 wood burner | 8% | 504 | 14 | 21% |
| 2006-2011 wood burner | 8% | 463 | 13 | 20% |
| 2011-2020 wood burner | 3% | 161 | 5 | 7% |
| Post-2020 wood burner | 1% | 60 | 2 | 3% |
| ULEB | 11% | 645 | 18 | 27% |
| Multi-fuel burners | 5% | 325 | | |
| Multi-fuel burners-wood | 5% | 308 | 10 | 15% |
| Multi-fuel burners-coal | 3% | 154 | 3 | 4% |
| Pellet burners | 3% | 206 | 1.3 | 2% |
| Wood fired cooker | 6% | 51 | 0.4 | 3% |
| Total wood | 36% | 2,176 | 63 | 95% |
| Total coal | 3% | 171 | 3 | 4% |
| Total | | 5,996 | 67 | 100% |

## 3.5 Home heating methods Milton

Wood burners and electricity were the most common heating methods in Milton with 66% and 56% of households using these methods respectively (Table 3.6) in their main living area during 2026. Multi fuel burners were used by 10% of households and pellet burners are used by 6% of households.

Around 13 tonnes of wood and less than one tonne of coal were burnt per typical winter's night in Milton during 2026.

**Table 3.6: Home heating methods and fuels in Milton.**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | Households | t/day | % |
| Electricity | 66% | 556 | | |
| Total Gas | 1% | 8 | 0.0 | 0% |
| Flued gas | 0% | 0 | | |
| Unflued gas | 1% | 8 | | |
| Oil | 5% | 42 | 0.03 | 0% |
| Open fire | 1% | 8 | | |
| Open fire - wood | 1% | 8 | 0 | 0% |
| Open fire - coal | 0% | 0 | 0 | 0% |
| Total Wood burner | 56% | 468 | 10 | 75% |
| Pre 2006 wood burner | 13% | 111 | 2 | 18% |
| 2006-2011 wood burner | 13% | 111 | 2 | 18% |
| 2011-2020 wood burner | 10% | 86 | 2 | 14% |
| Post-2020 wood burner | 1% | 11 | | |
| ULEB | 18% | 148 | 3 | 24% |
| Multi-fuel burners | 10% | 84 | | |
| Multi-fuel burners-wood | 10% | 84 | 2 | 12% |
| Multi-fuel burners-coal | 6% | 51 | 0.5 | 4% |
| Pellet burners | 6% | 51 | 1.2 | 9% |
| Wood fired cooker | 0.3% | 17 | 0.1 | 0.3% |
| Total wood | 67% | 561 | 13 | 96% |
| Total coal | 6% | 51 | 0.5 | 4% |
| Total | | 842 | 13 | 100% |

## 3.6 Emissions from domestic heating in Alexandra.

Around 133 kilograms of $PM_{10}$ and $PM_{2.5}$ are emitted from domestic home heating in Alexandra on an average winter's night (Table 3.7). Days when households may not be using specific home heating methods are accounted for in this method. This may increase to around 143 kilograms if all households are using their wood burners on a given night (Table 3.8).

Figure 3.1 shows that wood burners installed pre 2006 contribute 41% of the daily winter $PM_{10}$ and Table 3.3 shows that this age categories includes only 21% of households using wood burners.

The seasonal variation in contaminant emissions is shown in Table 3.9 which also illustrates an annual $PM_{10}$ and $PM_{2.5}$ loading of just under 16 tonnes per year. Figure 3.2 indicates that the majority of the annual $PM_{10}$ emissions from domestic home heating occur during May, June, July and August.

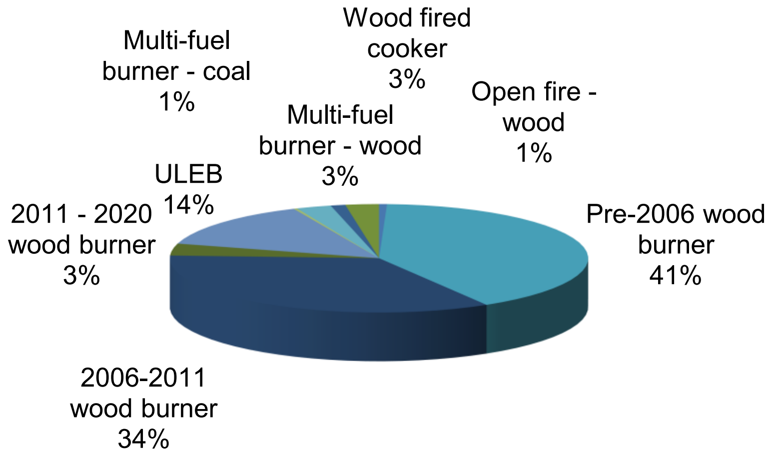


**Figure 3.1: Relative contribution of different heating methods to average daily $PM_{10}$ (winter average) from domestic heating.**

**Table 3.7: Alexandra winter daily domestic heating emissions by appliance type (average daily).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.1 | 0% | 1 | 1 | 1% | 6 | 6 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 3 | 3 | 1% | 0 | 0 | 0% | 1 | 1 | 1% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 26.1 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 5.4 | 20% | 54 | 56 | 41% | 760 | 778 | 42% | 3 | 3 | 19% | 1 | 1 | 16% | 179 | 183 | 29% | 9 | 9 | 20% | 54 | 56 | 41% |
| 2006-2011 burner | 10.2 | 37% | 46 | 47 | 34% | 457 | 468 | 25% | 5 | 5 | 35% | 2 | 2 | 30% | 203 | 208 | 33% | 16 | 17 | 37% | 46 | 47 | 34% |
| 2011-2020 burners | 1.1 | 4% | 5 | 5 | 4% | 47 | 48 | 3% | 1 | 1 | 4% | 0 | 0 | 3% | 21 | 22 | 3% | 2 | 2 | 4% | 5 | 5 | 4% |
| Post 2020 burner | | | | | | | | | | | | | | | | | | | | | | | |
| ULEB | 9.3 | 34% | 19 | 19 | 13% | 417 | 428 | 22% | 5 | 5 | 30% | 2 | 2 | 26% | 186 | 190 | 28% | 15 | 15 | 31% | 19 | 19 | 13% |
| Pellet burner | 0.2 | 1% | 0.4 | 0 | 0% | 4 | 4 | 0% | 0 | 0 | 1% | 0 | 0 | 1% | 4 | 4 | 1% | 0 | 0 | 1% | 0 | 0 | 0% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 0.4 | 1% | 4 | 4 | 3% | 50 | 52 | 3% | 0 | 0 | 1% | 0 | 0 | 1% | 7 | 7 | 1% | 1 | 1 | 1% | 4 | 4 | 3% |
| Multi fuel – coal | 0.1 | 0% | 2 | 2 | 1% | 9 | 9 | 0% | 0 | 0 | 1% | 1 | 1 | 9% | 1 | 1 | 0% | 0 | 0 | 0% | 1 | 1 | 1% |
| Wood fired cooker | 0.3 | 1% | 3.4 | 4 | 3% | 48 | 49 | 3% | 0 | 0 | 1% | 0 | 0 | 1% | 7 | 7 | 1% | 1 | 1 | 1% | 3 | 4 | 3% |
| Gas | 0.2 | 1% | 0.01 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Oil | 0.2 | 1% | 0.05 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 3% | 1 | 1 | 10% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Total Wood | 27 | 98% | 131 | 135 | 99% | 1789 | 1833 | 100% | 14 | 14 | 94% | 5 | 6 | 80% | 610 | 625 | 100% | 43 | 44 | 97% | 131 | 135 | 99% |
| Total Coal | 0.1 | 0% | 1.51 | 2 | 1% | 9 | 9 | 0% | 0 | 0 | 1% | 1 | 1 | 9% | 1 | 1 | 0% | 0 | 0 | 0% | 1 | 1 | 1% |
| Total | 27 | | 133 | 136 | | 1798 | 1842 | | 14 | 15 | | 7 | 7 | | 611 | 626 | | 44 | 45 | | 133 | 136 | |

**Table 3.8: Alexandra winter daily domestic heating emissions by appliance type (worst case).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.1 | 0% | 1 | 1 | 1% | 6 | 7 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 3 | 4 | 1% | 0 | 0 | 0% | 1 | 1 | 1% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 17.8 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 5.8 | 20% | 58 | 60 | 41% | 813 | 833 | 42% | 3 | 3 | 19% | 1 | 1 | 16% | 192 | 196 | 29% | 9 | 10 | 20% | 58 | 60 | 41% |
| 2006-2011 burner | 10.9 | 37% | 49 | 50 | 34% | 489 | 501 | 25% | 5 | 6 | 35% | 2 | 2 | 30% | 217 | 223 | 33% | 17 | 18 | 37% | 49 | 50 | 34% |
| 2011-2020 burners | 1.1 | 4% | 5 | 5 | 4% | 51 | 52 | 3% | 1 | 1 | 4% | 0 | 0 | 3% | 22 | 23 | 3% | 2 | 2 | 4% | 5 | 5 | 4% |
| Post 2020 burner | | | | | | | | | | | | | | | | | | | | | | | |
| ULEB | 9.9 | 34% | 20 | 20 | 14% | 447 | 458 | 23% | 5 | 5 | 32% | 2 | 2 | 28% | 199 | 204 | 30% | 16 | 16 | 33% | 20 | 20 | 14% |
| Pellet burner | 0.2 | 1% | 0 | 0 | 0% | 4 | 4 | 0% | 0 | 0 | 1% | 0 | 0 | 1% | 4 | 4 | 1% | 0 | 0 | 1% | 0 | 0 | 0% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 0.4 | 1% | 4 | 4 | 3% | 59 | 60 | 3% | 0 | 0 | 1% | 0 | 0 | 1% | 8 | 9 | 1% | 1 | 1 | 1% | 4 | 4 | 3% |
| Multi fuel – coal | 0.1 | 0% | 2 | 2 | 1% | 10 | 10 | 1% | 0 | 0 | 1% | 1 | 1 | 10% | 1 | 1 | 0% | 0 | 0 | 1% | 2 | 2 | 1% |
| Wood fired cooker | 0.4 | | 4 | 4 | 3% | 56 | 58 | 3% | 0 | 0 | 1% | 0 | 0 | 1% | 8 | 8 | 1% | 1 | 1 | 1% | 4 | 4 | 3% |
| Gas | 0.2 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Oil | 0.2 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 3% | 1 | 1 | 9% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Total Wood | 29 | 98% | 141 | 145 | 99% | 1925 | 1973 | 99% | 15 | 15 | 95% | 6 | 6 | 80% | 654 | 670 | 100% | 46 | 47 | 97% | 141 | 145 | 99% |
| Total Coal | 0 | 0% | 2 | 2 | 1% | 10 | 10 | 1% | 0 | 0 | 1% | 1 | 1 | 10% | 1 | 1 | 0% | 0 | 0 | 1% | 2 | 2 | 1% |
| Total | 29 | | 143 | 147 | | 1936 | 1983 | | 15 | 16 | | 7 | 7 | | 655 | 671 | | 48 | 49 | | 143 | 147 | |

**Table 3.9: Monthly variations in contaminant emissions from domestic heating in Alexandra.**

| | $PM_{10}$ kg/day | CO kg/day | NOx kg/day | SOx kg/day | VOC kg/day | $CO_2$ t/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| January | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 0 | 4 | 0 | 0 | 2 | 0 | 0 |
| March | 2 | 24 | 0 | 0 | 8 | 1 | 2 |
| April | 16 | 212 | 2 | 1 | 67 | 5 | 16 |
| May | 105 | 1418 | 11 | 5 | 484 | 34 | 104 |
| June | 128 | 1737 | 13 | 6 | 595 | 42 | 128 |
| July | 133 | 1796 | 14 | 6 | 611 | 43 | 133 |
| August | 114 | 1540 | 12 | 5 | 524 | 37 | 114 |
| September | 25 | 338 | 2 | 1 | 108 | 8 | 25 |
| October | 8 | 99 | 1 | 1 | 33 | 2 | 8 |
| November | 2 | 27 | 0 | 0 | 10 | 1 | 2 |
| December | 1 | 7 | 0 | 0 | 2 | 0 | 1 |
| Total (kg/year) | 16334 | 220919 | 1673 | 751 | 74975 | 5318 | 16309 |

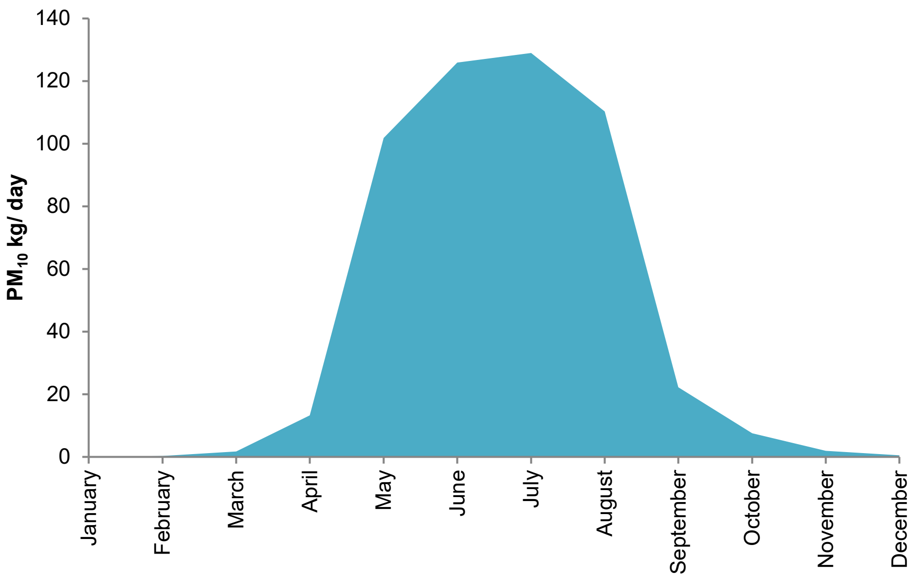


**Figure 3.2: Monthly variations in $PM_{10}$ emissions from domestic heating.**

## 3.7 Emissions from domestic heating in Arrowtown.

Almost 50% of the daily $PM_{10}$ emissions from domestic heating during the winter are from post 2006 wood burners that do not meet the ULEB criteria (Figure 3.3). Older wood burners contribute 20% of the daily domestic heating $PM_{10}$ emissions and the more modern ULEB burners contribute 30%. Pellet burners are a minor contributor at around 1% of daily winter $PM_{10}$.

Tables 3.10 and 3.11 show the estimates of emissions for different heating methods under average and worst-case scenarios. Average daily wintertime $PM_{10}$ and $PM_{2.5}$ emissions are around 32 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method. Under the worst-case scenario around 38 kilograms of $PM_{10}$ are discharged from all households using solid fuel burners on a particular night.

The seasonal variation in contaminant emissions is shown in Table 3.12 and indicates around 4 tonnes per year of $PM_{10}$ and $PM_{2.5}$ is emitted from domestic heating in Arrowtown. Figure 3.8 indicates that the majority of the annual $PM_{10}$ emissions from domestic home heating occur during June, July and August.

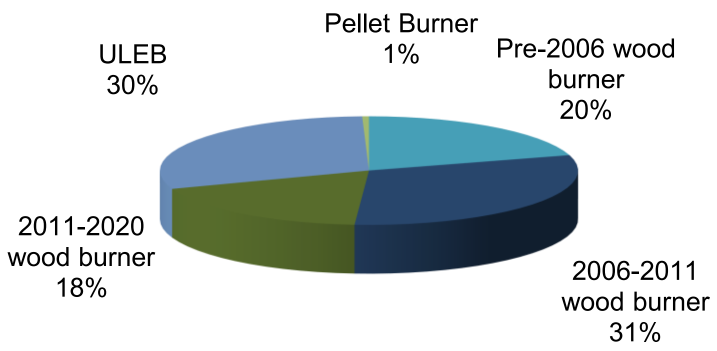


**Figure 3.3: Relative contribution of different heating methods to average daily $PM_{10}$ (winter average) from domestic heating.**

**Table 3.10: Arrowtown winter daily domestic heating emissions by appliance type (average daily).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 9.1 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 0.7 | 7% | 7 | 29 | 20% | 92 | 400 | 20% | 0 | 1 | 7% | 0 | 1 | 6% | 22 | 94 | 11% | 1 | 5 | 7% | 7 | 29 | 20% |
| 2006-2011 burner | 2.2 | 23% | 10 | 43 | 31% | 99 | 429 | 21% | 1 | 5 | 22% | 0 | 2 | 20% | 44 | 191 | 23% | 4 | 15 | 23% | 10 | 43 | 31% |
| 2011-2020 burners | 1.3 | 14% | 6 | 26 | 18% | 59 | 257 | 13% | 1 | 3 | 13% | 0 | 1 | 12% | 26 | 114 | 14% | 2 | 9 | 14% | 6 | 26 | 18% |
| Post 2020 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% |
| ULEB | 4.8 | 52% | 10 | 42 | 25% | 217 | 943 | 40% | 2 | 10 | 41% | 1 | 4 | 38% | 97 | 419 | 44% | 8 | 34 | 44% | 10 | 42 | 25% |
| Pellet burner | 0.1 | 1% | 0.2 | 1 | 1% | 2 | 7 | 0% | 0 | 0 | 1% | 0 | 0 | 1% | 2 | 7 | 1% | 0 | 1 | 1% | 0 | 1 | 1% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Multi fuel – coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood fired cookers | 0 | 0% | | | | | | | | | | | | | | | | | | | | | |
| Gas | 0.2 | 2% | 0.01 | 0 | 0% | 0 | 0 | 0% | 0 | 1 | 4% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 2 | 3% | 0 | 0 | 0% |
| Oil | 0.1 | 1% | 0.03 | 0 | 0% | 0 | 0 | 0% | 0 | 1 | 5% | 0 | 2 | 18% | 0 | 0 | 0% | 0 | 2 | 2% | 0 | 0 | 0% |
| Total Wood | 9.1 | 97% | 32 | 140 | 100% | 469 | 2036 | 100% | 5 | 20 | 91% | 2 | 8 | 82% | 190 | 826 | 100% | 15 | 63 | 95% | 32 | 140 | 100% |
| Total Coal | 0.0 | 0% | 0.00 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total | 9 | | 32 | 140 | | 469 | 2037 | | 5 | 22 | | 2 | 10 | | 190 | 826 | | 15 | 66 | | 32 | 140 | |

