Environment Waikato Technical Report 2006/43

# Air Emission Inventory – Te Awamutu, Turangi and Ngaruawahia 2006

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# Abstract

Air quality monitoring and other air quality investigations are required to better characterise the extent of NES compliance within the Region. Air quality monitoring in the Waikato Region has been carried out in Hamilton, Tokoroa, Taupo, Te Kuiti and Matamata. Concentrations of $PM_{10}$ in excess of National Environment Standards (NES) have been observed in all of these towns excluding Matamata. Emission inventory studies, which estimate the quantity of $PM_{10}$ and other contaminants discharged into air and the relative contribution of different sources, have been carried out in these areas.

This report outlines the results of an air emission inventory carried out in the areas of Te Awamutu, Turangi and Ngaruawahia. Contaminants included were: particles ($PM_{10}$ and $PM_{2.5}$), carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide. This report primarily focuses on emissions of particles ($PM_{10}$), as the only contaminant in breach of the NES in the Waikato Region. Sources included in the inventory were: domestic heating, motor vehicles, industrial and commercial activities, and outdoor rubbish burning.

A survey of household heating methods and the frequency of outdoor rubbish burning was carried out for each of the areas. Results showed that wood burners were the main method of heating used in all areas and were used by 27%, 64% and 41% of households in Te Awamutu, Turangi and Ngaruawahia respectively. Other common heating methods included electricity and gas. Many households used more than one method to heat the main living area of their home.

The main source of $PM_{10}$ emissions in all three areas during the winter was domestic home heating, which accounted for 59%, 89% and 85% of total emissions in Te Awamutu, Turangi and Ngaruawahia respectively. The other significant contributor to $PM_{10}$ emissions in Te Awamutu were outdoor burning (23%) and industry (15%). The industrial contribution to contaminant concentrations is likely to be much less than the contribution to emissions because industrial discharge is via high stacks that promote more effective dispersion of contaminants. Outdoor rubbish burning contributed 7% in Turangi and 12% in Ngaruawahia. Industrial emissions in both these areas were negligible.

# 1 Introduction

Air quality monitoring in the Waikato Region has been carried out in Hamilton, Tokoroa, Taupo, Te Kuiti and Matamata. Concentrations of $PM_{10}$ in excess of National Environment Standards (NES) have been observed in all of these towns excluding Matamata. The NES specifies that air quality monitoring be carried out in all airsheds where $PM_{10}$ concentrations are likely to exceed the NES.

In areas where the NES is not met by 2013, Environment Waikato will be unable to grant resource consents for discharges to air. In addition, between September 2005 and 2013 consents for discharges to air can only be granted if Councils can demonstrate a “straight-line path” to compliance that will not be impinged on by the granting of the consent.

Emission inventory studies, which estimate quantity of $PM_{10}$ and other contaminants discharged into air and the relative contribution of different sources, have been carried out in a number of urban areas of the Waikato, including all areas where monitoring has been conducted. In addition to providing a useful tool for evaluating the effectiveness of different management measures in reducing pollution, these studies can assist with prioritising areas for monitoring and the setting of straight-line paths should monitoring indicate non-compliance with the NES.

Other variables involved in setting a straight or curved-line path to compliance include:
1. Monitoring data to determine the starting point; that is the extent to which existing concentrations exceed the NES.
2. Meteorological data and airshed modelling to determine the relationship between emissions and concentrations.

The latter variable is used to determine the relationship between emissions and concentrations. This modelling indicates the relationship between the reduction required in $PM_{10}$ concentrations relative to the reduction required in emissions. Many areas do not have detailed modelling data illustrating the relationship between 24-hour emissions and concentrations of $PM_{10}$. One detailed study for Christchurch suggests that the relationship is linear in that a 1% reduction in emissions would result in a 1% reduction in concentrations (Gimson & Fisher, 1997). Thus in the absence of modelling information for other areas, the relationship has often been assumed to be linear.

This report details the results of an air emission inventory carried out for Te Awamutu, Turangi and Ngaruawahia for 2006. The purpose of the inventory is to estimate the amount of $PM_{10}$ discharged into the air in these areas on a worst-case and average winter’s night, the relative contribution from different sources and to provide information from which management measures to reduce $PM_{10}$ can be evaluated.

# 2 Inventory Design

The inventory has been designed with a focus on emissions of $PM_{10}$, although it does include estimates of emissions of other contaminants. With the exception of Hamilton and monitoring of benzene in Tokoroa, no monitoring of other contaminants has been carried out by Environment Waikato. It is unlikely, based on monitoring carried out in other areas of New Zealand, that concentrations of other contaminants will exceed the NES or air quality guidelines. One exception may be the air quality guideline for benzo(a)pyrene (BaP) as concentrations of this contaminant have been found to be high in areas where $PM_{10}$ concentrations are elevated as a result of emissions from domestic home heating. No NES has been proposed for BaP at this stage.

## 2.1 Selection of sources

The inventory includes detailed estimates of emissions from domestic heating, outdoor burning, motor vehicles and industry. Emissions from a number of other minor sources are also discussed in the report.

## 2.2 Selection of contaminants

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

Emissions of $PM_{10}$, CO, SOx and NOx are included as these contaminants comprise class one air quality indicators as described by MfE (1994) and are included in the NES because of their potential for adverse health impacts. Carbon dioxide is typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas $CO_2$ emissions. The finer $PM_{2.5}$ size fraction was also included, as this size fraction is also of interest from a health impacts perspective.

Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. These have been retained in the inventory to allow an assessment of emissions of precursors to ozone should future monitoring indicate concentrations of concern.