**Table 3.11: Arrowtown winter daily domestic heating emissions by appliance type (worst case).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.2 | 2% | 1 | 6 | 4% | 10 | 43 | 2% | 0 | 1 | 4% | 0 | 0 | 1% | 5 | 24 | 2% | 0 | 1 | 2% | 1 | 6 | 4% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 4.7 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 0.7 | 7% | 7 | 32 | 20% | 105 | 454 | 19% | 0 | 2 | 6% | 0 | 1 | 6% | 25 | 107 | 11% | 1 | 5 | 7% | 7 | 32 | 20% |
| 2006-2011 burner | 2.5 | 23% | 11 | 49 | 30% | 112 | 487 | 21% | 1 | 5 | 21% | 0 | 2 | 20% | 50 | 216 | 23% | 4 | 17 | 23% | 11 | 49 | 30% |
| 2011-2020 burners | 1.5 | 14% | 7 | 29 | 18% | 67 | 292 | 12% | 1 | 3 | 13% | 0 | 1 | 12% | 30 | 130 | 14% | 2 | 10 | 14% | 7 | 29 | 18% |
| Post 2020 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% |
| ULEB | 5.5 | 51% | 11 | 48 | 29% | 247 | 1071 | 45% | 3 | 12 | 47% | 1 | 5 | 44% | 110 | 476 | 50% | 9 | 38 | 50% | 11 | 48 | 29% |
| Pellet burner | 0.1 | 1% | 0 | 1 | 1% | 2 | 8 | 0% | 0 | 0 | 1% | 0 | 0 | 1% | 2 | 8 | 1% | 0 | 1 | 1% | 0 | 1 | 1% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Multi fuel – coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood fired cooker | 0 | 0 | | | | | | | | | | | | | | | | | | | | | |
| Gas | 0.2 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 1 | 4% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 2 | 2% | 0 | 0 | 0% |
| Oil | 0.1 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 1 | 4% | 0 | 2 | 16% | 0 | 0 | 0% | 0 | 2 | 2% | 0 | 0 | 0% |
| Total Wood | 10 | 97% | 38 | 165 | 100% | 543 | 2355 | 100% | 5 | 23 | 92% | 2 | 9 | 84% | 221 | 961 | 100% | 17 | 73 | 96% | 38 | 165 | 100% |
| Total Coal | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total | 11 | | 38 | 165 | | 543 | 2355 | | 6 | 25 | | 3 | 11 | | 221 | 961 | | 18 | 76 | | 38 | 165 | |

**Table 3.12: Monthly variations in contaminant emissions from domestic heating in Arrowtown.**

| | $PM_{10}$ kg/day | CO kg/day | NOx kg/day | SOx kg/day | VOC kg/day | $CO_2$ t/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| January | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | 0 | 2 | 0 | 0 | 1 | 0 | 0 |
| April | 1 | 17 | 0 | 0 | 7 | 1 | 1 |
| May | 24 | 348 | 4 | 1 | 141 | 11 | 24 |
| June | 31 | 451 | 4 | 2 | 182 | 14 | 31 |
| July | 32 | 469 | 5 | 2 | 190 | 15 | 32 |
| August | 31 | 448 | 5 | 2 | 181 | 14 | 31 |
| September | 6 | 82 | 1 | 0 | 33 | 3 | 6 |
| October | 3 | 38 | 0 | 0 | 15 | 1 | 3 |
| November | 0 | 6 | 0 | 0 | 2 | 0 | 0 |
| December | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (kg/year) | 3921 | 57177 | 584 | 220 | 23088 | 1827 | 3921 |

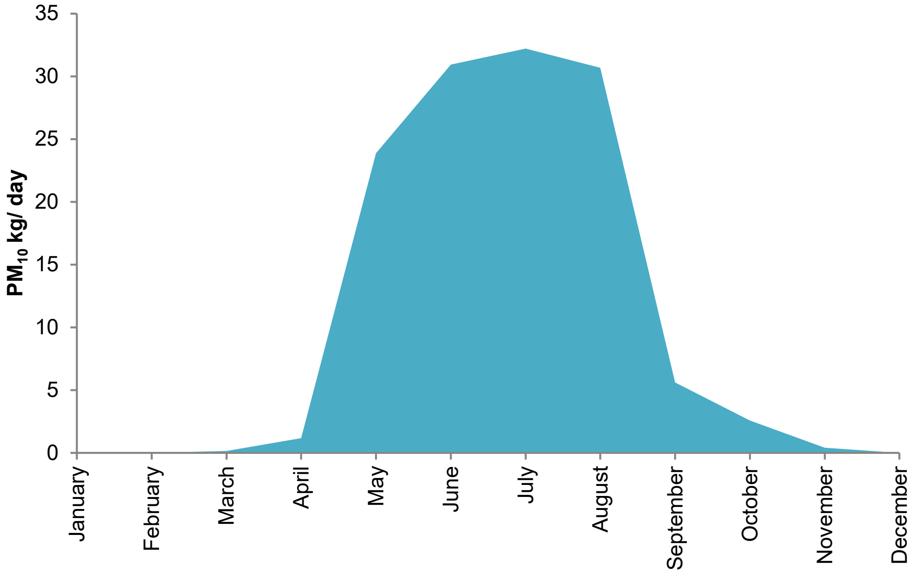


**Figure 3.4: Monthly variations in $PM_{10}$ emissions from domestic heating.**

## 3.8 Emissions from domestic heating in Mosgiel.

Around 246 kilograms of $PM_{10}$ and 243 kilograms of $PM_{2.5}$ was emitted from domestic home heating in Milton on an average winter's day (Table 3.14). Days when households may not be using specific home heating methods are accounted for in this method. This may increase to around 286 kilograms for $PM_{10}$ and 281 kilograms for $PM_{2.5}$ if all households are using their wood burners on a given night (Table 3.15).

Around one third of the daily winter $PM_{10}$ emissions in Mosgiel were from older pre 2006 wood burners (Figure 3.5).

The seasonal variation in contaminant emissions is shown in Table 3.16. This also illustrates around 33 tonnes of $PM_{10}$ and $PM_{2.5}$ are emitted per year in Mosgiel from domestic heating. Figure 3.6 indicates that the majority of the annual $PM_{10}$ and $PM_{2.5}$ emissions from domestic home heating occur during May June, July and August.

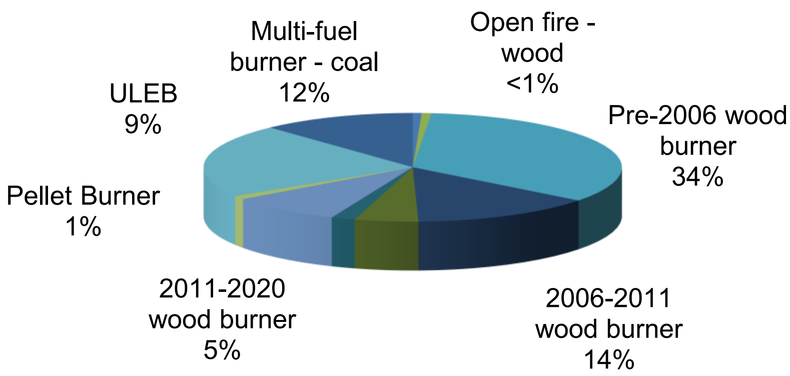


**Figure 3.5: Relative contribution of different heating methods to average daily $PM_{10}$ (winter average) from domestic heating.**

**Table 3.13: Mosgiel winter daily domestic heating emissions by appliance type (average daily).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.2 | 0.6% | 2 | 2 | 1% | 12 | 17 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 7 | 9 | 1% | 0 | 0 | 1% | 2 | 2 | 1% |
| Open fire - coal | 0.1 | 0% | 2 | 3 | 1% | 6 | 8 | 0% | 0 | 0 | 2% | 1 | 1 | 3% | 1 | 2 | 0% | 0 | 0 | 0% | 2 | 2 | 1% |
| Wood burner | 31.7 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 8.3 | 21% | 83 | 114 | 34% | 1167 | 1597 | 37% | 4 | 6 | 19% | 2 | 2 | 8% | 275 | 376 | 31% | 13 | 18 | 21% | 83 | 114 | 34% |
| 2006-2011 burner | 7.7 | 19% | 35 | 47 | 14% | 345 | 472 | 11% | 4 | 5 | 17% | 2 | 2 | 7% | 153 | 210 | 17% | 12 | 17 | 19% | 35 | 47 | 14% |
| 2011-2020 burners | 2.7 | 7% | 12 | 16 | 5% | 120 | 164 | 4% | 1 | 2 | 6% | 1 | 1 | 3% | 53 | 73 | 6% | 4 | 6 | 7% | 12 | 16 | 5% |
| Post 2020 burner | 1.0 | 3% | 5 | 6 | 2% | 45 | 62 | 1% | 1 | 1 | 2% | 0 | 0 | 1% | 20 | 27 | 2% | 2 | 2 | 2% | 5 | 6 | 2% |
| ULEB | 10.7 | 27% | 21 | 29 | 7% | 480 | 657 | 13% | 5 | 7 | 21% | 2 | 3 | 8% | 213 | 292 | 21% | 17 | 23 | 23% | 21 | 29 | 8% |
| Pellet burner | 1.3 | 3% | 2.7 | 4 | 1% | 27 | 36 | 1% | 1 | 1 | 3% | 0 | 0 | 1% | 27 | 36 | 3% | 2 | 3 | 3% | 3 | 4 | 1% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 5.4 | 14% | 54 | 73 | 22% | 752 | 1029 | 24% | 3 | 4 | 12% | 1 | 1 | 5% | 107 | 147 | 12% | 9 | 12 | 13% | 54 | 73 | 22% |
| Multi fuel – coal | 1.5 | 4% | 29 | 40 | 12% | 170 | 232 | 5% | 2 | 3 | 11% | 12 | 17 | 60% | 23 | 32 | 3% | 4 | 5 | 6% | 26 | 35 | 11% |
| Wood fired cooker | 0.1 | 0% | 1 | 2 | 0% | 19 | 26 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 3 | 4 | 0% | 0 | 0 | 0% | 1 | 2 | 0% |
| Gas | 0.3 | 1% | 0.01 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Oil | 0.1 | 0% | 0.02 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total Wood | 37 | 95% | 215 | 294 | 87% | 2968 | 4060 | 94% | 19 | 26 | 85% | 7 | 10 | 36% | 859 | 1175 | 97% | 60 | 82 | 92% | 215 | 294 | 89% |
| Total Coal | 1.6 | 4% | 31 | 43 | 13% | 176 | 240 | 6% | 3 | 4 | 13% | 13 | 18 | 63% | 24 | 33 | 3% | 4 | 6 | 7% | 27 | 37 | 11% |
| Total | 39 | | 246 | 337 | | 3143 | 4301 | | 22 | 30 | | 21 | 28 | | 883 | 1208 | | 65 | 89 | | 243 | 332 | |

**Table 3.14: Mosgiel winter daily domestic heating emissions by appliance type (worst case).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.5 | 1% | 4 | 5 | 1% | 28 | 39 | 1% | 1 | 1 | 2% | 0 | 0 | 0% | 15 | 21 | 2% | 1 | 1 | 1% | 4 | 5 | 1% |
| Open fire - coal | 0.2 | 0% | 4 | 6 | 2% | 14 | 20 | 0% | 1 | 1 | 3% | 2 | 2 | 7% | 3 | 4 | 0% | 1 | 1 | 1% | 4 | 5 | 1% |
| Wood burner | 20.8 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 9.3 | 21% | 93 | 127 | 32% | 1298 | 1776 | 36% | 5 | 6 | 18% | 2 | 3 | 7% | 306 | 419 | 30% | 15 | 20 | 20% | 93 | 127 | 33% |
| 2006-2011 burner | 8.5 | 19% | 38 | 53 | 13% | 384 | 525 | 11% | 4 | 6 | 16% | 2 | 2 | 7% | 171 | 233 | 17% | 14 | 19 | 18% | 38 | 53 | 14% |
| 2011 - 2020 | 3.0 | 7% | 13 | 18 | 5% | 134 | 183 | 4% | 1 | 2 | 6% | 1 | 1 | 2% | 59 | 81 | 6% | 5 | 6 | 6% | 13 | 18 | 5% |
| Post 2020 burner | 1.1 | 2% | 5 | 7 | 2% | 50 | 69 | 1% | 1 | 1 | 2% | 0 | 0 | 1% | 22 | 30 | 2% | 2 | 2 | 2% | 5 | 7 | 2% |
| ULEB | 11.9 | 26% | 24 | 32 | 8% | 534 | 731 | 15% | 6 | 8 | 23% | 2 | 3 | 9% | 237 | 325 | 24% | 19 | 26 | 26% | 24 | 32 | 8% |
| Pellet burner | 1.6 | 4% | 3 | 5 | 1% | 33 | 45 | 1% | 1 | 1 | 3% | 0 | 0 | 1% | 33 | 45 | 3% | 3 | 4 | 4% | 3 | 5 | 1% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 6.4 | 14% | 64 | 88 | 23% | 902 | 1234 | 25% | 3 | 4 | 12% | 1 | 2 | 5% | 129 | 176 | 13% | 10 | 14 | 14% | 64 | 88 | 23% |
| Multi fuel – coal | 1.9 | 4% | 35 | 48 | 12% | 204 | 278 | 6% | 3 | 4 | 11% | 15 | 20 | 59% | 28 | 38 | 3% | 5 | 7 | 6% | 31 | 42 | 11% |
| Wood fired cooker | 0.2 | 0% | 2 | 2 | 1% | 23 | 32 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 3 | 5 | 0% | 0 | 0 | 0% | 2 | 2 | 1% |
| Gas | 0.3 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| Oil | 0.1 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total Wood | 43 | 95% | 246 | 337 | 86% | 3387 | 4633 | 94% | 22 | 30 | 84% | 9 | 12 | 34% | 976 | 1336 | 97% | 68 | 93 | 92% | 246 | 337 | 88% |
| Total Coal | 2 | 5% | 39 | 54 | 14% | 218 | 298 | 6% | 4 | 5 | 15% | 16 | 23 | 65% | 31 | 42 | 3% | 5 | 7 | 7% | 35 | 48 | 12% |
| Total | 45 | | 286 | 391 | | 3605 | 4932 | | 26 | 35 | | 25 | 34 | | 1007 | 1378 | | 74 | 102 | | 281 | 385 | |

**Table 3.15: Monthly variations in contaminant emissions from domestic heating in Mosgiel.**

| | $PM_{10}$ kg/day | CO kg/day | NOx kg/day | SOx kg/day | VOC kg/day | $CO_2$ t/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| January | 3 | 20 | 0 | 1 | 4 | 0 | 2 |
| February | 7 | 64 | 1 | 2 | 16 | 1 | 6 |
| March | 13 | 131 | 1 | 3 | 35 | 3 | 12 |
| April | 41 | 485 | 4 | 5 | 139 | 10 | 39 |
| May | 184 | 2383 | 16 | 14 | 675 | 49 | 182 |
| June | 235 | 3017 | 20 | 19 | 850 | 62 | 231 |
| July | 246 | 3144 | 22 | 21 | 883 | 64 | 243 |
| August | 225 | 2879 | 20 | 19 | 808 | 59 | 222 |
| September | 79 | 956 | 7 | 9 | 292 | 21 | 77 |
| October | 36 | 416 | 3 | 5 | 124 | 9 | 34 |
| November | 10 | 112 | 1 | 2 | 32 | 2 | 10 |
| December | 3 | 31 | 0 | 1 | 7 | 1 | 3 |
| Total (kg/year) | 33094 | 417993 | 2922 | 3046 | 118467 | 8632 | 32508 |

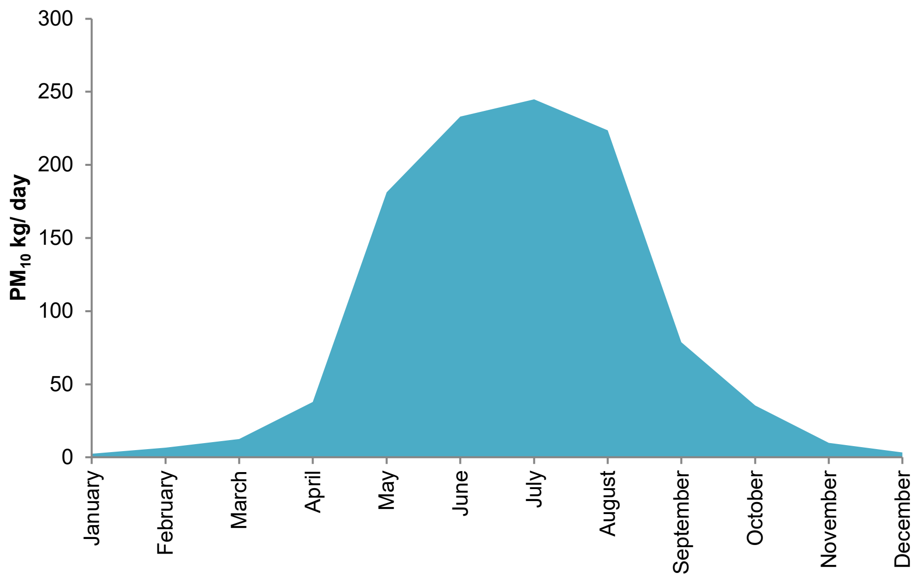


**Figure 3.6: Monthly variations in $PM_{10}$ emissions from domestic heating.**

## 3.9 Emissions from domestic heating in Milton.

Around 76 kilograms of $PM_{10}$ are emitted from domestic home heating in Milton on an average winter's night (Table 3.16). Days when households may not be using specific home heating methods are accounted for in this method. This may increase to around 87 kilograms if all households are using their wood burners on a given night (Table 3.17).

Just less than 30% of the daily $PM_{10}$ emissions from domestic heating during the winter are from pre 2006 wood burners (Figure 3.7). Around 8% of the daily winter $PM_{10}$ emissions are from ULEB burners and 5% are from wood fired cookers. Multi fuel burners contribute 31% with around one third of that occurring as a result of burning coal.

The seasonal variation in contaminant emissions is shown in Table 3.18, and this also indicates around 11 tonnes per year of $PM_{10}$ and $PM_{2.5}$ is emitted in Milton. Figure 3.8 indicates that the majority of the annual $PM_{10}$ emissions from domestic home heating occur during May, June, July and August.

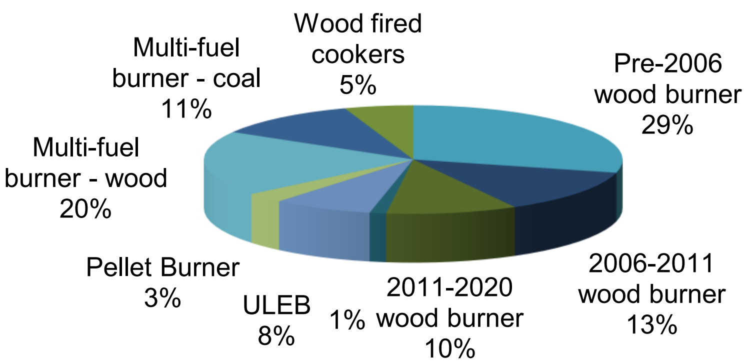


**Figure 3.7: Relative contribution of different heating methods to average daily $PM_{10}$ (winter average) from domestic heating.**

**Table 3.16: Milton winter daily domestic heating emissions by appliance type (average daily).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 11.1 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 2.4 | 17% | 24 | 99 | 29% | 330 | 1387 | 32% | 1 | 5 | 16% | 0 | 2 | 7% | 78 | 327 | 26% | 4 | 16 | 17% | 24 | 99 | 29% |
| 2006-2011 burner | 2.4 | 17% | 11 | 45 | 13% | 106 | 446 | 10% | 1 | 5 | 16% | 0 | 2 | 7% | 47 | 198 | 16% | 4 | 16 | 17% | 11 | 45 | 13% |
| 2011-2020 burners | 1.8 | 13% | 8 | 35 | 10% | 82 | 347 | 8% | 1 | 4 | 12% | 0 | 2 | 6% | 37 | 154 | 12% | 3 | 12 | 13% | 8 | 35 | 10% |
| Post 2020 burner | 0.2 | 2% | 1 | 4 | 1% | 10 | 43 | 1% | 0 | 0 | 2% | 0 | 0 | 1% | 5 | 19 | 2% | 0 | 2 | 2% | 1 | 4 | 1% |
| ULEB | 3.1 | 23% | 6 | 26 | 7% | 141 | 594 | 12% | 2 | 7 | 20% | 1 | 3 | 8% | 63 | 264 | 20% | 5 | 21 | 21% | 6 | 26 | 7% |
| Pellet burner | 1.2 | 9% | 2.4 | 10 | 3% | 24 | 102 | 2% | 1 | 3 | 8% | 0 | 1 | 4% | 24 | 102 | 8% | 2 | 8 | 9% | 2 | 10 | 3% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 1.6 | 12% | 16 | 66 | 19% | 221 | 931 | 22% | 1 | 3 | 11% | 0 | 1 | 5% | 32 | 133 | 11% | 3 | 11 | 11% | 16 | 66 | 20% |
| Multi fuel – coal | 0.5 | 4% | 9 | 38 | 11% | 53 | 223 | 5% | 1 | 3 | 10% | 4 | 16 | 58% | 7 | 30 | 2% | 1 | 5 | 6% | 8 | 34 | 10% |
| Wood fired cooker | 0.4 | 3% | 4 | 18 | 5% | 61 | 255 | 6% | 0 | 1 | 3% | 0 | 0 | 1% | 9 | 36 | 3% | 1 | 3 | 3% | 4 | 18 | 5% |
| Gas | 0.0 | 0% | 0.00 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Oil | 0.0 | 0% | 0.01 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 1 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total Wood | 13.1 | 96% | 72.2 | 304 | 89% | 975.6 | 4105 | 95% | 6.6 | 28 | 89% | 2.6 | 11 | 40% | 293.3 | 1234 | 98% | 21.0 | 88 | 94% | 72.2 | 304 | 90% |
| Total Coal | 0.5 | 4% | 9 | 38 | 11% | 53 | 223 | 5% | 1 | 3 | 10% | 4 | 16 | 58% | 7 | 30 | 2% | 1 | 5 | 6% | 8 | 34 | 10% |
| Total | 14 | | 81 | 342 | | 1029 | 4328 | | 7 | 31 | | 7 | 28 | | 300 | 1264 | | 22 | 94 | | 80 | 338 | |

**Table 3.17: Milton winter daily domestic heating emissions by appliance type (worst case).**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/day | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | kg | g/ha | % | T | kg/ha | % | kg | g/ha | % |
| Open fire | | | | | | | | | | | | | | | | | | | | | | | |
| Open fire - wood | 0.1 | 1% | 1 | 4 | 1% | 7 | 29 | 1% | 0 | 1 | 2% | 0 | 0 | 0% | 4 | 16 | 1% | 0 | 1 | 1% | 1 | 4 | 1% |
| Open fire - coal | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Wood burner | 7.1 | | | | | | | | | | | | | | | | | | | | | | |
| Pre 2006 burner | 2.5 | 18% | 25 | 107 | 28% | 356 | 1497 | 31% | 1 | 5 | 16% | 1 | 2 | 7% | 84 | 353 | 27% | 4 | 17 | 17% | 25 | 107 | 28% |
| 2006-2011 burner | 2.5 | 18% | 11 | 48 | 13% | 114 | 481 | 10% | 1 | 5 | 16% | 1 | 2 | 7% | 51 | 214 | 16% | 4 | 17 | 17% | 11 | 48 | 13% |
| 2011 - 2020 | 2.0 | 14% | 9 | 37 | 10% | 89 | 374 | 8% | 1 | 4 | 12% | 0 | 2 | 5% | 40 | 166 | 12% | 3 | 13 | 13% | 9 | 37 | 10% |
| Post 2020 burner | 0.2 | 2% | 1 | 5 | 1% | 11 | 47 | 1% | 0 | 1 | 2% | 0 | 0 | 1% | 5 | 21 | 2% | 0 | 2 | 2% | 1 | 5 | 1% |
| ULEB | 3.4 | 24% | 7 | 29 | 7% | 153 | 642 | 13% | 2 | 7 | 21% | 1 | 3 | 9% | 68 | 285 | 21% | 5 | 23 | 23% | 7 | 29 | 8% |
| Pellet burner | 0.4 | 3% | 1 | 3 | 1% | 8 | 34 | 1% | 0 | 1 | 3% | 0 | 0 | 1% | 8 | 34 | 3% | 1 | 3 | 3% | 1 | 3 | 1% |
| Multi fuel burner | | | | | | | | | | | | | | | | | | | | | | | |
| Multi fuel– wood | 2.0 | 14% | 20 | 84 | 22% | 279 | 1173 | 24% | 1 | 4 | 13% | 0 | 2 | 5% | 40 | 168 | 13% | 3 | 13 | 14% | 20 | 84 | 22% |
| Multi fuel – coal | 0.6 | 4% | 12 | 48 | 13% | 67 | 281 | 6% | 1 | 4 | 12% | 5 | 20 | 63% | 9 | 38 | 3% | 2 | 7 | 7% | 10 | 43 | 11% |
| Wood fired cooker | 0.4 | 3% | 4 | 18 | 5% | 61 | 255 | 5% | 0 | 1 | 3% | 0 | 0 | 1% | 9 | 36 | 3% | 1 | 3 | 3% | 4 | 18 | 5% |
| Gas | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Oil | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 1 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| Total Wood | 14 | 95% | 80 | 335 | 87% | 1077 | 4533 | 94% | 7 | 29 | 87% | 3 | 11 | 35% | 307 | 1293 | 97% | 22 | 92 | 93% | 80 | 335 | 89% |
| Total Coal | 1 | 4% | 12 | 48 | 13% | 67 | 281 | 6% | 1 | 4 | 12% | 5 | 20 | 63% | 9 | 38 | 3% | 2 | 7 | 7% | 10 | 43 | 11% |
| Total | 14 | | 91 | 384 | | 1144 | 4813 | | 8 | 34 | | 8 | 32 | | 316 | 1332 | | 24 | 99 | | 90 | 378 | |

**Table 3.18: Monthly variations in contaminant emissions from domestic heating in Milton.**

| | $PM_{10}$ kg/day | CO kg/day | NOx kg/day | SOx kg/day | VOC kg/day | $CO_2$ t/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| January | 1 | 13 | 0 | 0 | 2 | 0 | 1 |
| February | 3 | 47 | 0 | 0 | 13 | 1 | 3 |
| March | 8 | 112 | 1 | 0 | 34 | 2 | 8 |
| April | 29 | 385 | 3 | 1 | 130 | 9 | 29 |
| May | 66 | 825 | 6 | 5 | 249 | 18 | 65 |
| June | 82 | 1036 | 7 | 6 | 304 | 22 | 81 |
| July | 81 | 1028 | 7 | 6 | 300 | 22 | 80 |
| August | 78 | 987 | 7 | 6 | 288 | 21 | 77 |
| September | 25 | 332 | 2 | 1 | 106 | 7 | 25 |
| October | 15 | 201 | 1 | 1 | 63 | 4 | 15 |
| November | 5 | 73 | 0 | 0 | 21 | 1 | 5 |
| December | 3 | 37 | 0 | 0 | 10 | 1 | 3 |
| Total (kg/year) | 12118 | 155382 | 1108 | 859 | 46579 | 3402 | 11990 |

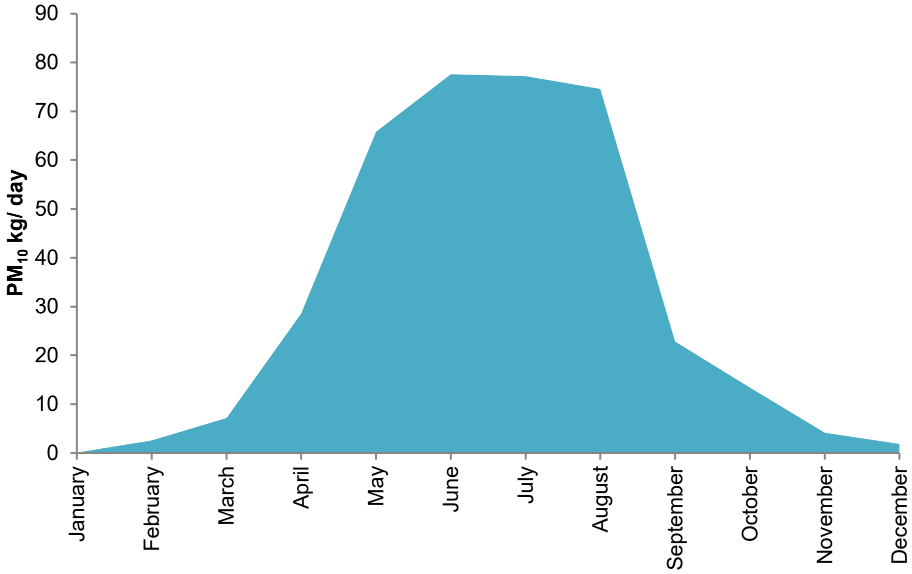


**Figure 3.8: Monthly variations in $PM_{10}$ emissions from domestic heating.**

# 4 MOTOR VEHICLES

## 4.1 Methodology

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

Emission factors for motor vehicles are determined using the Vehicle Emission Prediction Model VEPM 7.2[2]. These have been based on the default settings and were used for all variables except for the temperature data. Temperature data was based on an average winter temperature of five degrees (July average range of 2 – 7 degrees across the four areas) and an average speed the default setting of 50 km/hr was assumed. In previous inventories a vehicle fleet profile based on vehicle registration data for each district was used. The approach of using the National Fleet average vehicle profile has been adopted in preference to this approach as it more fully accounts for the vehicle fleet including state highway VKT. Resulting emission factors are shown in Table 4.1.

It is noted that VEPM version 7.2 includes different emission factors for non-exhaust $PM_{10}$ and $PM_{2.5}$ emissions to previous versions. One method difference between version 7.1 and 7.2 is the inclusion of resuspended road dust in the latter model.

Emission factors for SOx were estimated for diesel vehicles based on the sulphur content of the fuel (0.01%) and the assumption of 100% conversion to SOx. Total VKT for diesel vehicles were estimated based on the proportion of diesels in the vehicle fleet.

The number of vehicle kilometres travelled (VKT) for the each airshed was estimated using the New Zealand Transport Authority VKT data for 2024/2025 for the districts of Central Otago (Alexandra), Queenstown Lakes (Arrowtown), Clutha (Milton), Dunedin (Mosgiel) based on the urban areas (local roads and state highway). These data were multiplied by ratios of 43% (Alexandra), 6% (Arrowtown), 14% (Mosgiel) and 30% (Milton) of urban VKT for the District occur within each town. The ratios estimated based on the relative population of each town to the combined urban centres of the district. The resulting total VKT for each area were estimated at 63,476 (Alexandra), 26,306 (Arrowtown), 190,224 (Mosgiel) and 39,324 (Milton) per day. These were used as the best indication of VKT for 2026 in conjunction with 2026 emission factors to estimate motor vehicle emissions.

**Table 4.1: Emission factors based on national fleet profile for 2026**

| CO g/VKT | $CO_2$ g/VKT | VOC g/VKT | NOx g/VKT | $PM_{10}$ g/VKT | $PM_{2.5}$ g/VKT | $PM_{10}$ brake & tyre g/VKT | $PM_{2.5}$ brake & tyre g/VKT |
|---|---|---|---|---|---|---|---|
| 1.44 | 239 | 0.12 | 0.58 | 0.015 | 0.015 | 0.06 | 0.037 |

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

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

There are several changes in the emission factor and VKT basis in the 2026 inventory when compared with previous inventories. These include a) use of the national vehicle fleet profile rather than the registrations for each territorial local authority b) revised particulate non exhaust emission factors and c) assumptions around VKT allocations. Inventories carried out in 2016 included estimates of non-tailpipe brake and tyre emissions but not resuspended road dust. The methodology applied to the 2026 has been applied in retrospect for 20 years in section 4.3 for each area to illustrate a more robust motor vehicle emissions trend assessment.

[2] https://www.vepm.co.nz/

## 4.2 Motor vehicle emissions

Tables 4.2 to 4.5 show that daily winter $PM_{10}$ emissions range from less than two kilograms in Arrowtown to 11 kilograms in Mosgiel. Similarly, for $PM_{2.5}$ the range was two to four kilograms per day. The annual contributions are shown in Table 4.7 are less than one tonne to four tonnes for $PM_{10}$ and <1 – 2.6 tonnes per year. Around 74% of the $PM_{10}$ and 59% of the $PM_{2.5}$ from motor vehicles is estimated to occur as a result of the wearing of brakes and tyres (Figure 4.1).

**Table 4.2: Summary of daily motor vehicle emissions in Alexandra.**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Tailpipe | 1.0 | 1.0 | 92 | 94 | 37 | 38 | 0 | 0 |
| Brake and tyre | 2.7 | 2.8 | | | | | | |
| Total | 3.7 | 3.8 | 92 | 94 | 37 | 38 | 0 | 0 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | kg | g/ha | t | kg/ha | kg | g/ha | | |
| Tailpipe | 7 | 8 | 15 | 16 | 1.0 | 1.0 | | |
| Brake and tyre | | | | | 1.4 | 1.4 | | |
| Total | 7 | 8 | 15 | 16 | 2.3 | 2.4 | | |

**Table 4.3: Summary of daily motor vehicle emissions in Arrowtown.**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Tailpipe | 0.4 | 1.7 | 38 | 165 | 15 | 66 | 0 | 0 |
| Brake and tyre | 1.1 | 4.9 | | | | | | |
| Total | 1.5 | 6.6 | 38 | 165 | 15 | 66 | 0 | 0 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | kg | g/ha | t | kg/ha | kg | g/ha | | |
| Tailpipe | 3 | 13 | 6 | 27 | 0.0 | 0.0 | | |
| Brake and tyre | | | | | 0.6 | 2.5 | | |
| Total | 3 | 13 | 6 | 27 | 0.6 | 2.5 | | |

**Table 4.4: Summary of daily motor vehicle emissions in Mosgiel.**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Tailpipe | 2.9 | 3.9 | 275 | 376 | 110 | 150 | 0 | 0 |
| Brake and tyre | 8.2 | 11.2 | | | | | | |
| Total | 11.0 | 15.1 | 275 | 376 | 110 | 150 | 0 | 0 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | kg | g/ha | t | kg/ha | kg | g/ha | | |
| Tailpipe | 22 | 31 | 46 | 62 | 0.0 | 0.0 | | |
| Brake and tyre | | | | | 4.2 | 5.7 | | |
| Total | 22 | 31 | 46 | 62 | 4.2 | 5.7 | | |

**Table 4.5: Summary of daily motor vehicle emissions in Milton.**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Tailpipe | 0.6 | 2.5 | 57 | 239 | 23 | 96 | 0 | 0 |
| Brake and tyre | 1.7 | 7.1 | | | | | | |
| Total | 2.3 | 9.6 | 57 | 239 | 23 | 96 | 0 | 0 |

| | VOC | | $CO_2$ | | $PM_{2.5}$ | |
|---|---|---|---|---|---|---|
| | kg | g/ha | t | kg/ha | kg | g/ha |
| Tailpipe | 5 | 20 | 9 | 40 | 0.0 | 0.0 |
| Brake and tyre | | | | | 0.9 | 3.6 |
| Total | 5 | 20 | 9 | 40 | 0.9 | 3.6 |

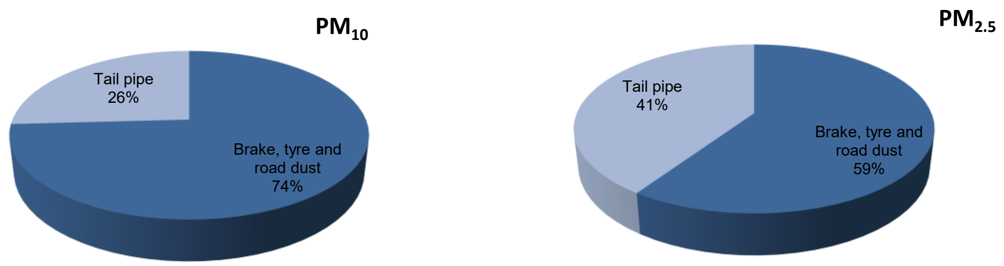


**Figure 4.1: Contribution of tailpipe, brake and tyre wear and road dust to motor vehicle $PM_{10}$ and $PM_{2.5}$ emissions across all four urban areas.**

**Table 4.7: Summary of motor vehicle annual emissions.**

| | $PM_{10}$ t/year | CO t/year | NOx t/year | SOx t/year | VOC t/year | $CO_2$ t/year | $PM_{2.5}$ t/year |
|---|---|---|---|---|---|---|---|
| Alexandra | 1.3 | 33 | 5 | 0.01 | 3 | 5546 | 0.9 |
| Arrowtown | 0.6 | 14 | 2 | 0.00 | 1 | 2298 | 0.4 |
| Mosgiel | 4.0 | 100 | 15 | 0.02 | 8 | 16619 | 2.6 |
| Milton | 0.8 | 21 | 3 | 0.00 | 2 | 3436 | 0.5 |

## 4.3 Motor vehicle emissions trend assessment

Figures 4.2 – 4.5 show $PM_{10}$ emission estimates for each of the urban areas from 2010 to 2025 using the urban VKT data from NZTA and emission estimates for a range of years using the national vehicle fleet profile. IN most areas the improvement in tailpipe exhaust emissions outweighs the increased VKT over the period. The exception is Arrowtown between 2010 and 2017 where VKT increases are substantial and reflect growth across the Queenstown Lakes area during this time. It is possible that the trend observed is more reflective of the District rather than Arrowtown specifically.