## 2.3 Selection of areas

The study areas were based on census area units with the Te Awamutu area including Te Awamutu West, Te Awamutu Central, Te Awamutu East and Te Awamutu South. Both Turangi and Ngaruawahia were based on the single census area unit areas named accordingly.

## 2.4 Temporal distribution

Most data were collected based on wintertime daily average emissions. Domestic heating data were collected based on average and worst-case wintertime emissions. For most sources, data were also collected by month of the year to provide an estimate of the relative contributions of different sources to annual average $PM_{10}$ concentrations. No differentiation was made for weekday and weekend emissions, as variances are likely to be minimal for most sources. One exception is outdoor rubbish burning which may occur with greater frequency during the weekend.

Limited time of day breakdowns were obtained for the data. The main focus of the study is on daily $PM_{10}$ emissions during the winter period as this is when concentrations invariably exceeded the ambient air quality guidelines and NES for $PM_{10}$ (24-hour average). In addition, the inclusion of an annual average guideline for $PM_{10}$ in the ambient air quality guidelines (MfE, 2002) increases the importance of including emission estimates for different seasons. The inventory has therefore also been designed for the collection of seasonal data.

Data are presented for four different time of day periods. For domestic heating these are based on time of day distributions from the 2001 Hamilton domestic heating study as it is not possible to collect information on both time of day and seasonal variations in fuel use, owing to issues of survey length. The time of day breakdown is as follows:

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

# 3 Domestic heating

## 3.1 Methodology

The activity data for domestic heating was collected using a telephone survey of 245 to 280 households within each study area during the winter of 2006. The survey was carried out by Digipol during late May and early June 2006. The number of households within each study area was based on 2001 census data for occupied dwellings extrapolated for 2006 based on Statistics New Zealand population projections for the districts of Waipa (Te Awamutu), Taupo (Turangi) and Waikato (Ngaruawahia). A copy of the survey questionnaire is shown in Appendix one. Summary data for the survey and study area are shown in Table 3-1.

**Table 3-1: Home heating survey area and sample details**

| | Households | Sample size | Area (ha) | Sample error |
|---|---|---|---|---|
| Te Awamutu | 3731 | 280 | 731 | 5.6% |
| Turangi | 1332 | 245 | 969 | 5.6% |
| Ngaruawahia | 1605 | 256 | 756 | 5.6% |

Home heating methods were classified as electricity, open fires, wood burners 10 years or older (pre 1996), wood burners 5-10 years old (1996-2001), wood burners less than 5 years old (post 2001), multi fuel burners, gas burners and oil burners.

Emission factors were applied to the results of the home heating survey to provide an estimate of emissions for the urban areas of Te Awamutu, Turangi and Ngaruawahia. The emission factors used to estimate emissions from domestic heating are shown in Table 3-2. These were reviewed for 2006 to incorporate results from more recent burner testing. As for previous inventories carried out for the Waikato Region, the open fire and multi fuel burner factors were based on the Christchurch 1999 emission factors. The basis for these is detailed in Appendix B. The older wood burner emission rates were based on testing of older wood burners “in situ” in Tokoroa during 2005 as detailed in Wilton and Smith, 2006, with adjustments for wet wood. The gas and oil $PM_{10}$ emission factors have also been revised as a result of more recent testing in New Zealand (Scott, 2004).

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

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

**Table 3-2: Emission factors for domestic heating methods**

| | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | $SO_2$ g/kg | VOC g/kg | $CO_2$ g/kg | $PM_{2.5}$ g/kg |
|---|---|---|---|---|---|---|---|
| Open fire - wood | 10 | 100 | 1.6 | 0.2 | 30 | 1600 | 10 |
| Open fire - coal | 21 | 80 | 4 | 5.0 | 15 | 2600 | 12 |
| Pre 1996 burners | 11 | 110 | 0.5 | 0.2 | 33 | 1800 | 11 |
| 1996-2001 burners | 6.5 | 65 | 0.5 | 0.2 | 19.5 | 1800 | 6.5 |
| Post 2001 burners | 6 | 60 | 0.5 | 0.2 | 18 | 1800 | 6 |
| Multi-fuel[1] - wood | 13 | 130 | 0.5 | 0.2 | 39 | 1600 | 13 |
| Multi-fuel[1] - coal | 28 | 120 | 1.2 | 3.0 | 15 | 2600 | 12 |
| Oil | 0.3 | 0.6 | 2.2 | 3.8 | 0.25 | 3200 | 0.7 |
| Gas | 0.03 | 0.18 | 1.3 | 7.6E-09 | 0.2 | 2500 | 0.6 |

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

One of the assumptions underlying the emissions calculations is the average weight for a log of wood. Average log weights used for inventories in New Zealand have included 1.6 kg, 1.4 kg and more recently 1.9 kg. The latter value is based on a survey of 219 households in Christchurch during 2002 and represents the most comprehensive assessment of average fuel weight. A recent burner emission testing programme carried out in Tokoroa during 2005 gave an average log weight of 1.3 kilograms. The sample size (pieces of wood weighed) for this study was 845. However, these were spread across only 12 households so it is uncertain how representative of the Tokoroa population a fuel weight of 1.3 kilograms per log might be.

There is some potential for fuel size to vary by region although factors such as appliance design should limit these variations. The first three average fuel weight values noted above were derived based on measurements carried out in Christchurch. In addition, Environment Canterbury carried out some survey work of the size of chopped wood at five wood suppliers in Christchurch. A total of 132 logs were weighed and gave an average fuel weight of 2.3 kilograms per log (Scott, 2006, pers. comm.). The extent to which this represents wood weight used by households in Christchurch is uncertain, as further chopping of wood by the householder is possible.