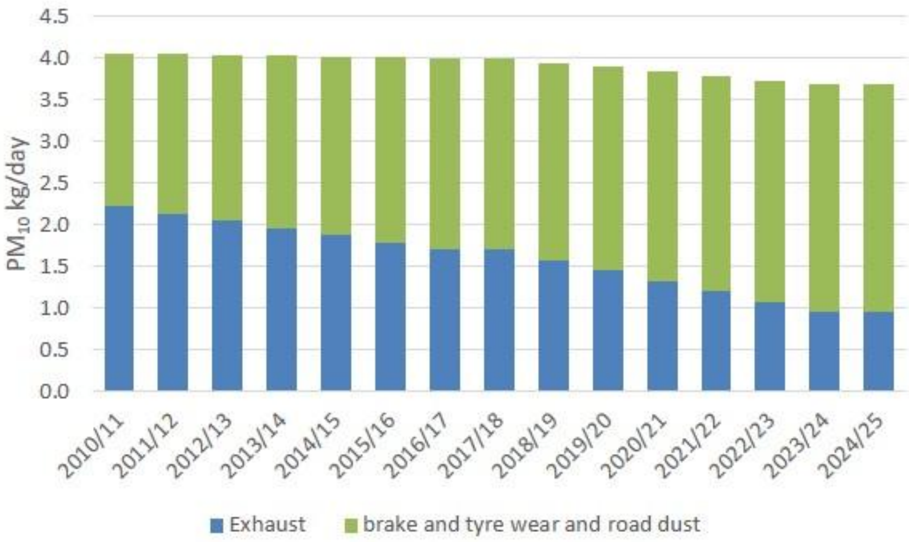


**Figure 4.2: Trends in $PM_{10}$ emissions from motor vehicles in Alexandra from 2005 to 2025**

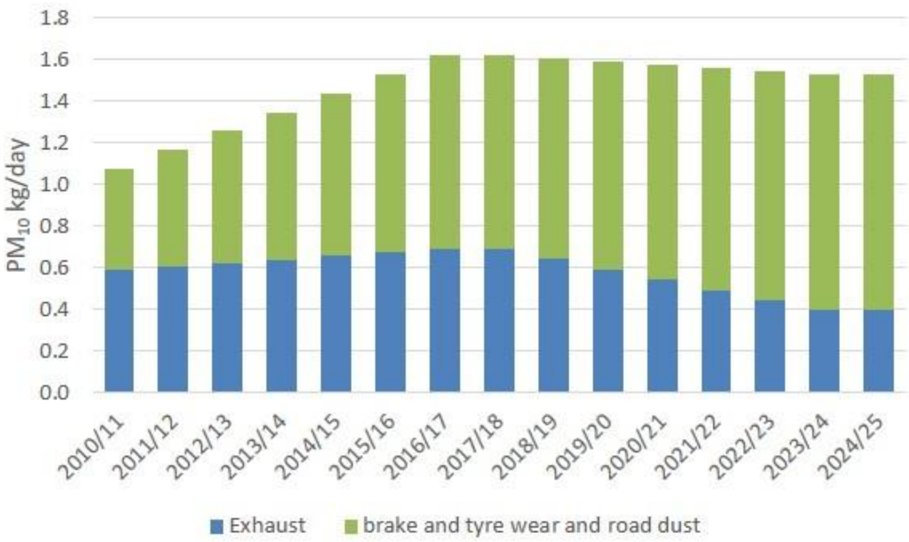


**Figure 4.3: Trends in $PM_{10}$ emissions from motor vehicles in Arrowtown from 2005 to 2025**

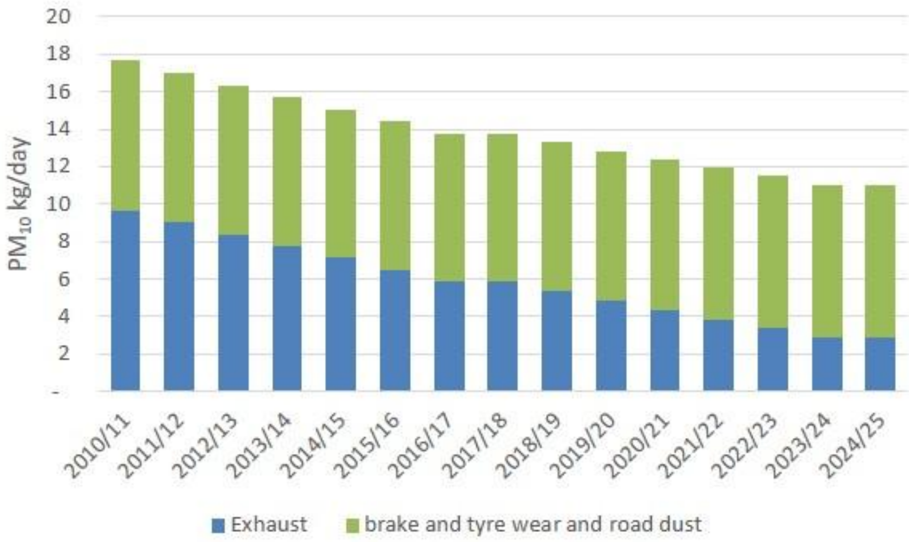


**Figure 4.4: Trends in $PM_{10}$ emissions from motor vehicles in Mosgiel from 2005 to 2025**

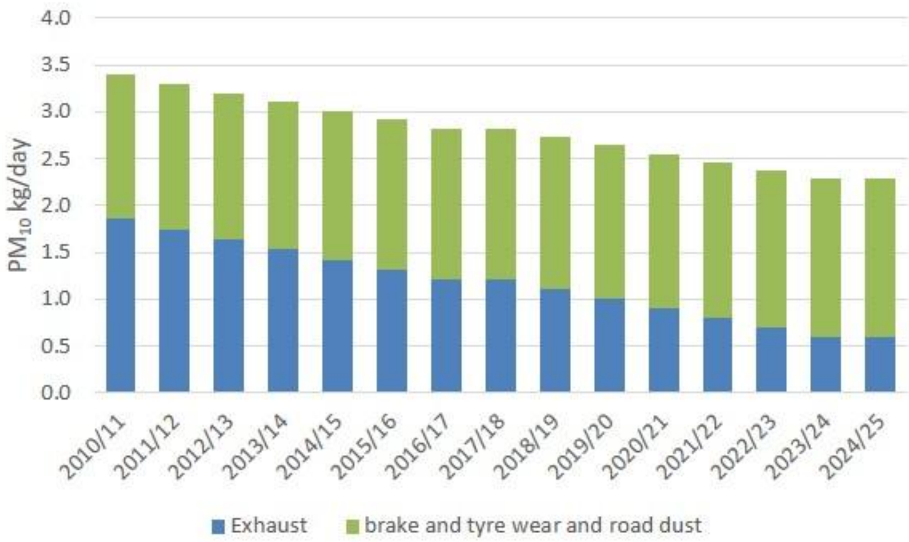


**Figure 4.5: Trends in $PM_{10}$ emissions from motor vehicles in Milton from 2005 to 2025**

# 5 INDUSTRIAL AND COMMERCIAL

## 5.1 Methodology

Identification of industrial or commercial activities discharging to air in Alexandra, Arrowtown, Milton and Mosgiel was based on the current resource consent database held by the Otago Regional Council. One industrial and commercial premise was included in the inventory for Alexandra, none for Arrowtown, two for Milton and four for Mosgiel.

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

For a few industries included in the assessment site specific emissions data was available from the resource consent application or other Council records. In these cases emissions were estimated based on equation 5.1.

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

Where site specific emissions data were not available, emissions were estimated using activity data and emission factor information, as indicated in Equation 5.2. Activity data from industry includes information such as the quantities of fuel used, or in the case of non-combustion activities, materials used or produced. Activity data was collected using a phone and email survey. Data were collected for winter, autumn, spring and summer.

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

The emission factors used to estimate the quantity of emissions discharged are shown in Table 5.1. The coal fired boiler emission factors for $PM_{10}$ are based on New Zealand specific emission factors as described in Wilton & Baynes, (2010). Other emission factors are from the USEPA AP42 or EEA database3.

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

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**Table 5.1: Emission factors for industrial discharges.**

| | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | SOx g/kg | VOC g/kg | $CO_2$ g/kg | $PM_{2.5}$ g/kg |
|---|---|---|---|---|---|---|---|
| Diesel boiler | 0.3 | 0.67 | 3.2 | 0.02 | 0.2 | 3194 | 0.2 |
| LPG boiler | 0.1 | 1.0 | 1.7 | 0.002 | 0.1 | 1630 | 0.1 |
| Pellet Boiler | 0.8 | 6.8 | 0.8 | 0.0 | 0.1 | 1069 | 0.7 |
| Crematoria (kg per cremation) | 0.03 | 0.14 | 0.82 | 0.11 | 0.01 | | 0.03 |

[3] http://www.epa.gov/ttn/chief/ap42/index.html, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/emission-factors-database

## 5.2 Industrial and commercial emissions

Table 5.2 shows the estimated emissions to air from industrial and commercial activities in each of the urban areas. The great industrial quantity of industrial emissions occur in Mosgiel which has around four kilograms of $PM_{10}$ and three kilograms of $PM_{2.5}$ per day from industry during winter. In Milton industrial emissions have decreased as a result of the closure of two main contributors since 2016. These include the Pan Pac site in Milton which was relocated to north of Milton in 2017 and the closure of the Woollen Mill. Table 5.3 shows the annual quantities of emissions for each area for 2026.

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

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| Hectares | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Alexandra | 0.02 | 0.0 | 0.1 | 0.1 | 0.5 | 0.5 | 0.0 | 0.0 |
| Arrowtown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mosgiel | 4 | 5 | 19 | 26 | 14 | 19 | 0 | 0 |
| Milton | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| Hectares | kg | g/ha | t | kg/ha | kg | g/ha | | |
| Alexandra | 0.01 | 0.0 | 0.0 | 0.0 | 0.02 | 0.0 | | |
| Arrowtown | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Mosgiel | 1 | 0 | 12 | 0 | 3 | 4 | | |
| Milton | 0 | 0 | 0 | 0 | 0 | 0 | | |

**Table 5.3: Summary of industrial annual emissions.**

| | $PM_{10}$ t/year | CO t/year | NOx t/year | SOx t/year | VOC t/year | $CO_2$ t/year | $PM_{2.5}$ t/year |
|---|---|---|---|---|---|---|---|
| Alexandra | 0.01 | 0.03 | 0.16 | 0.00 | 0.00 | 0.00 | 0.01 |
| Arrowtown | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mosgiel | 1 | 4 | 5 | 0 | 0 | 4093 | 1 |
| Milton | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# 6 OUTDOOR BURNING

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

Existing regulations prohibit outdoor burning in airzones 1 and 2 areas if the fire is within 100 metres of the property boundary for production land and for residential land if the fire is within 50 metres of the property boundary.

Recreational burning of wood in solid fuel barbeques, pizza ovens, braziers and in outdoor open fires can also give rise to emissions which have not previously been quantified in the air emission inventory.

## 6.1 Methodology

Outdoor burning emissions for each area were estimated based on data collected during the 2026 domestic home heating survey.

Emissions were calculated based on the assumption of an average weight of material per burn of 159 kilograms per cubic metre of material[4] and using the emission factors in Table 6.1 with an average fire size of 0.9 $m^3$ (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. 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. In comparison the European Environment Agency air pollution emission inventory guidebook (EEA, 2016) tier one assessment emission factors are based on tree slash for two species and tree pruning for two species only.

**Table 6.1: Outdoor burning emission factors (AP42).**

| | $PM_{10}$ g/kg | $PM_{2.5}$ g/kg | CO g/kg | NOx g/kg | SOx g/kg | VOC g/kg | $CO_2$ g/kg |
|---|---|---|---|---|---|---|---|
| Outdoor burning | 8.0 | 8.0 | 42.0 | 3.0 | 0.5 | 4.0 | 1470 |

**Table 6.2: Use of solid fuel, pizza ovens, braziers and outdoor fires**

| | Alexandra | | Arrowtown | | Mosgiel | | Milton | |
|---|---|---|---|---|---|---|---|---|
| | households | % | households | % | households | % | households | % |
| Solid fuel barbeque | 54 | 2% | 24 | 2% | 86 | 1% | 25 | 3% |
| Pizza oven | 31 | 1% | 12 | 1% | 51 | 1% | 0 | 0% |
| Brazier | 46 | 2% | 49 | 5% | 120 | 2% | 8 | 1% |
| Outdoor fire | 69 | 3% | 24 | 2% | 17 | 0% | 25 | 3% |
| Total | 201 | 8% | 109 | 11% | 274 | 5% | 59 | 7% |
| Wood fire hot tub | 18 | 1% | 12 | 1% | 17 | 0.3% | 8 | 1% |

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

## 6.2 Outdoor burning emissions in Alexandra

Despite being regulated in higher density areas of Alexandra, Table 6.2 shows that around 16 kilograms of $PM_{10}$ from outdoor burning could be expected per day during the winter months on average. Recreational use of outdoor fires is relatively low in Alexandra with around one kilogram per day or less of $PM_{10}$ and $PM_{2.5}$ emitted across the year (Table 6.3). Wood fired hot tub emissions are minimal at around 0.2 kilograms per day of $PM_{10}$ and $PM_{2.5}$ during winter and 0.1 per year (Table 6.4). Total emissions from outdoor burning and recreational burning in Alexandra are shown in Table 6.5. The main source of outdoor burning $PM_{10}$ emissions in Alexandra is outdoor waste burning at around 87% (daily winter) to 94% (annual) with recreational fires and wood fired hot tubs each contributing less than 10% (Figure 6.1).

It should be noted, that there are a number of uncertainties relating to the calculations. In particular it is assumed that outdoor garden waste burning is carried out evenly throughout the winter, whereas in reality it is highly probable that a disproportionate amount of burning is carried out on days more suitable for burning. Thus, on some days no $PM_{10}$ from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment. In addition, the emission factors vary by a factor of three for different materials being burnt. 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 type and density.

**Table 6.3: Outdoor burning emission estimates for Alexandra.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Autumn (Mar-May) | 3 | 16 | 1 | 0 | 2 | 1 | 3 |
| Winter (June-Aug) | 16 | 82 | 6 | 1 | 8 | 3 | 16 |
| Spring (Sept-Nov) | 1 | 8 | 1 | 0 | 1 | 0 | 1 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 1.8 | 9.7 | 0.7 | 0.1 | 0.9 | 0.3 | 1.8 |

**Table 6.4: Brazier, pizza oven and wood fired barbeque emission estimates for Alexandra.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Autumn (Mar-May) | 1 | 5 | 0 | 0 | 0 | 0 | 1 |
| Winter (June-Aug) | 1 | 4 | 0 | 0 | 0 | 0 | 1 |
| Spring (Sept-Nov) | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.2 | 1.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |

**Table 6.5: Wood fire hot tub emission estimates for Alexandra.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0.2 | 1 | 0 | 0 | 0 | 0 | 0.2 |
| Autumn (Mar-May) | 0.0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Winter (June-Aug) | 0.2 | 1 | 0 | 0 | 0 | 0 | 0.2 |
| Spring (Sept-Nov) | 0.6 | 3 | 0 | 0 | 0 | 0 | 0.6 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |

**Table 6.6: Total outdoor burning emissions in Alexandra.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Autumn (Mar-May) | 4 | 21 | 2 | 0 | 2 | 1 | 4 |
| Winter (June-Aug) | 16 | 87 | 6 | 1 | 8 | 3 | 16 |
| Spring (Sept-Nov) | 2 | 12 | 1 | 0 | 1 | 0 | 2 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 2 | 11 | 1 | 0 | 1 | 0 | 2 |

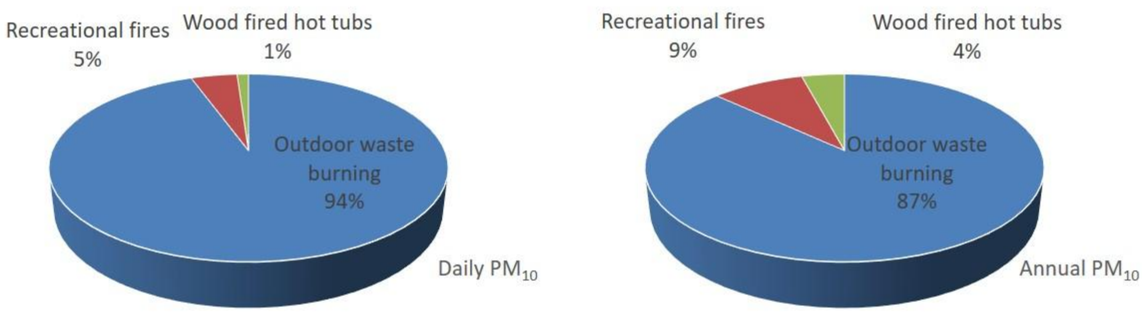



**Figure 6.1: Relative contribution of sources to outdoor burning emissions in Alexandra**

## 6.3 Outdoor burning emissions in Arrowtown

Table 6.7 shows only a very small prevalence of outdoor burning emissions in Arrowtown with just three kilograms of $PM_{10}$ and $PM_{2.5}$ from outdoor burning per day during the winter months on average. Recreational use of outdoor fires is relatively low in Arrowtown with around one kilogram per day or less of $PM_{10}$ and $PM_{2.5}$ emitted across the year (Table 6.8). Wood fired hot tub emission are also minimal (Table 6.8). Total emissions from outdoor burning and recreational burning in Arrowtown are shown in Table 6.9.

The main source of winter daily outdoor burning $PM_{10}$ emissions in Arrowtown is outdoor waste burning at around 67%. In terms of annual emissions however, wood fired hot tubs are the dominant contributor at 49%. For outdoor burning results for $PM_{10}$ will also reflect contributions of $PM_{2.5}$. Recreational fires contribute around 7% of the annual $PM_{10}$ emissions (Figure 6.3).

Table 6.7: Outdoor burning emission estimates for Arrowtown.

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Autumn (Mar-May) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Winter (June-Aug) | 3 | 16 | 1 | 0 | 1 | 1 | 3 |
| Spring (Sept-Nov) | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.3 | 1.7 | 0.1 | 0.0 | 0.2 | 0.1 | 0.3 |

Table 6.8: Brazier, pizza oven and wood fired barbeque emission estimates for Arrowtown.

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| Autumn (Mar-May) | 0.1 | 1 | 0 | 0 | 0 | 0 | 0.1 |
| Winter (June-Aug) | 0.2 | 1 | 0 | 0 | 0 | 0 | 0.2 |
| Spring (Sept-Nov) | 0.2 | 1 | 0 | 0 | 0 | 0 | 0.2 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.2 | 1.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |

Table 6.9: Wood fired hot tub emission estimates for Arrowtown.

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 1.3 | 7 | 0 | 0 | 1 | 0 | 1.3 |
| Autumn (Mar-May) | 0.6 | 3 | 0 | 0 | 0 | 0 | 0.6 |
| Winter (June-Aug) | 1.3 | 7 | 0 | 0 | 1 | 0 | 1.3 |
| Spring (Sept-Nov) | 0.6 | 3 | 0 | 0 | 0 | 0 | 0.6 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.3 | 1.8 | 0.1 | 0.0 | 0.2 | 0.1 | 0.3 |

Table 6.10: Total outdoor burning emissions in Arrowtown.

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 1 | 7 | 1 | 0 | 1 | 0 | 1 |
| Autumn (Mar-May) | 1 | 4 | 0 | 0 | 0 | 0 | 1 |
| Winter (June-Aug) | 4 | 23 | 2 | 0 | 2 | 1 | 4 |
| Spring (Sept-Nov) | 1 | 7 | 0 | 0 | 1 | 0 | 1 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 1 | 4 | 0 | 0 | 0 | 0 | 1 |

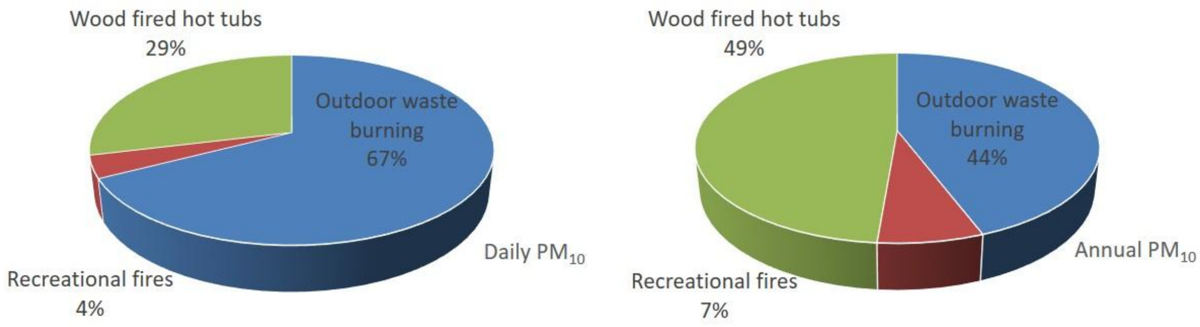



**Figure 6.2: Relative contribution of sources to outdoor burning emissions in Arrowtown**

## 6.4 Outdoor burning emissions in Mosgiel

Around seven kilograms of $PM_{10}$ and $PM_{2.5}$ from outdoor burning per day are emitted during the winter months on average in Mosgiel (Table 6.11). Recreational use of outdoor fires is relatively low in Mosgiel with around one kilogram per day or less of $PM_{10}$ and $PM_{2.5}$ emitted across the year (Table 6.12) as are wood fired hot tub emissions (Table 6.13). Total emissions from outdoor burning and recreational burning in Mosgiel are shown in Table 6.14. The main source of outdoor burning $PM_{10}$ emissions in Mosgiel is outdoor waste burning at around 75% of the annual and 82% of the daily winter emissions. Recreational fires are not a significant contributor to daily winter emissions but emit around 12% of the annual $PM_{10}$ emissions. Wood fired hot tubs contribute 13% and 12% of the daily winter and annual $PM_{10}$ emissions from outdoor burning respectively (Figure 6.3).

**Table 6.11: Outdoor burning emission estimates for Mosgiel.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 5 | 24 | 2 | 0 | 2 | 1 | 5 |
| Autumn (Mar-May) | 4 | 21 | 2 | 0 | 2 | 1 | 4 |
| Winter (June-Aug) | 7 | 35 | 2 | 0 | 3 | 1 | 7 |
| Spring (Sept-Nov) | 7 | 39 | 3 | 0 | 4 | 1 | 7 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/year | SOx tonnes/year | VOC tonnes/year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 2.1 | 10.9 | 0.8 | 0.1 | 1.0 | 0.4 | 2.1 |

**Table 6.12: Brazier, pizza oven and wood fired barbeque emission estimates for Mosgiel.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 1 | 7 | 0 | 0 | 1 | 0 | 1 |
| Autumn (Mar-May) | 1 | 7 | 0 | 0 | 1 | 0 | 1 |
| Winter (June-Aug) | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Spring (Sept-Nov) | 1 | 5 | 0 | 0 | 0 | 0 | 1 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.4 | 1.9 | 0.1 | 0.0 | 0.2 | 0.1 | 0.4 |

**Table 6.13: Wood fired hot tub emission estimates for Mosgiel.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0.5 | 3 | 0 | 0 | 0 | 0 | 0.5 |
| Autumn (Mar-May) | 1.1 | 6 | 0 | 0 | 1 | 0 | 1.1 |
| Winter (June-Aug) | 1.1 | 6 | 0 | 0 | 1 | 0 | 1.1 |
| Spring (Sept-Nov) | 1.1 | 6 | 0 | 0 | 1 | 0 | 1.1 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.3 | 1.8 | 0.1 | 0.0 | 0.2 | 0.1 | 0.3 |

**Table 6.14: Total outdoor burning emissions in Mosgiel.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 6 | 34 | 2 | 0 | 3 | 1 | 6 |
| Autumn (Mar-May) | 6 | 34 | 2 | 0 | 3 | 1 | 6 |
| Winter (June-Aug) | 8 | 43 | 3 | 1 | 4 | 1 | 8 |
| Spring (Sept-Nov) | 9 | 50 | 4 | 1 | 5 | 2 | 9 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 3 | 15 | 1 | 0 | 1 | 1 | 3 |

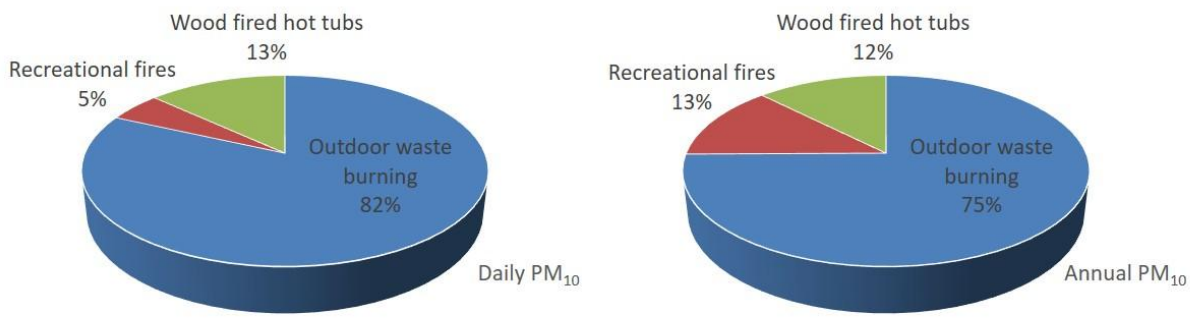



**Figure 6.3: Relative contribution of sources to outdoor burning emissions in Mosgiel**

## 6.5 Outdoor burning emissions in Milton

Around five kilograms of $PM_{10}$ and $PM_{2.5}$ from outdoor burning per day are emitted during the winter months on average in Milton (Table 6.15). Recreational use of outdoor fires is relatively low in Milton with less than one kilogram per day of $PM_{10}$ and $PM_{2.5}$ emitted across the year (Table 6.16). Emissions from wood fired hot tubs in Milton is not significant at less than 0.1 kg/day for $PM_{10}$ and $PM_{2.5}$ (Table 6.18). Total emissions from outdoor burning and recreational burning in Milton are shown in Table 6.18. The main source of outdoor burning $PM_{10}$ emissions in Milton is outdoor waste burning at around 90% with recreational fires and wood fired hot tubs each contributing around 4-6 (Figure 6.4).

**Table 6.15: Outdoor burning emission estimates for Milton.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 3 | 16 | 1 | 0 | 2 | 1 | 3 |
| Autumn (Mar-May) | 3 | 15 | 1 | 0 | 1 | 1 | 3 |
| Winter (June-Aug) | 5 | 24 | 2 | 0 | 2 | 1 | 5 |
| Spring (Sept-Nov) | 3 | 13 | 1 | 0 | 1 | 0 | 3 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 1.2 | 6.2 | 0.4 | 0.1 | 0.6 | 0.2 | 1.2 |

**Table 6.16: Brazier, pizza oven and wood fired barbeque emission estimates for Milton.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0.2 | 1.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |
| Autumn (Mar-May) | 0.2 | 0.9 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |
| Winter (June-Aug) | 0.2 | 1.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |
| Spring (Sept-Nov) | 0.2 | 1.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.2 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |

**Table 6.17: Wood fired hot tub emission estimates for Milton.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Autumn (Mar-May) | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Winter (June-Aug) | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Spring (Sept-Nov) | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**Table 6.18: Total outdoor burning emissions in Milton.**

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC Kg/day | $CO_2$ tonnes/day | $PM_{2.5}$ kg/day |
|---|---|---|---|---|---|---|---|
| Summer (Dec-Feb) | 3 | 17 | 1 | 0 | 2 | 1 | 3 |
| Autumn (Mar-May) | 3 | 16 | 1 | 0 | 2 | 1 | 3 |
| Winter (June-Aug) | 5 | 26 | 2 | 0 | 2 | 1 | 5 |
| Spring (Sept-Nov) | 3 | 14 | 1 | 0 | 1 | 1 | 3 |
| | $PM_{10}$ tonnes/ year | CO tonnes/ year | NOx tonnes/ year | SOx tonnes/ year | VOC tonnes/ year | $CO_2$ tonnes/year | $PM_{2.5}$ tonnes/ year |
| Annual emissions | 1 | 7 | 0 | 0 | 1 | 0 | 1 |

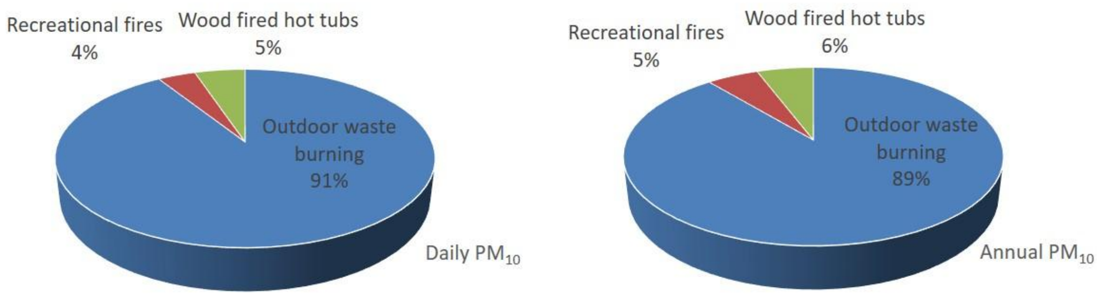



**Figure 6.4: Relative contribution of sources to outdoor burning emissions in Milton**

# 7 OTHER SOURCES OF EMISSIONS

This inventory includes all likely major sources of $PM_{10}$ that can be adequately estimated using inventory techniques. Two additional categories not included in the 2016 inventories are wood fired hot tubs and wood fired cookers. Emissions from these sources were estimated by surveying households to ascertain prevalence of the activity and fuel use and the application of basic wood burning emission factors[5].

Other sources of emissions not included in the inventory that may contribute to measured $PM_{10}$ concentrations at some times during the year include dusts (a portion of which occur in the $PM_{10}$ size fraction) and sea spray, although the latter is likely to be minimal in Alexandra and Arrowtown.

Lawn mowers, leaf blowers and chainsaws can also contribute small amounts of particulate. These are not typically included in emission inventory studies owing to the relatively small contribution, particularly in areas where solid fuel burning is a common method of home heating. Based on data for other areas, $PM_{10}$ emissions from lawn mowing in all areas are likely to be less than one kilogram per day[6].

[5] Emission factors for pre 2006 wood burners were used for both wood fired hot tubs and wood fired cookers.

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

# 8 TOTAL EMISSIONS

## 8.1 Total Emissions Alexandra

Around 153 kilograms of $PM_{10}$ is discharged to air in Alexandra on an average winter's day. This compares with around 190 kilograms per day for 2016 (after adjusting for method differences[7]) and reflects a decrease in daily winter $PM_{10}$ of around 19%. This is less than the reduction that occurred between 2005 and 2016 as a result of the reduction in the proportion of households using coal and as a result of the replacement of older burners with those that meet the NES design criteria for wood burners.

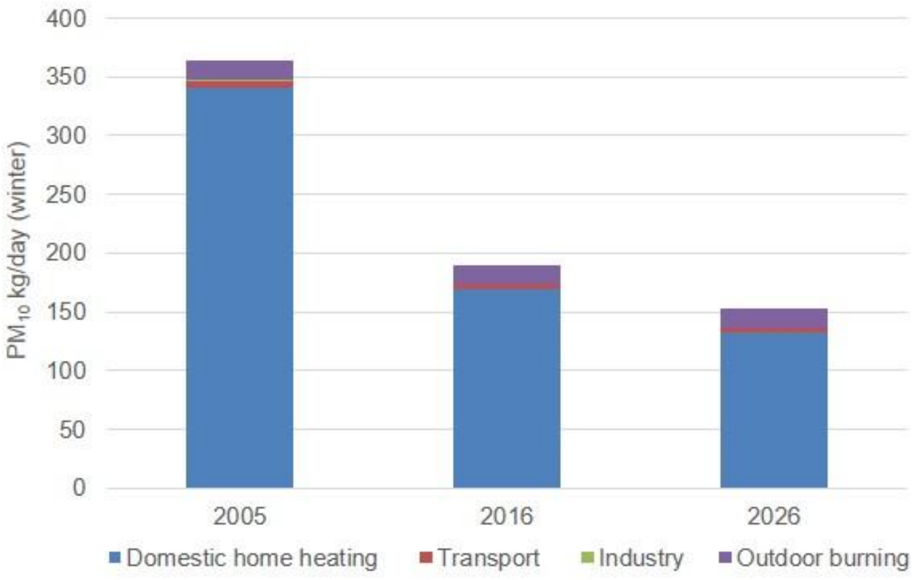



**Figure 8.1: Trends in daily $PM_{10}$ emissions in Alexandra 2005 to 2026.**

Figures 8.2 and 8.3 show that domestic home heating is the main source of daily and annual $PM_{10}$ emissions contributing just less than 90% of the daily wintertime emissions. Outdoor burning contributes around 11% to the daily and annual particulate emissions. The motor vehicles contribution to particulate emissions is minor.

Domestic home heating is also the main source of $PM_{2.5}$, CO, SOx, VOCs and $CO_2$ in Alexandra. Motor vehicles are the main source of NOx (Figure 8.4). Table 8.1 shows seasonal variations in $PM_{10}$ emissions. Daily wintertime emissions of $PM_{10}$ and other contaminants (kg/day and g/day/ha) are shown in Table 8.2.

[7] This includes assuming that outdoor burning would have contributed similarly at the time of previous emission inventories.

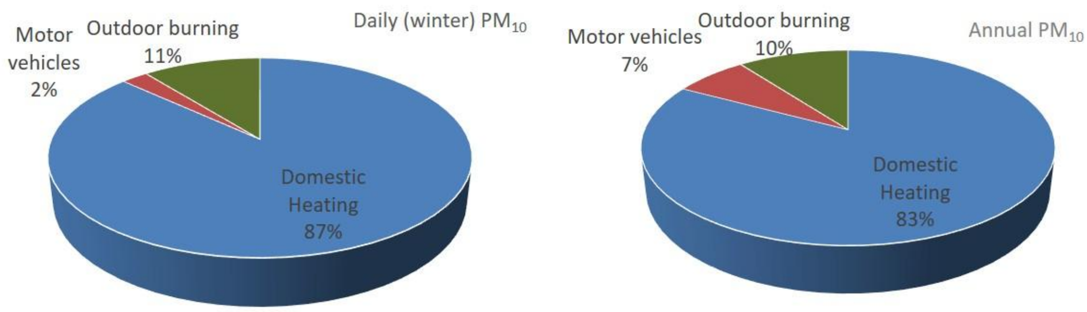



Figure 8.2: Relative contribution of sources to daily winter and annual $PM_{10}$ emissions in Alexandra.

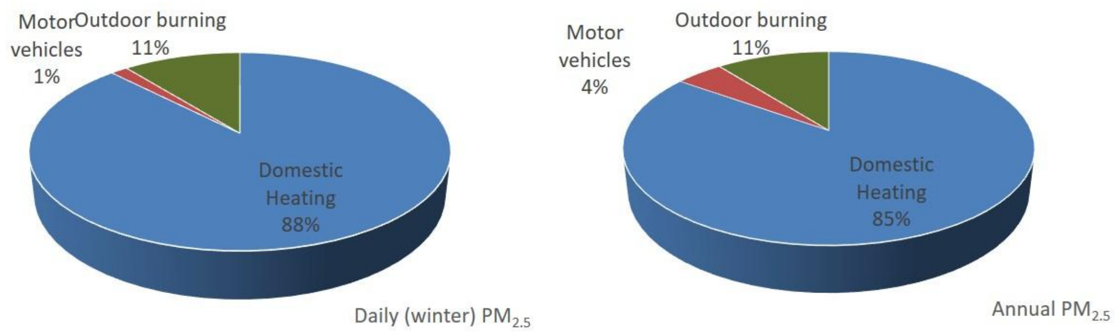



Figure 8.3: Relative contribution of sources to daily winter and annual $PM_{2.5}$ emissions in Alexandra.