Because of the uncertainty surrounding the applicability of fuel weights derived for Christchurch to Te Awamutu, Turangi and Ngaruawahia and the lower sized wood from the more local Tokoroa study (albeit a smaller household sample size) a fuel weight of 1.6 kilograms per log was used for this study.

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

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

Where:

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

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.6 kg.
- The average weight of a bucket of coal is 9 kg.

## 3.2 Home heating methods

### 3.2.1 Te Awamutu

Electricity was the main heating method in Te Awamutu for 2006 with 48% of households using this method to heat their main living area. Gas was the second most common method (33%) followed by wood burners (27%). Table 3-3 shows that households rely on more than one method of heating their main living area during the winter months.

Wood burning is the most common fuel for households using solid fuel heating methods in Te Awamutu with 36% of households using this fuel. About 26 tonnes of wood is burnt on an average winter's night. In comparison coal is used by around 2% of Te Awamutu households and less than half a tonne is burnt per night.

Only a small proportion of Te Awamutu residents use open fires (4%) or multi fuel burners (5%) to heat their main living area.

**Table 3-3: Home heating methods and fuels in Te Awamutu**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | HH | t/day | % |
| **Electricity** | 48% | 1,799 | | |
| **Total Gas** | 33% | 1,239 | 1 | 2% |
| **Flued gas** | 19% | 698 | | |
| **Unflued gas** | 15% | 541 | | |
| **Oil** | 1% | 27 | - | 0% |
| **Open fire** | 4% | 133 | - | 0% |
| **Open fire - wood** | 4% | 133 | 5 | 19% |
| **Open fire - coal** | 1% | 27 | 0.1 | 1% |
| **Total Wood burner** | 27% | 999 | 18 | 67% |
| **Pre 1996 wood burner** | 11% | 406 | 8 | 21% |
| **1996-2001 wood burner** | 9% | 328 | 6 | 27% |
| **Post 2001 wood burner** | 7% | 265 | 5 | 18% |
| **Multi fuel burners** | 5% | 200 | | |
| **Multi fuel burners-wood** | 5% | 200 | 3 | 10% |
| **Multi fuel burners-coal** | 1% | 40 | 0.3 | 1% |
| **Pellet burners** | 0% | - | - | 0% |
| **Total wood** | 36% | 1,333 | 26 | 96% |
| **Total coal** | 2% | 67 | 0.4 | 2% |
| **Total** | | 3,731 | 27 | |

### 3.2.2 Turangi

In Turangi, wood burners were the most commonly used home heating method during 2006 with 64% of households using this method to heat their main living area. Electricity and gas were the second most common methods (33% and 25%). Table 3-4 shows that households rely on more than one method of heating their main living area during the winter months.

The most common fuel for households using solid fuel heating methods in Turangi was wood with 76% of households using this fuel. About 19 tonnes of wood is burnt on an average winter's night in Turangi. Coal was used by around 2% of Turangi households with less than 100 kilograms being burnt per night.

Around 6% of Turangi households use open fires and 6% use multi fuel burners to heat their main living area.

**Table 3-4: Home heating methods and fuels in Turangi**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | HH | t/day | % |
| **Electricity** | 33% | 427 | | |
| **Total Gas** | 25% | 327 | 0.1 | 1% |
| **Flued gas** | 5% | 70 | | |
| **Unflued gas** | 20% | 257 | | |
| **Oil** | 2% | 26 | 0.0 | 0% |
| **Open fire** | 6% | 79 | | |
| **Open fire - wood** | 6% | 74 | 1 | 8% |
| **Open fire - coal** | 0% | - | - | 0% |
| **Total Wood burner** | 64% | 829 | 17 | 84% |
| **Pre 1996 wood burner** | 24% | 304 | 6 | 28% |
| **1996-2001 wood burner** | 18% | 237 | 5 | 29% |
| **Post 2001 wood burner** | 22% | 287 | 6 | 27% |
| **Multi fuel burners** | 6% | 74 | | |
| **Multi fuel burners-wood** | 6% | 74 | 1 | 6% |
| **Multi fuel burners-coal** | 2% | 21 | 0.1 | 1% |
| **Pellet burners** | 0% | 5 | 0.1 | 0% |
| **Total wood** | 76% | 976 | 19 | 98% |
| **Total coal** | 2% | 21 | 0 | 1% |
| **Total** | | 1,293 | 20 | |

### 3.2.3 Ngaruawahia

Wood burners and gas heaters were the most commonly used home heating methods in Ngaruawahia during 2006 with 41% and 37% of households using these methods respectively. Electricity was the next most common method with 29% of households using electricity in their main living area. Table 3-5 shows that households rely on more than one method of heating their main living area during the winter months.

The most common fuel for households using solid fuel heating methods in Ngaruawahia was wood with 61% of households using this fuel. About 27 tonnes of wood is burnt on an average winter's night in Ngaruawahia. Coal use is more common in Ngaruawahia than in Te Awamutu or Turangi with around 10% of Ngaruawahia households using this fuel and burning around two tonnes per night.

Open fire and multi fuel burner use in Ngaruawahia is higher than Turangi and Te Awamutu with 9% of households using open fires and 12% of households using multi fuel burners to heat their main living area.