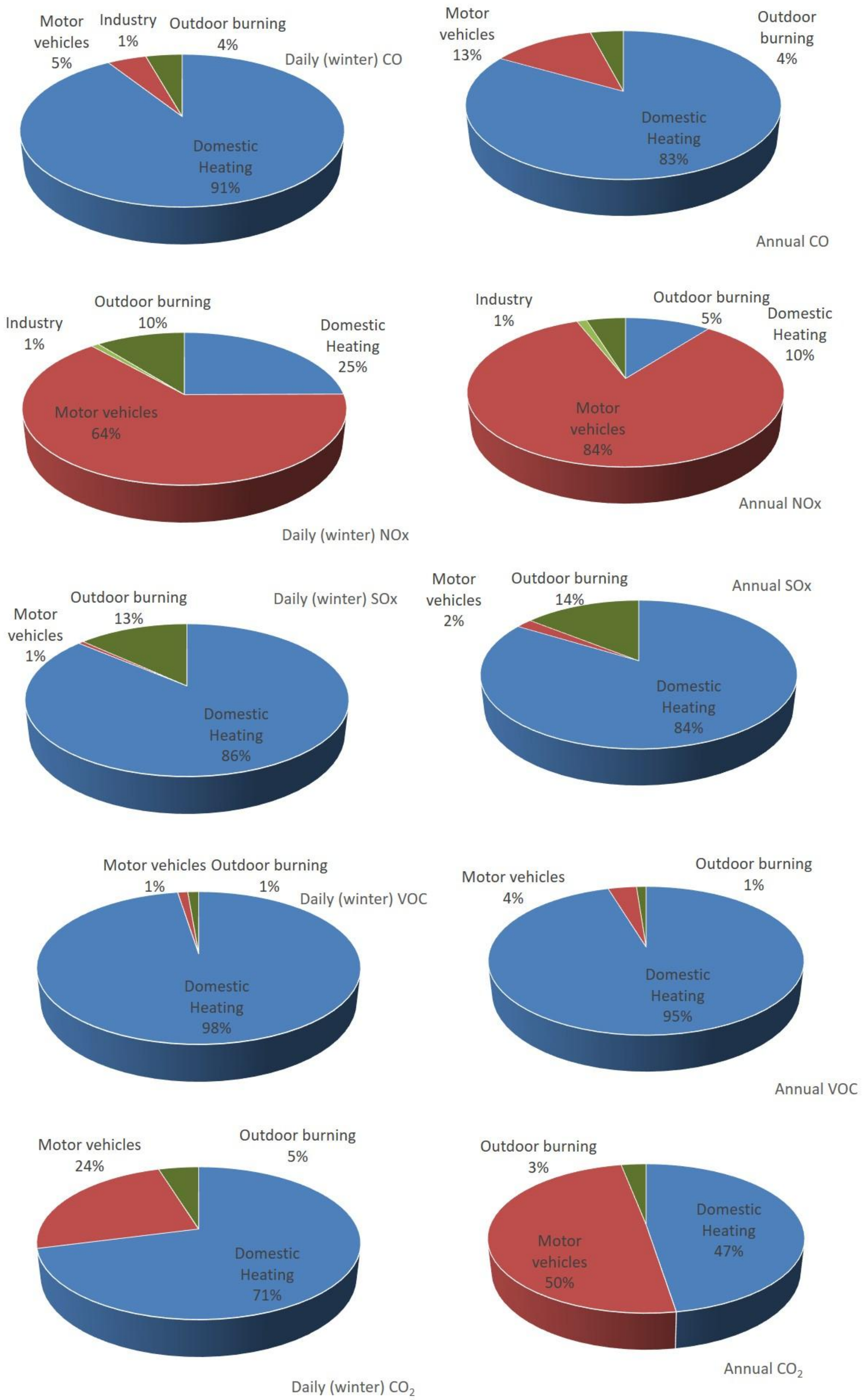



**Figure 8.4: Relative contribution of sources to daily winter contaminant emissions in Alexandra.**

**Table 8.1: Monthly variations in daily $PM_{10}$ emissions in Alexandra.**

| | Domestic heating kg/day | % | Outdoor burning kg/day | % | Industry kg/day | % | Motor vehicles kg/day | % | Total kg/day |
|---|---|---|---|---|---|---|---|---|---|
| January | 0 | 0% | 0 | 2% | 0.02 | 1% | 4 | 97% | 4 |
| February | 0 | 8% | 0 | 2% | 0.02 | 1% | 4 | 89% | 4 |
| March | 2 | 19% | 4 | 42% | 0.02 | 0% | 4 | 39% | 9 |
| April | 16 | 67% | 4 | 17% | 0.02 | 0% | 4 | 16% | 23 |
| May | 105 | 93% | 4 | 4% | 0.02 | 0% | 4 | 3% | 112 |
| June | 128 | 86% | 16 | 11% | 0.02 | 0% | 4 | 2% | 148 |
| July | 133 | 87% | 16 | 11% | 0.02 | 0% | 4 | 2% | 153 |
| August | 114 | 85% | 16 | 12% | 0.02 | 0% | 4 | 3% | 134 |
| September | 25 | 82% | 2 | 6% | 0.02 | 0% | 4 | 12% | 31 |
| October | 8 | 58% | 2 | 13% | 0.02 | 0% | 4 | 28% | 13 |
| November | 2 | 27% | 2 | 23% | 0.02 | 0% | 4 | 49% | 7 |
| December | 1 | 12% | 0 | 2% | 0.02 | 1% | 4 | 85% | 4 |
| Total kg year | 16334 | 83% | 2037 | 10% | 8 | 0% | 1344 | 7% | 19723 |

**Table 8.2: Daily contaminant emissions from all sources in Alexandra (winter average).**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Domestic home heating | 133 | 136 | 1798 | 1842 | 14 | 15 | 7 | 7 |
| Transport | 4 | 4 | 92 | 94 | 37 | 38 | 0 | 0 |
| Industry | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Outdoor burning | 16 | 17 | 86 | 88 | 6 | 6 | 1 | 1 |
| Total | 153 | 157 | 1976 | 2024 | 58 | 59 | 8 | 8 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | kg | g/ha | tonnes | kg/ha | kg | g/ha | | |
| Domestic home heating | 611 | 626 | 44 | 45 | 133 | | | |
| Transport | 7 | 8 | 15 | 16 | 2 | | | |
| Industry | 0 | 0 | 0 | 0 | 0 | | | |
| Outdoor burning | 8 | 8 | 3 | 3 | 16 | | | |
| Total | 627 | 642 | 63 | 64 | 151 | | | |

## 8.2 Total Emissions Arrowtown

Around 38 kilograms of $PM_{10}$ is discharged to air in Arrowtown on an average winter's day for 2026 and this compares with an estimated 100 kg/day in 2016 indicating a significant reduction (Figure 8.5). This occurs primarily because over half of the wood burners being used in Arrowtown are now ULEB burners. This is the largest proportion of any of the four urban areas. A significant reduction in emissions also occurred between 2006 and 2016 which was noted in the 2016 inventory as occurring as a result of a decrease in the proportion of households using coal and due to the replacement of older burners with those that meet the NES design criteria for wood burners. Figures 8.6 and 8.7 shows that domestic heating contributes around 80-85% of the daily and annual winter $PM_{10}$ emissions and $PM_{2.5}$ emissions. Table 8.3 shows seasonal variations in $PM_{10}$ emissions and annual totals. Daily wintertime emissions of $PM_{10}$ and other contaminants (kg/day and g/day/ha) are shown in Table 8.4.


**Figure 8.5: Trends in daily winter $PM_{10}$ emissions in Arrowtown.**

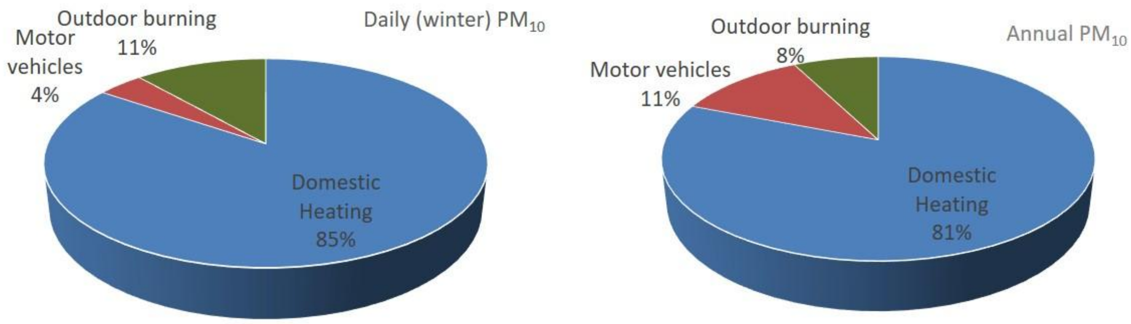



**Figure 8.6: Relative contribution of sources to daily winter and annual $PM_{10}$ emissions in Arrowtown.**

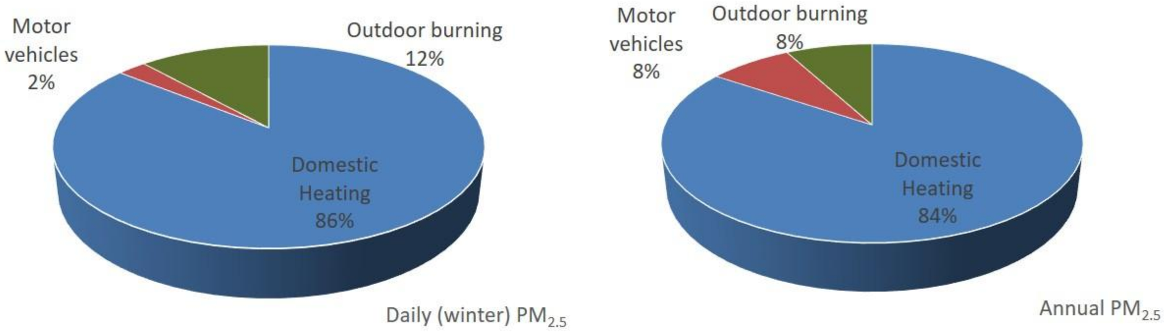



**Figure 8.7: Relative contribution of sources to daily winter and annual $PM_{2.5}$ emissions in Arrowtown.**

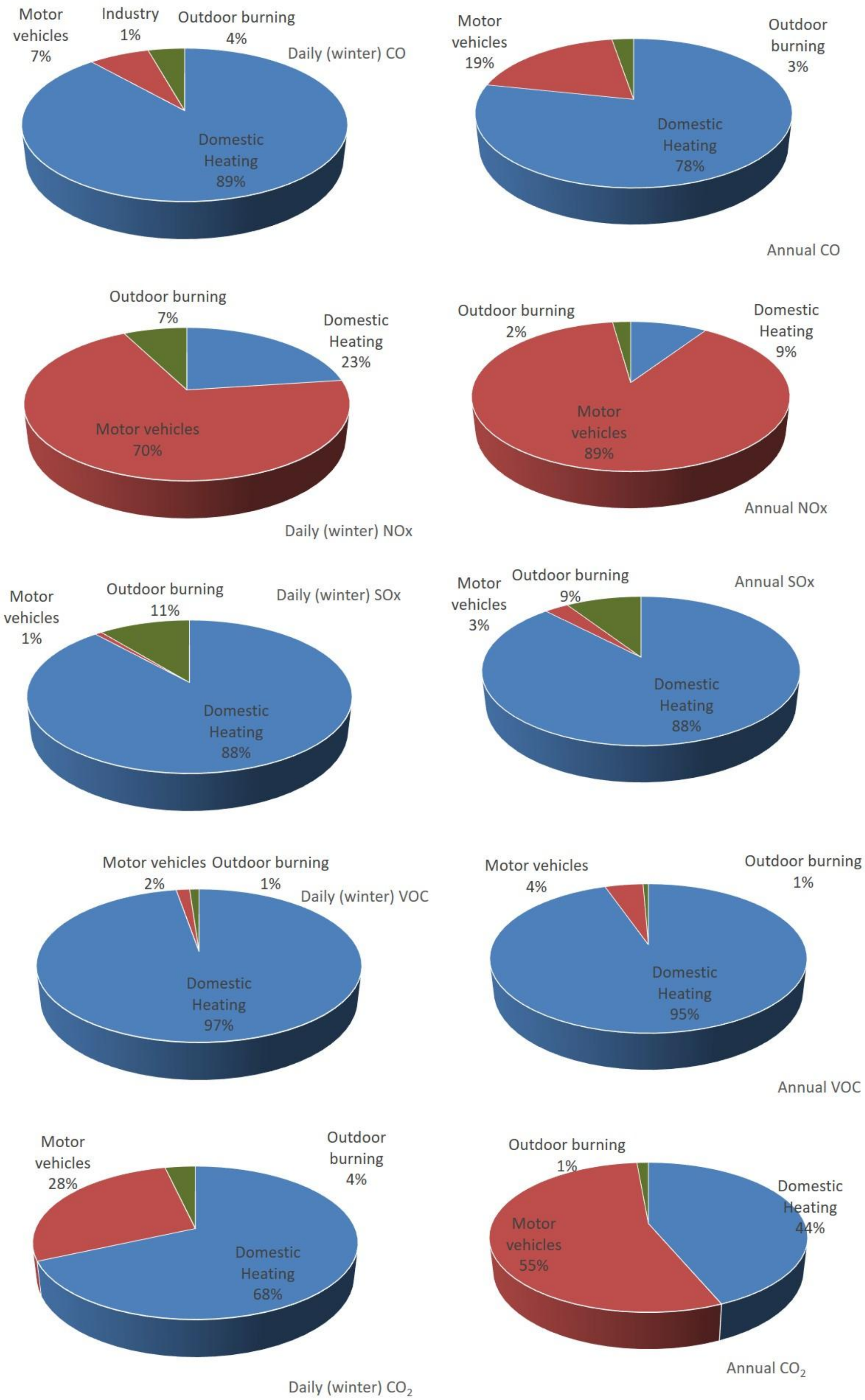



**Figure 8.8: Relative contribution of sources to daily winter contaminant emissions in Arrowtown.**

**Table 8.3: Monthly variations in daily $PM_{10}$ emissions in Arrowtown.**

| | Domestic heating kg/day | % | Outdoor burning kg/day | % | Industry kg/day | % | Motor vehicles kg/day | % | Total kg/day |
|---|---|---|---|---|---|---|---|---|---|
| January | 0 | 0% | 0 | 4% | 0 | 0% | 2 | 96% | 2 |
| February | 0 | 0% | 0 | 4% | 0 | 0% | 2 | 96% | 2 |
| March | 0 | 9% | 0 | 8% | 0 | 0% | 2 | 83% | 2 |
| April | 1 | 41% | 0 | 5% | 0 | 0% | 2 | 54% | 3 |
| May | 24 | 93% | 0 | 1% | 0 | 0% | 2 | 6% | 26 |
| June | 31 | 87% | 3 | 9% | 0 | 0% | 2 | 4% | 36 |
| July | 32 | 87% | 3 | 8% | 0 | 0% | 2 | 4% | 37 |
| August | 31 | 87% | 3 | 9% | 0 | 0% | 2 | 4% | 35 |
| September | 6 | 72% | 1 | 9% | 0 | 0% | 2 | 19% | 8 |
| October | 3 | 54% | 1 | 14% | 0 | 0% | 2 | 32% | 5 |
| November | 0 | 16% | 1 | 26% | 0 | 0% | 2 | 58% | 3 |
| December | 0 | 0% | 0 | 4% | 0 | 0% | 2 | 96% | 2 |
| Total kg year | 3921 | 81% | 368 | 8% | 0 | 0% | 557 | 11% | 4846 |

**Table 8.4: Daily contaminant emissions from all sources in Arrowtown (winter average).**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Domestic home heating | 32 | 140 | 469 | 2037 | 5 | 22 | 2 | 10 |
| Transport | 2 | 7 | 38 | 165 | 15 | 66 | 0 | 0 |
| Industry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Outdoor burning | 4 | 19 | 23 | 100 | 2 | 7 | 0.3 | 1 |
| Total | 38 | 166 | 530 | 2302 | 22 | 95 | 3 | 11 |
| | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | kg | g/ha | tonnes | kg/ha | kg | g/ha | | |
| Domestic home heating | 190 | 826 | 15 | 66 | 32 | 140 | | |
| Transport | 3 | 13 | 6 | 27 | 1 | 4 | | |
| Industry | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Outdoor burning | 2 | 10 | 1 | 3 | 4 | 19 | | |
| Total | 196 | 849 | 22 | 97 | 38 | 163 | | |

## 8.3 Total Emission Mosgiel

Around 269 kilograms of $PM_{10}$ is discharged to air in Mosgiel on an average winter's day. This represents around a 30% reduction in emissions since 2016 (Figure 8.9). A more significant reduction occurred in between 2013 and 2016 as a result of a reduction in the proportion of households using coal and the replacement of older burners with those that meet the NES design criteria for wood burners as well as industry closure or fuel switching.

Figure 8.10 shows that domestic home heating is the main source of $PM_{10}$ and $PM_{2.5}$ emissions contributing between 82% and 93% of the daily wintertime and annual emissions.

Domestic home heating is also the main source of CO, SOx, VOCs and $CO_2$ in Mosgiel. Motor vehicles are the main source of NOx (Figure 8.11).

Table 8.5 shows seasonal variations in $PM_{10}$ emissions. Daily wintertime emissions of $PM_{10}$ and other contaminants (kg/day and g/day/ha) are shown in Table 8.6.