**Table 3-5: Home heating methods and fuels in Ngaruawahia**

| | Heating methods | | Fuel Use | |
|---|---|---|---|---|
| | % | HH | t/day | % |
| **Electricity** | 29% | 470 | | |
| **Total Gas** | 37% | 589 | 1 | 2% |
| **Flued gas** | 10% | 162 | | |
| **Unflued gas** | 27% | 427 | | |
| **Oil** | 2% | 25 | 0.0 | 0% |
| **Open fire** | 9% | 138 | | |
| **Open fire - wood** | 8% | 125 | 4 | 14% |
| **Open fire - coal** | 3% | 44 | 0 | 2% |
| **Total Wood burner** | 41% | 658 | 16 | 49% |
| **Pre 1996 wood burner** | 17% | 277 | 7 | 19% |
| **1996-2001 wood burner** | 11% | 172 | 4 | 18% |
| **Post 2001 wood burner** | 13% | 209 | 5 | 12% |
| **Multi fuel burners** | 12% | 188 | | |
| **Multi fuel burners-wood** | 12% | 188 | 7 | 27% |
| **Multi fuel burners-coal** | 7% | 113 | 2 | 7% |
| **Pellet burners** | 0% | - | - | 0% |
| **Total wood** | 61% | 972 | 27 | 90% |
| **Total coal** | 10% | 157 | 2 | 8% |
| **Total** | | 1,605 | 30 | |

# 4 Emissions from domestic heating

## 4.1 Te Awamutu

The greatest amount of $PM_{10}$ from domestic heating during the winter comes from pre 1996 wood burners (33%) and open fires (21%). Multi fuel burners contribute around 16% (Figure 4-1).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-1 and Table 4-2. The emission estimates indicate the following:

- Around 315 kilograms of $PM_{10}$ are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime $PM_{10}$ emissions are less at around 245 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this $PM_{10}$ is in the finer $PM_{2.5}$ size fraction.
- The majority (95%) of the wintertime domestic $PM_{10}$ emissions come from the burning of wood with 5% from the burning of coal.

Monthly variations in appliance use and average days per week used are shown in Figure 4-2 and Figure 4-3. Table 4-3 shows seasonal variations in contaminant emissions. The majority of the annual $PM_{10}$ from domestic home heating occurs during the months June, July and August (Figure 4-4).

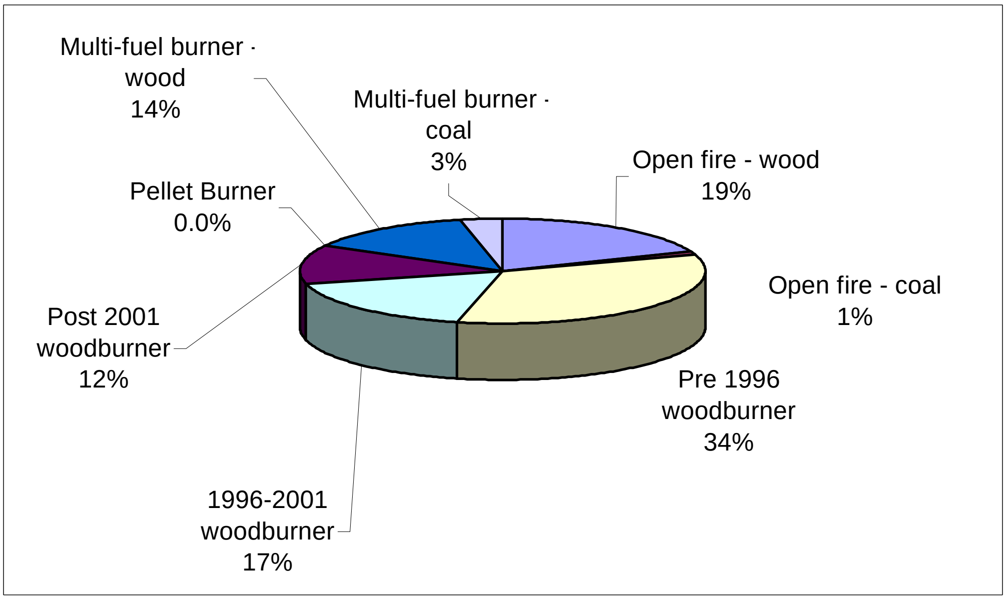


**Figure 4-1: Relative contribution of different heating methods to average daily $PM_{10}$ (July) from domestic heating in Te Awamutu**

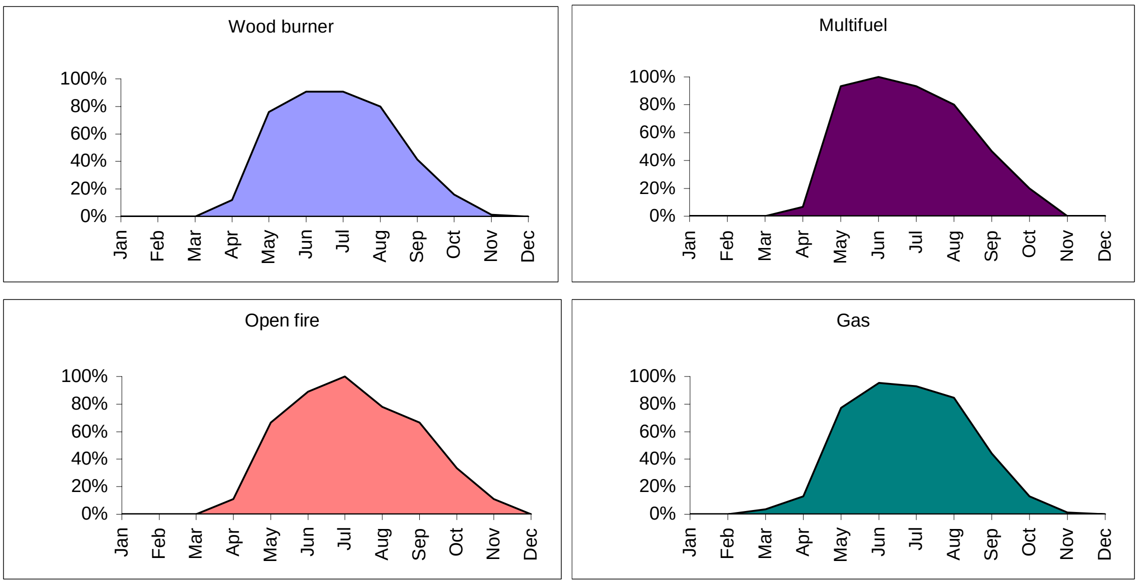


**Figure 4-2: Monthly variations in appliance use in Te Awamutu**

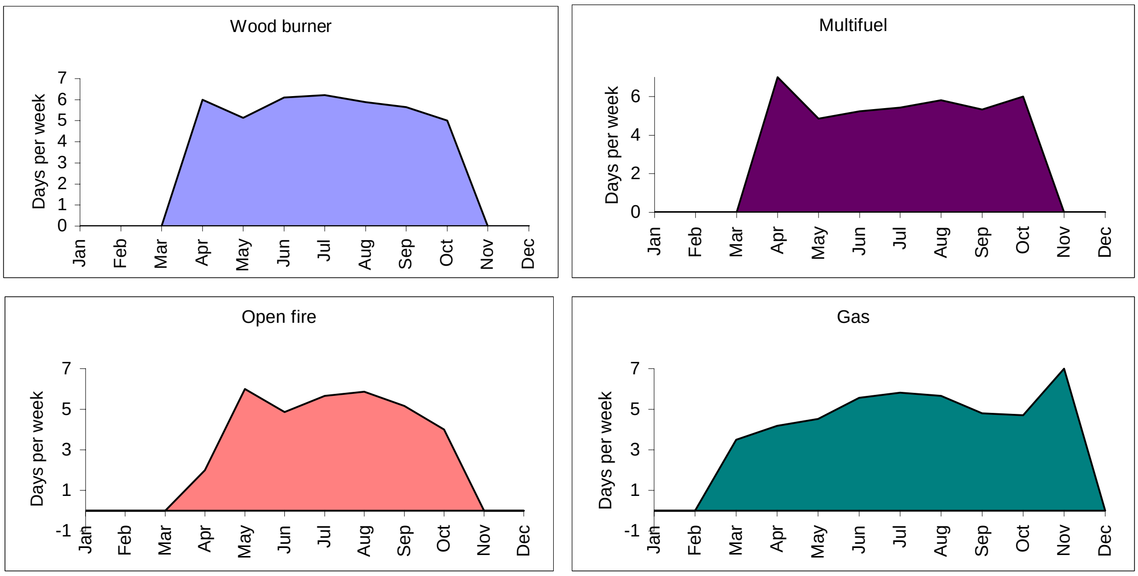


**Figure 4-3: Average number of days per week appliances are used in Te Awamutu per month**

**Table 4-1: Te Awamutu worst-case winter daily domestic heating emissions by appliance type**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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** | 4.8 | 14% | 48 | 66 | 15% | 481 | 658 | 16% | 8 | 11 | 32% | 1 | 1 | 11% | 144 | 197 | 16% | 8 | 11 | 14% | 48 | 66 | 16% |
| **Open fire - coal** | 0.2 | 1% | 5 | 7 | 2% | 19 | 26 | 1% | 1 | 1 | 4% | 1 | 2 | 14% | 4 | 5 | 0% | 1 | 1 | 1% | 3 | 4 | 1% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 9.3 | 28% | 102 | 140 | 32% | 1025 | 1402 | 33% | 5 | 6 | 20% | 2 | 3 | 21% | 307 | 421 | 34% | 15 | 20 | 27% | 102 | 140 | 33% |
| **1996-2001 wood burner** | 7.5 | 22% | 53 | 72 | 17% | 527 | 720 | 17% | 4 | 5 | 16% | 2 | 2 | 17% | 158 | 216 | 17% | 12 | 16 | 22% | 53 | 72 | 17% |
| **Post 2001 wood burner** | 6.1 | 18% | 37 | 50 | 12% | 365 | 500 | 12% | 3 | 4 | 13% | 1 | 2 | 14% | 110 | 150 | 12% | 10 | 13 | 18% | 37 | 50 | 12% |
| **Pellet Burner** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 4.7 | 14% | 60 | 83 | 19% | 605 | 827 | 20% | 2 | 3 | 10% | 1 | 1 | 11% | 181 | 248 | 20% | 7 | 10 | 13% | 60 | 83 | 20% |
| **Multi fuel burner – coal** | 0.4 | 1% | 10 | 14 | 3% | 43 | 59 | 1% | 0 | 1 | 2% | 1 | 1 | 12% | 5 | 7 | 1% | 1 | 1 | 2% | 6 | 8 | 2% |
| **Gas** | 0.7 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 4% | 0 | 0 | 0% | 0 | 0 | 0% | 2 | 3 | 3% | 0 | 0 | 0% |
| **Oil** | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 32 | 96% | 300 | 411 | 95% | 3003 | 4107 | 98% | 21 | 29 | 90% | 6 | 9 | 74% | 901 | 1232 | 99% | 52 | 71 | 94% | 300 | 411 | 97% |
| **Total Coal** | 1 | 2% | 15 | 21 | 5% | 62 | 85 | 2% | 1 | 2 | 6% | 2 | 3 | 26% | 9 | 12 | 1% | 2 | 2 | 3% | 9 | 12 | 3% |
| **Total** | **34** | | **315** | **431** | | **3065** | **4193** | | **24** | **33** | | **9** | **12** | | **910** | **1245** | | **55** | **76** | | **309** | **423** | |