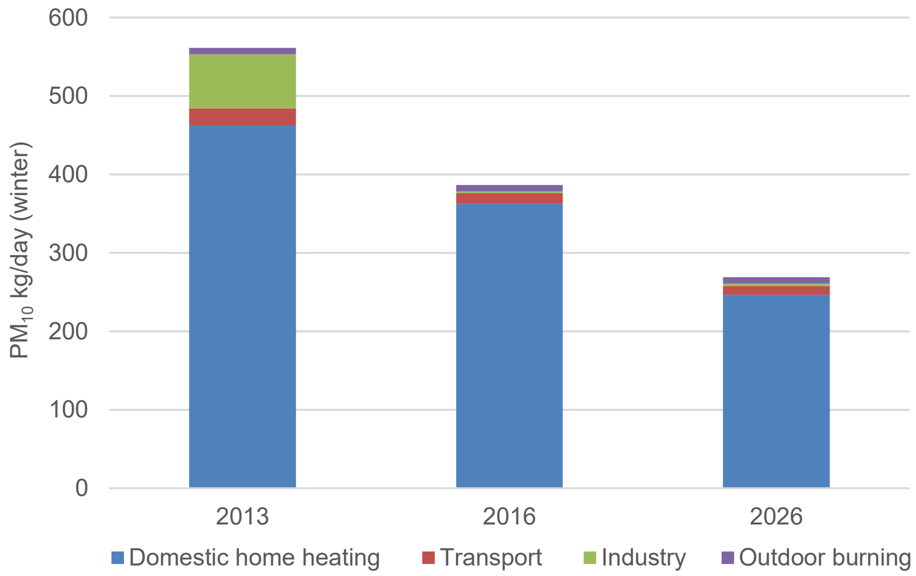



**Figure 8.9: Trends in daily winter $PM_{10}$ emissions in Mosgiel**

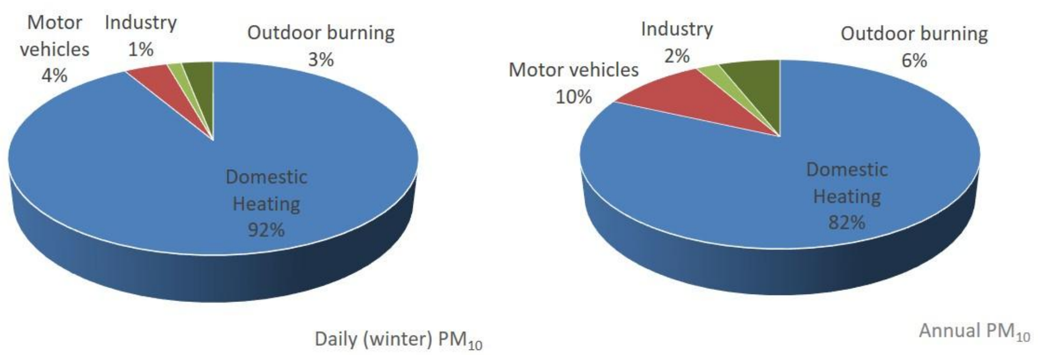
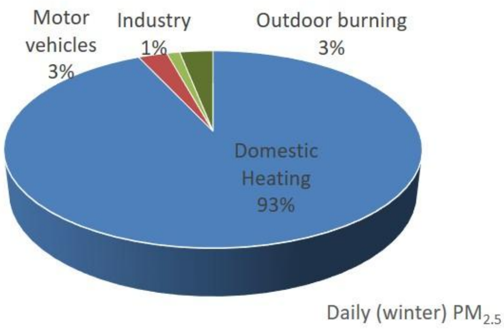



**Figure 8.10: Relative contribution of sources to daily winter and annual $PM_{10}$ emissions in Mosgiel**



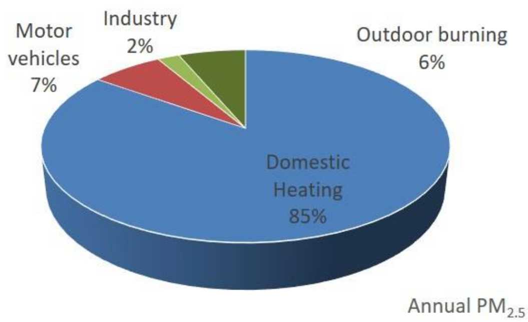




**Figure 8.11: Relative contribution of sources to daily winter and annual $PM_{2.5}$ emissions in Mosgiel.**

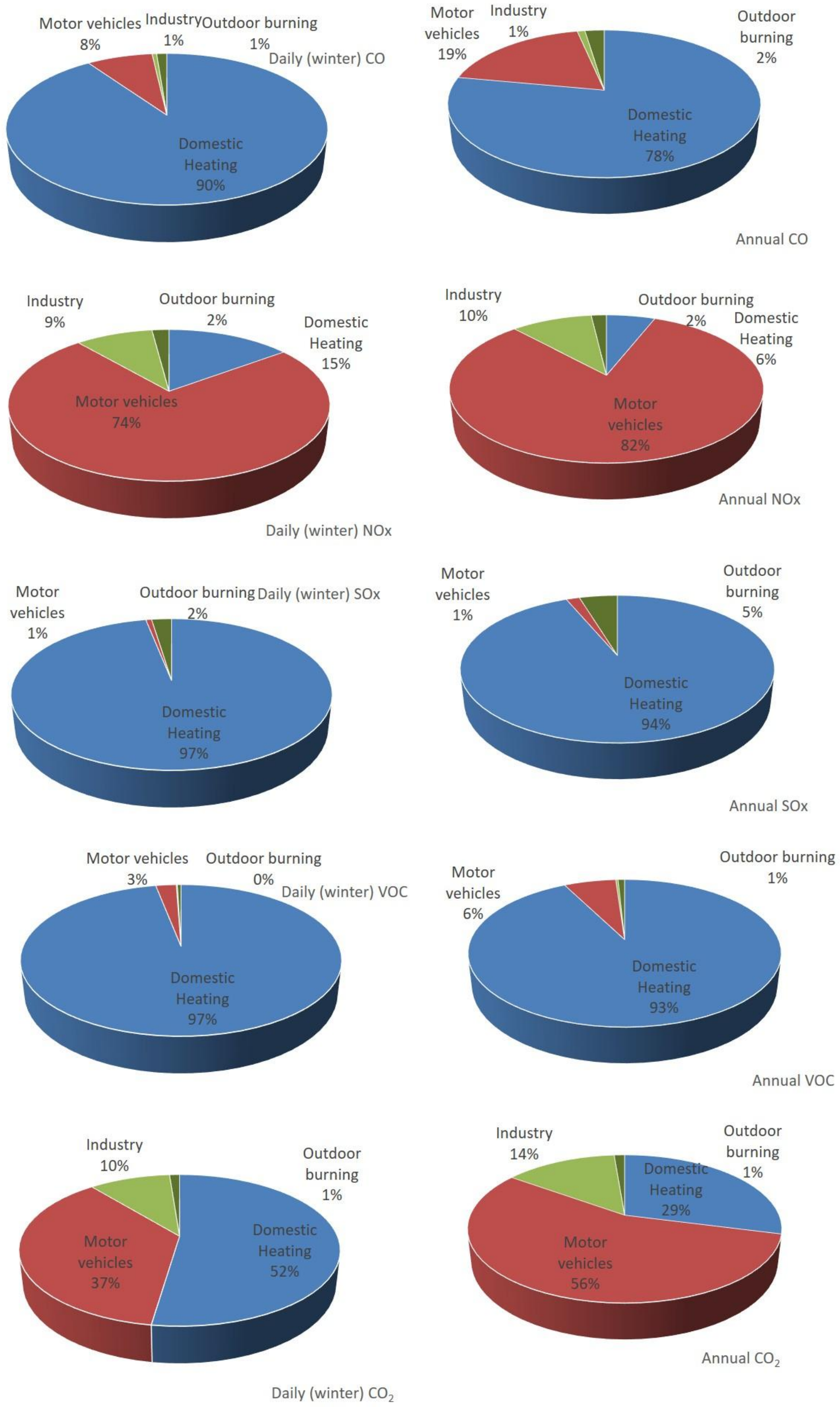



**Figure 8.12: Relative contribution of sources to daily winter contaminant emissions in Mosgiel.**

**Table 8.5: Monthly variations in daily $PM_{10}$ emissions in Mosgiel**

| | Domestic heating kg/day | % | Outdoor burning kg/day | % | Industry kg/day | % | Motor vehicles kg/day | % | Total kg/day |
|---|---|---|---|---|---|---|---|---|---|
| January | 3 | 12% | 6 | 29% | 1 | 6% | 11 | 53% | 21 |
| February | 7 | 27% | 6 | 24% | 1 | 5% | 11 | 44% | 25 |
| March | 13 | 39% | 5 | 16% | 4 | 11% | 11 | 34% | 33 |
| April | 41 | 67% | 5 | 9% | 4 | 6% | 11 | 18% | 61 |
| May | 184 | 90% | 5 | 3% | 4 | 2% | 11 | 5% | 204 |
| June | 235 | 91% | 7 | 3% | 4 | 1% | 11 | 4% | 256 |
| July | 246 | 92% | 7 | 3% | 4 | 1% | 11 | 4% | 268 |
| August | 225 | 91% | 7 | 3% | 4 | 1% | 11 | 4% | 247 |
| September | 79 | 79% | 8 | 8% | 1 | 1% | 11 | 11% | 99 |
| October | 36 | 63% | 8 | 15% | 1 | 2% | 11 | 20% | 56 |
| November | 10 | 32% | 8 | 27% | 1 | 4% | 11 | 36% | 31 |
| December | 3 | 15% | 6 | 28% | 1 | 6% | 11 | 52% | 21 |
| Total kg year | 33094 | 82% | 2430 | 6% | 898 | 2% | 4027 | 10% | 40450 |

**Table 8.6: Daily contaminant emissions from all sources in Mosgiel (winter average).**

| | $PM_{10}$ kg | g/ha | CO kg | g/ha | NOx kg | g/ha | SOx kg | g/ha |
|---|---|---|---|---|---|---|---|---|
| Domestic home heating | 246 | 337 | 3143 | 4301 | 22 | 30 | 0.0 | 0.0 |
| Transport | 11 | 15 | 275 | 376 | 110 | 150 | 0.1 | 0.2 |
| Industry | 4 | 5 | 19 | 26 | 14 | 19 | 0.0 | 0.0 |
| Outdoor burning | 8 | 11 | 37 | 51 | 3 | 4 | 0.4 | 0.6 |
| Total | 269 | 368 | 3474 | 4753 | 149 | 203 | 1 | 1 |
| | **VOC kg** | **g/ha** | **$CO_2$ tonnes** | **kg/ha** | **$PM_{2.5}$ kg** | **g/ha** | | |
| Domestic home heating | 883 | 1208 | 65 | 89 | 0 | 0 | | |
| Transport | 22 | 31 | 46 | 62 | 7 | 10 | | |
| Industry | 1 | 2 | 12 | 17 | 3 | 4 | | |
| Outdoor burning | 4 | 5 | 1 | 2 | 7 | 10 | | |
| Total | 910 | 1245 | 124 | 169 | 17 | 24 | | |

## 8.4 Total Emissions Milton

Around 89 kilograms of $PM_{10}$ is discharged to air in Milton on an average winter's day. A comparison of the daily winter $PM_{10}$ emission estimates for 2026 to the 2016 inventory and a previous national assessment from 2013 are shown in Figure 8.13. This indicates a reduction in daily winter $PM_{10}$ emissions of around 30% since

2016 with the majority occurring as a result of a decrease in industrial emissions. Figure 8.13 also suggests a reduction in $PM_{10}$ between 2013 and 2016 which is attributed in the 2016 inventory to a reduction in the proportion of households using coal and as a result of the replacement of older burners with those that meet the NES design criteria for wood burners.

Figures 8.14 and 8.15 show that domestic home heating is the main source of $PM_{10}$ and $PM_{2.5}$ emissions contributing 92% of the daily wintertime $PM_{10}$ and $PM_{2.5}$ emissions and 85% and 87% of the annual $PM_{10}$ and $PM_{2.5}$ emissions respectively. Outdoor burning is the next most significant contributor.

Domestic home heating is also the main source of CO, $SO_2$, VOCs and $CO_2$ in Milton (Figure 8.16).

Table 8.7 shows seasonal variations in $PM_{10}$ emissions. Daily wintertime emissions of $PM_{10}$ and other contaminants (kg/day and g/day/ha) are shown in Table 8.8.

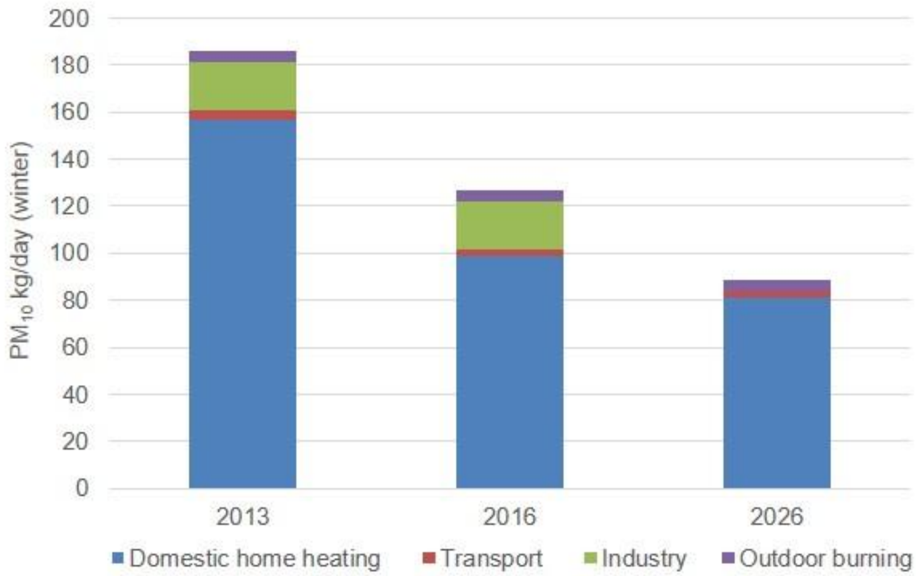



**Figure 8.13: Trends in daily winter $PM_{10}$ emissions in Milton.**

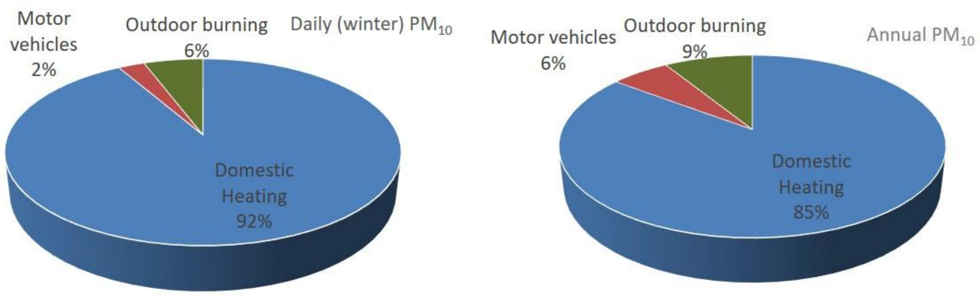



**Figure 8.14: Relative contribution of sources to daily winter and annual $PM_{10}$ emissions in Milton.**

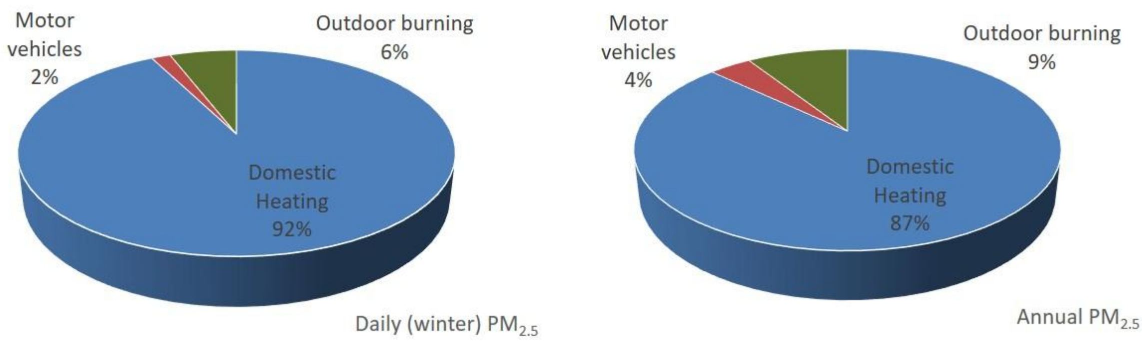



**Figure 8.15: Relative contribution of sources to daily winter and annual $PM_{2.5}$ emissions in Milton.**

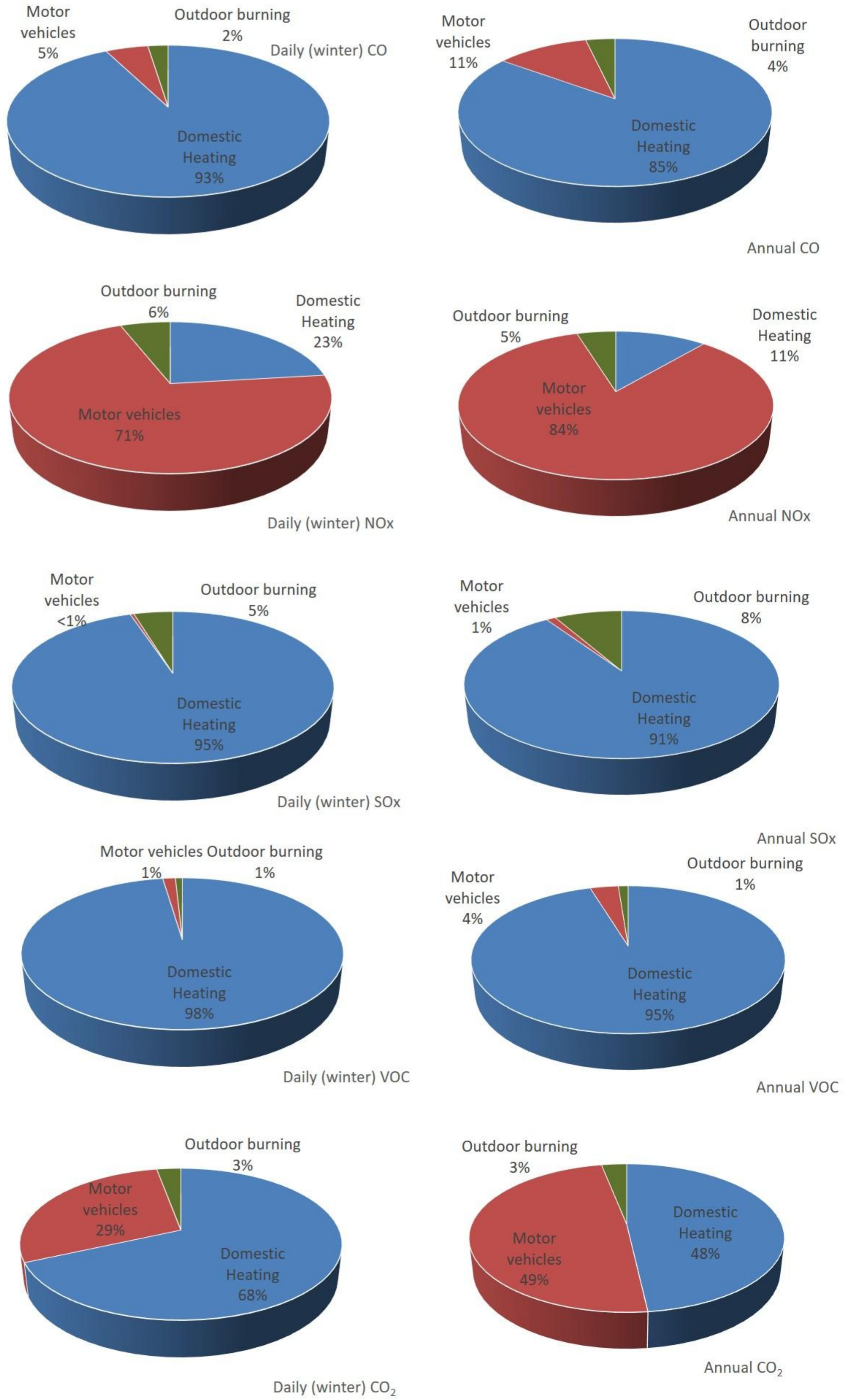



**Figure 8.16: Relative contribution of sources to daily winter contaminant emissions in Milton.**

**Table 8.7: Monthly variations in daily $PM_{10}$ emissions in Milton.**

| | Domestic heating | | Outdoor burning | | Industry | | Motor vehicles | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | kg/day | % | kg/day | % | kg/day | % | kg/day | % | kg/day |
| January | 1 | 14% | 3 | 50% | 0 | 0% | 2 | 36% | 6 |
| February | 3 | 38% | 3 | 36% | 0 | 0% | 2 | 26% | 9 |
| March | 8 | 61% | 3 | 22% | 0 | 0% | 2 | 17% | 14 |
| April | 29 | 84% | 3 | 9% | 0 | 0% | 2 | 7% | 34 |
| May | 66 | 93% | 3 | 4% | 0 | 0% | 2 | 3% | 71 |
| June | 82 | 92% | 5 | 5% | 0 | 0% | 2 | 3% | 89 |
| July | 81 | 92% | 5 | 5% | 0 | 0% | 2 | 3% | 89 |
| August | 78 | 92% | 5 | 6% | 0 | 0% | 2 | 3% | 85 |
| September | 25 | 83% | 3 | 9% | 0 | 0% | 2 | 8% | 30 |
| October | 15 | 75% | 3 | 14% | 0 | 0% | 2 | 12% | 20 |
| November | 5 | 52% | 3 | 26% | 0 | 0% | 2 | 22% | 10 |
| December | 3 | 33% | 3 | 39% | 0 | 0% | 2 | 28% | 8 |
| Total kg year | 12118 | 85% | 1255 | 9% | 0 | 0% | 832 | 6% | 14206 |