**Table 4-2: Te Awamutu average winter daily domestic heating emissions by appliance type**

| | 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** | 4.6 | 17% | 46 | 63 | 19% | 463 | 633 | 19% | 7 | 10 | 38% | 1 | 1 | 14% | 139 | 190 | 20% | 7 | 10 | 17% | 46 | 63 | 19% |
| **Open fire - coal** | 0.1 | 1% | 3 | 4 | 1% | 11 | 15 | 0% | 1 | 1 | 3% | 1 | 1 | 10% | 2 | 3 | 0% | 0 | 0 | 1% | 2 | 2 | 1% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 7.5 | 28% | 83 | 113 | 34% | 825 | 1129 | 35% | 4 | 5 | 19% | 2 | 2 | 22% | 248 | 339 | 35% | 12 | 16 | 28% | 83 | 113 | 34% |
| **1996-2001 wood burner** | 6.1 | 23% | 42 | 58 | 17% | 424 | 580 | 18% | 3 | 4 | 15% | 1 | 2 | 18% | 127 | 174 | 18% | 10 | 13 | 22% | 42 | 58 | 18% |
| **Post 2001 wood burner** | 4.9 | 18% | 29 | 40 | 12% | 294 | 403 | 12% | 2 | 3 | 13% | 1 | 1 | 15% | 88 | 121 | 12% | 8 | 11 | 18% | 29 | 40 | 12% |
| **Pellet Burner** | 0.0 | 0% | 0.0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 2.6 | 10% | 33 | 45 | 14% | 332 | 455 | 14% | 1 | 2 | 7% | 1 | 1 | 8% | 100 | 136 | 14% | 4 | 6 | 9% | 33 | 45 | 14% |
| **Multi fuel burner – coal** | 0.3 | 1% | 9 | 12 | 3% | 36 | 50 | 2% | 0 | 0 | 2% | 1 | 1 | 14% | 5 | 6 | 1% | 1 | 1 | 2% | 5 | 7 | 2% |
| **Gas** | 0.6 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 4% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 2 | 3% | 0 | 0 | 0% |
| **Oil** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 25.7 | 96% | 234 | 320 | 95% | 2339 | 3200 | 98% | 18 | 25 | 92% | 5 | 7 | 76% | 702 | 960 | 99% | 41 | 56 | 94% | 234 | 320 | 97% |
| **Total Coal** | 0.4 | 2% | 11 | 16 | 5% | 47 | 65 | 2% | 1 | 1 | 5% | 2 | 2 | 24% | 7 | 9 | 1% | 1 | 2 | 3% | 6 | 9 | 3% |
| **Total** | **27** | | **245** | **336** | | **2387** | **3265** | | **20** | **27** | | **7** | **9** | | **708** | **969** | | **44** | **60** | | **240** | **329** | |

**Table 4-3: Monthly variations in contaminant emissions from domestic heating in Te Awamutu**

| | $PM_{10}$ 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 | 0 | 0 | 0 | 0 | 0 | 0 |
| April | 4 | 44 | 0 | 0 | 13 | 1 | 4 |
| May | 161 | 1573 | 12 | 4 | 468 | 29 | 158 |
| June | 230 | 2244 | 17 | 6 | 667 | 41 | 226 |
| July | 245 | 2387 | 20 | 7 | 708 | 44 | 240 |
| August | 195 | 1896 | 15 | 5 | 563 | 35 | 191 |
| September | 74 | 710 | 5 | 2 | 210 | 13 | 72 |
| October | 12 | 109 | 1 | 0 | 32 | 2 | 11 |
| November | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| December | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total (kg/ year)** | **28241** | **274843** | **2141** | **783** | **81603** | **5044** | **27686** |

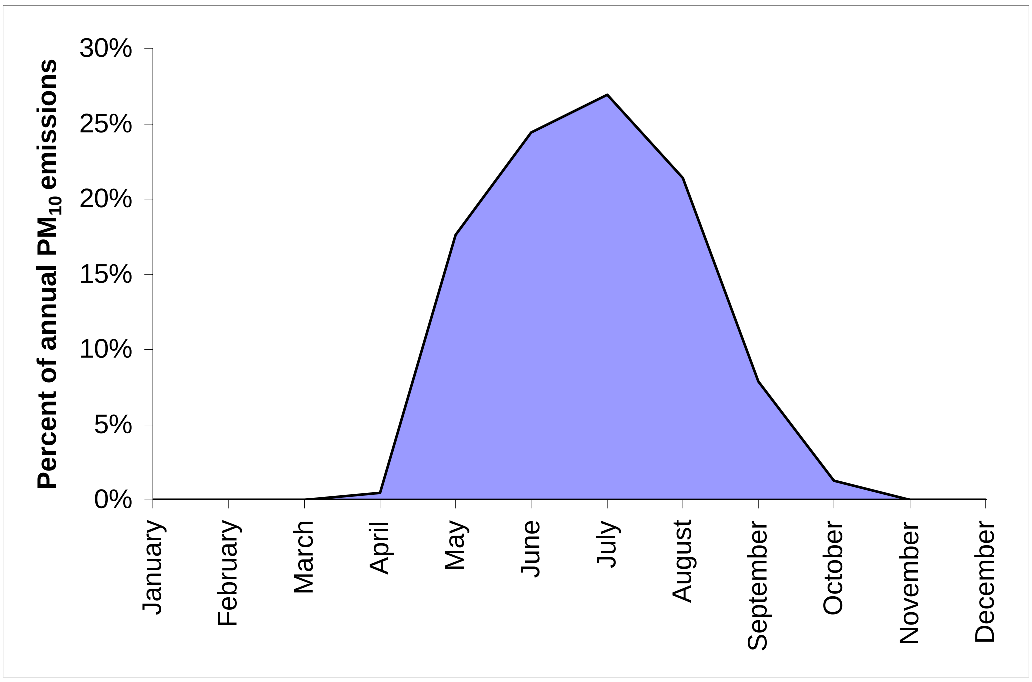


**Figure 4-4: Proportion of annual $PM_{10}$ emissions from domestic heating in Te Awamutu by month of year**

## 4.2 Turangi

Older (pre 1996) wood burners produce the greatest amount of $PM_{10}$ from domestic heating during the winter in Turangi contributing around 41% of the daily average wintertime $PM_{10}$. Overall wood burners contribute 82% of the domestic $PM_{10}$, with open fires contributing 8% and multi fuel burners 10% (Figure 4-5).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-4 and Table 4-5. The emission estimates indicate the following:

- Around 215 kilograms of domestic $PM_{10}$ are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime $PM_{10}$ emissions are less at around 167 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this $PM_{10}$ is in the finer $PM_{2.5}$ size fraction.
- The majority (98%) of the wintertime $PM_{10}$ emissions come from the burning of wood with 2% from the burning of coal.

Monthly variations in appliance use and average days per week used are shown in Figure 4-6 and Figure 4-7. Table 4-6 shows seasonal variations in contaminant emissions. The majority of the annual $PM_{10}$ from domestic home heating occur during the months June, July and August (Figure 4-8).

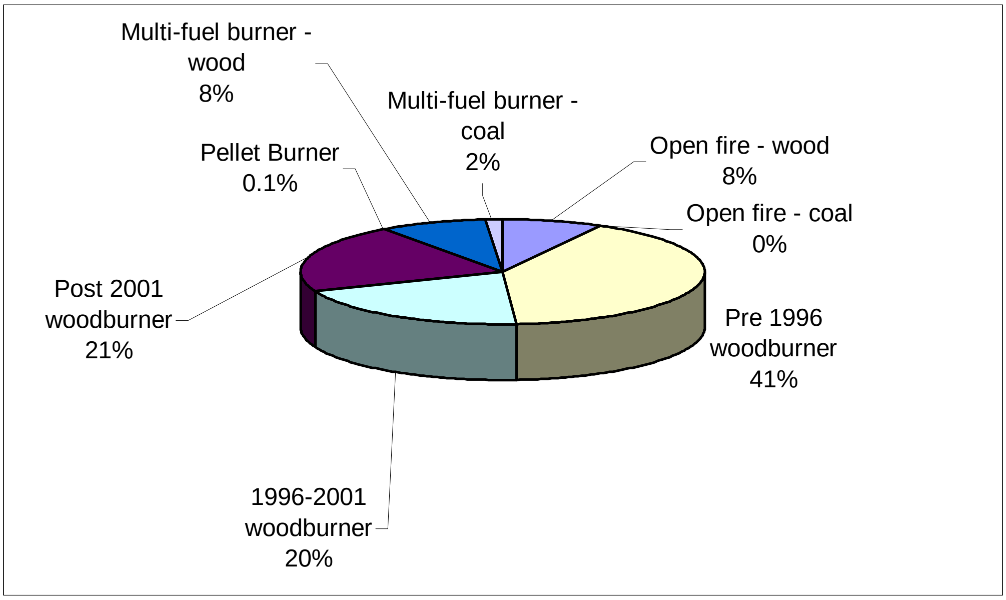


**Figure 4-5: Relative contribution of different heating methods to average daily $PM_{10}$ (July) from domestic heating in Turangi**