**Table 8.8: Daily contaminant emissions from all sources in Milton (winter average).**

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Domestic home heating | 81 | 342 | 1028 | 4328 | 7 | 31 | 6 | 27 |
| Transport | 2 | 10 | 57 | 239 | 23 | 96 | 0 | 0 |
| Industry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Outdoor burning | 5 | 22 | 27 | 113 | 2 | 8 | 0 | 1 |
| Total | 89 | 374 | 1112 | 4680 | 32 | 135 | 7 | 29 |
| | **VOC** | | **$CO_2$** | | **$PM_{2.5}$** | | | |
| | **kg** | **g/ha** | **tonnes** | **kg/ha** | **kg** | **g/ha** | | |
| Domestic home heating | 300 | 1264 | 22 | 94 | 80 | 338 | | |
| Transport | 5 | 20 | 9 | 40 | 1 | 6 | | |
| Industry | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Outdoor burning | 3 | | 1 | | 5 | | | |
| Total | 308 | 1295 | 33 | 137 | 87 | 366 | | |

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# APPENDIX A: URBAN AREA BOUNDARIES

Figure A1 shows the area of Arrowtown based on the SA2 area (Arrowtown brown border) and with CAU southern extent illustrated by a blue border. The exclusion of SA1 areas of 7036811 and 7036812 aligns the SA2 (2023) area and CAU (2013) area exactly. Figure A2 compares the boundaries for Mosgiel. The Mosgiel urban area has expanded since the 2016 inventory and now includes additional areas. Alignment with the previous boundaries is not feasible but emission estimates should be indicative of changes in the urban area. The exception is the area of Bush Road which could potentially have been included in the previous inventory. For Milton (Figure A3) the SA2 (2023) boundary and the CAU (2013) boundary are similar once the SA1 area of 7029058 is removed. There is an area of rural land included in the SA2 boundary that is excluded from the CAU but this will have minimal impact on the assessment.

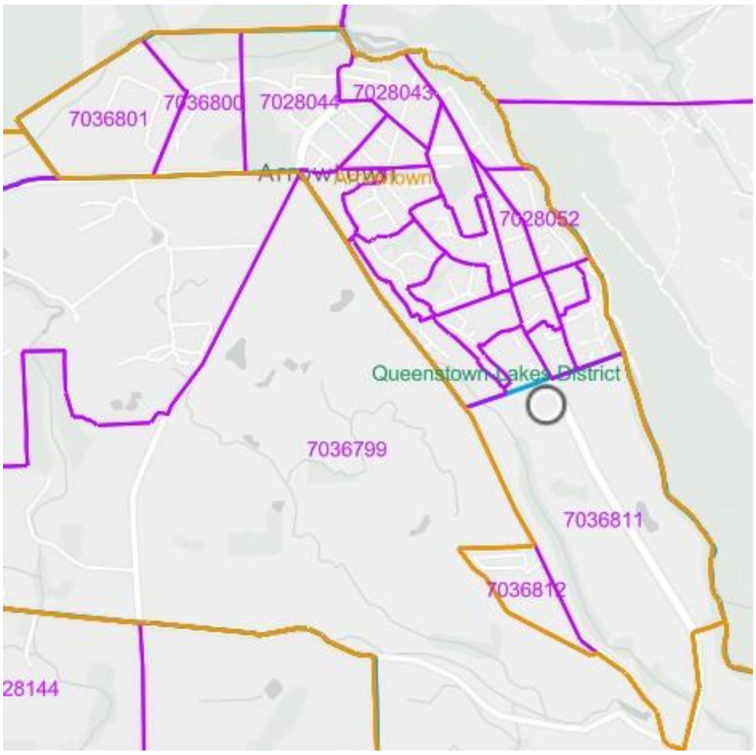


**Figure A1: Comparison of SA2 (2023) and CAU (2013) boundaries for Arrowtown.**

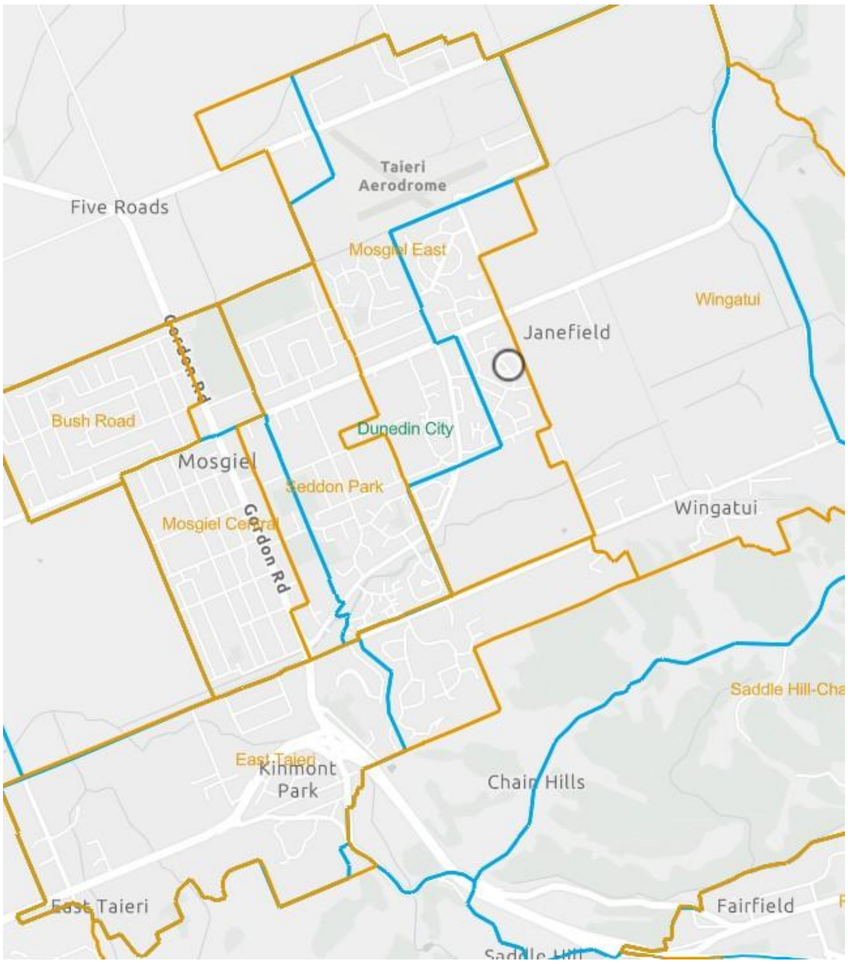


Figure A2: Comparison of SA2 (2023) and CAU (2013) boundaries for Mosgiel.

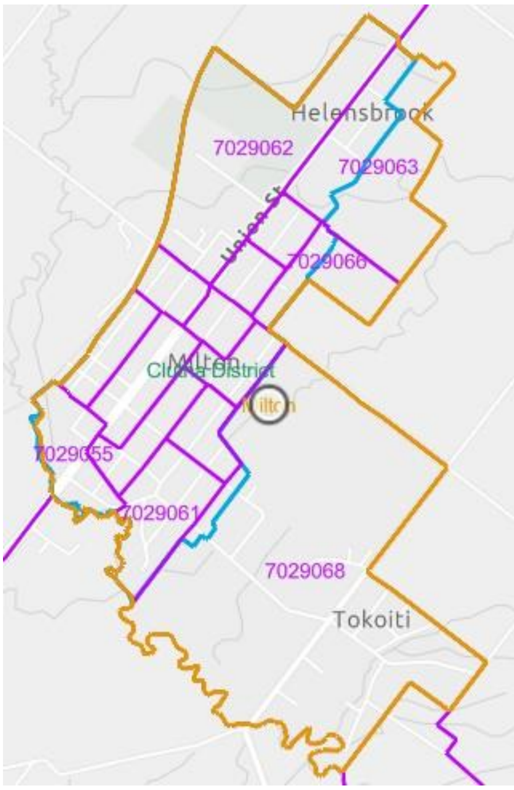


**Figure A3: Comparison of SA2 (2023) and CAU (2013) boundaries for Milton**

# APPENDIX B: HOME HEATING QUESTIONNAIRE

Good morning / afternoon/evening, I'm _________ calling from Symphony Research on behalf of the Otago Regional Council.
We are currently undertaking an anonymous survey in ------- on home heating methods. Can you please confirm you live in ---------?
May I please speak to an adult in your household who knows about how you heat your home?

**WHEN SPEAKING TO REQUIRED RESPONDENT** We wish to know what you use to heat your main living area during a typical year. The survey will take about 5-7 minutes depending on your answers. Is it a good time to talk to you now?

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

1. No

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

1. Yes
2. No
99. Don't Know

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?

1. Yes
2. No
99. Don't Know

2b.) Is it flued or unflued gas heating? If necessary: A flued gas heating appliance will have an external vent or chimney.

1. Flued
2. Unflued
3. Both
99. Don't know

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

1. Yes
2. No
99. Don't Know

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

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

99. Don't know

3c.) How many days per week would you typically use your wood burner during?

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

1. [DAYS]
99. Don't know/Refused

3f.) How old is your wood burner? *Read Out*

1. 20 years+ (pre 2006)
2. Between 15 and 20 years old
3. Between 5 and 15 years old
4. Less than 5 years old
99. Don't know/Refused

3f1.) Is your burner an ultra-low emission burner (ULEB)? **Interviewer note:** A ULEB is burner tested to the highest emission standard in NZ (if no go to question 3f2)

1. Yes
2. No
99. Don't know

3 f2 Do you know what is the make and model of your wood burner, if yes, can you please tell me:
Make:
Don’t know

Model
Don’t know

h.) How many pieces of wood do you use per day on an average winters day? (interviewer note – day means day/night or full 24-hour period)

1. [PCS]
99. Don't know

3h2.) *(ask only if they used their wood burner during non-winter months SEPT TO APRIL Q3B)* How many pieces of wood do you use per day during the other months? **Interviewer note:** By other months we mean September to April

1. [PCS]
99. Don't know

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

1. [$m^3$]

99. Don't know

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

1. Buy wood
2. Receive free of charge
3. Both

3k.) What percentage of wood would be bought?

1. [%]

99. Don't know

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? (This includes incinerators, pot belly stoves, McKay space heaters etc but does not include open fires.)

1. Yes
2. No

99. Don't Know

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 |

99. Don't know

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. [DAYS]

99. Don't know/ Rather not say

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

1. Yes
2. No

99. Don't know

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

1. [PCS]

99. Don't know

4h.) How many pieces of-wood do you use per day during the other months? **Interviewer note:** By other months we mean September to April

1. [PCS]

99. Don't know

4i.) In a typical year, how much wood would you use per year on your multi fuel burner? *(Record wood use in cubic metres)* **Interviewer 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

1. [m³]
99. Don't know

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

1. Yes
2. No
99. Don't know

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

1. [BUCKETS]
99. Don't know

4n.) How many buckets of coal do you use per day during the other months? **Interviewer note:** By other months we mean September to April

1. [BUCKETS]
99. Don't know

5a.) 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?

1. Yes
2. No
99. Don't know

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

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

99. Don't know

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 |

1. [DAYS]
99. Don't know

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

1. Yes
2. No
99. Don't know

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

1. [PCS]

99. Don't know

5h.) How many pieces of wood do you use per day during the other months? **Interviewer note:** By other months we mean September to April

1. [PCS]

99. Don't know

5i.) In a typical year, how much wood would you use per year on your open fire? *(Record wood use in cubic metres)* **Interviewer 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

1. [$m^3$]

99. Don't know

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

1. Yes
2. No

99. Don't know

5k.) 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

1. [BUCKETS]

99. Don't know

5l.) How many buckets of coal do you use per day during the other months? **Interviewer note:** By other months we mean September to April

1. [BUCKETS]

99. Don't know

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

1. Receive free of charge
2. Both

5n.) What percentage would be bought?

1. [%]

99. Don't know

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

1. Yes

2. No
99. Don't know

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

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

99. Don't know

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 |

1. [DAYS]
99. Don't know/ Rather not say

6f.) How many kilograms of pellets do you use per day on average on a typical winters day?
1. [KGs]
99. Don't know/ Rather not say

6h.)*)* How many kgs of pellets do you use per day during the other months? **Interviewer note:** By other months we mean September to April
1. [KGs]
99. Don't know

6i.) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?
1. [KGs]
99. Don't know

7a.) Do you use any other heating system in your MAIN living area during a typical year?
1. Yes
2. No
99. Don't know

7b.) What type of heating system do you use Diesel or oil burner
1. Wood fired boiler/ central heating
99. Other - specify
100. Don't know/ Rather not say

7e.) How much diesel/oil do you use per year?
1. [Litres]
99. Don't know

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) **Interviewer note:** pot belly stoves, chip heaters or wood burners are not wood fired cookers

1. Yes
2. No
99. Don't know

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 |

99. Don't know

8c.) How many days per week would you use your wood fuelled cooker during? *(Ask of the months mentioned at Q8b, Make sure only number in datafile e.g. '7', 'not 7 days')*

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

1. [DAYS]
99. Don't know/ Rather not say

8e.) In a typical year, how many pieces of wood do you use on an average winter's day on your wood fuelled cooker? Interviewer note: Winter is defined as May to August inclusive.

1. [PCS]
99. Don't know

9. Does your home have insulation? [MR]

*If yes:* Where do you have insulation in your home?

*If no select none*

1. Ceiling
2. Under floor
3. Wall
4. Cylinder wrap
5. Double glazing
98. Other
97. None
99. Don't know

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

1. Yes
2. No
99. Don't know

10b.) How many days would you burn waste or garden rubbish outdoors during winter? Interviewer note: Winter is defined as June, July and August?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

10c.) How many days would you burn waste or garden rubbish outdoors during Spring? Interviewer note: Spring is defined as September to November?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

10d.) How many days would you burn waste or garden rubbish outdoors during Summer? Interviewer note: Summer is defined as December to February?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

10e.) How many days would you burn waste or garden rubbish outdoors during Autumn? Interviewer note: Autumn is defined as March to May.

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

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

1. RECORD CUBIC METRES
99. Don't know

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

11a) If yes would that be a

- ☐ Wood fired bbq
- ☐ Pizza oven
- ☐ Brazier
- ☐ Outdoor open fire

11b) How many days would you use a pizza oven, brazier or outdoor open fire during winter? Interviewer note: Winter is defined as June, July and August?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

11c.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor open fire during Spring? Interviewer note: Spring is defined as September to November?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

11d.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor fire during Summer? Interviewer note: Summer is defined as December to February?

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

11e.) How many days would you use a wood fired bbq, pizza oven, brazier or outdoor fire during Autumn? Interviewer note: Autumn is defined as March to May.

1. [RECORD NUMBER OF DAYS]
97. None
99. Don't know

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

1. [PCS]

99. Don't know

12) Do you use a wood fired hot tub

12) How many days would you use a wood fired hot tub during winter? Interviewer note: Winter is defined as June, July and August?

2. [RECORD NUMBER OF DAYS]
98. None
100. Don't know

11c.) How many days would you use a wood fired hot tub during Spring? Interviewer note: Spring is defined as September to November?

2. [RECORD NUMBER OF DAYS]
98. None
100. Don't know

11d.) How many days would you use a wood fired hot tub during Summer? Interviewer note: Summer is defined as December to February?

2. [RECORD NUMBER OF DAYS]
98. None
100. Don't know

11e.) How many days would you use a wood fired hot tub during Autumn? Interviewer note: Autumn is defined as March to May.

2. [RECORD NUMBER OF DAYS]
98. None
100. Don't know

How many pieces of wood would you use on your wood fired hot tub per use

1. [PCS]

99. Don't know

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

D6. Do you own your home or rent it?

1. Own
2. Rent
99. Don't know/ Refused

D7. Approximately how old is your home?

1. 10 years or less
2. 11 to 20 years
3. 21 to 40 years
4. 41 years+
99. Don't know/ Refused

# APPENDIX C: 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 et al., 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 ultra low emissions burners (ULEB) was selected based on real life testing results detailed in (Webley, 2023). An emission factor of 2 g/kg was selected for $PM_{10}$ and $PM_{2.5}$ based on these data with other contaminant emissions based on a post 2006 wood burner.

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 publicly available form.