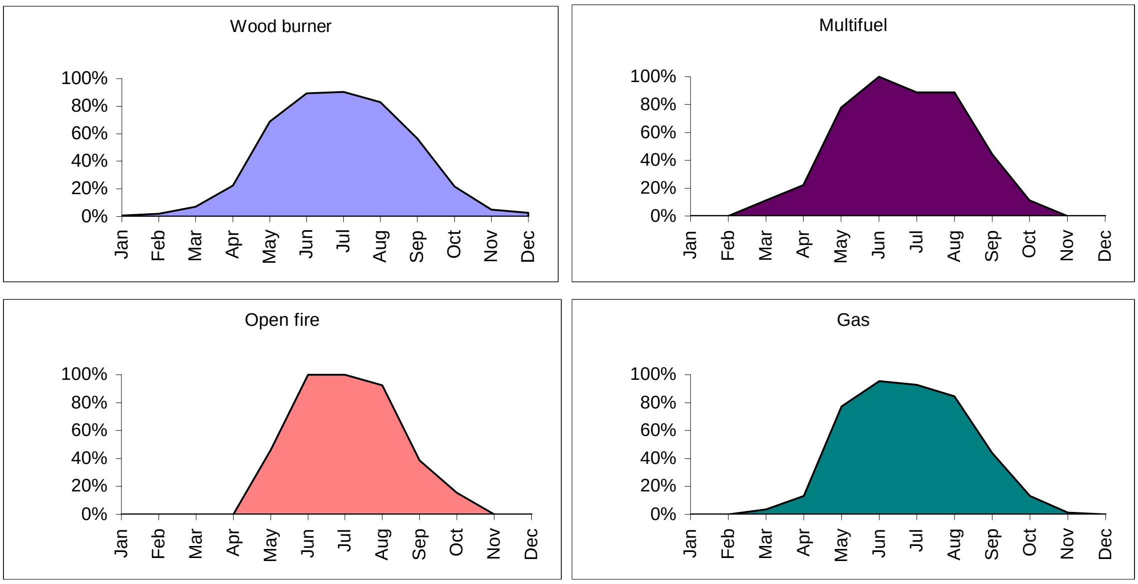


**Figure 4-6: Monthly variations in appliance use in Turangi**

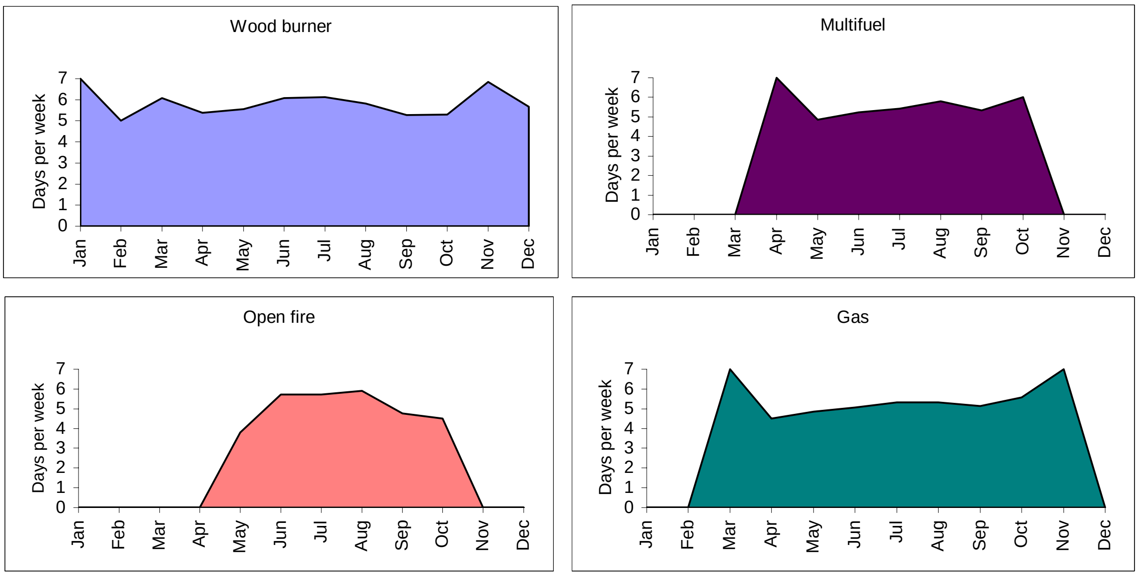


**Figure 4-7: Average number of days per week appliances are used in Turangi per month**

**Table 4-4: Turangi worst-case winter daily domestic heating emissions by appliance type**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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** | 1.5 | 6% | 15 | 16 | 7% | 152 | 157 | 7% | 2 | 3 | 17% | 0 | 0 | 5% | 46 | 47 | 7% | 2 | 3 | 6% | 15 | 16 | 7% |
| **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% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 7.8 | 31% | 86 | 89 | 40% | 858 | 885 | 41% | 4 | 4 | 27% | 2 | 2 | 28% | 257 | 266 | 41% | 12 | 13 | 31% | 86 | 89 | 40% |
| **1996-2001 wood burner** | 6.1 | 24% | 42 | 44 | 20% | 425 | 438 | 20% | 3 | 3 | 21% | 1 | 1 | 22% | 127 | 131 | 20% | 10 | 10 | 24% | 42 | 44 | 20% |
| **Post 2001 wood burner** | 7.4 | 30% | 44 | 46 | 21% | 442 | 456 | 21% | 4 | 4 | 25% | 1 | 2 | 26% | 133 | 137 | 21% | 12 | 12 | 29% | 44 | 46 | 21% |
| **Pellet Burner** | 0.1 | 0% | 0 | 0 | 0% | 1 | 1 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 1.6 | 6% | 21 | 22 | 10% | 210 | 217 | 10% | 1 | 1 | 6% | 0 | 0 | 6% | 63 | 65 | 10% | 3 | 3 | 6% | 21 | 22 | 10% |
| **Multi fuel burner – coal** | 0.2 | 1% | 7 | 7 | 3% | 28 | 29 | 1% | 0 | 0 | 2% | 1 | 1 | 13% | 4 | 4 | 1% | 1 | 1 | 2% | 4 | 4 | 2% |
| **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 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 24 | 98% | 209 | 215 | 97% | 2088 | 2154 | 99% | 14 | 14 | 96% | 5 | 5 | 87% | 626 | 646 | 99% | 39 | 40 | 97% | 209 | 215 | 98% |
| **Total Coal** | 0 | 1% | 7 | 7 | 3% | 28 | 29 | 1% | 0 | 0 | 2% | 1 | 1 | 13% | 4 | 4 | 1% | 1 | 1 | 2% | 4 | 4 | 2% |
| **Total** | **25** | | **215** | **222** | | **2116** | **2184** | | **14** | **15** | | **6** | **6** | | **630** | **650** | | **40** | **42** | | **213** | **219** | |

**Table 4-5: Turangi average winter daily domestic heating emissions by appliance type**

| | 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** | 1.3 | 7% | 13 | 14 | 8% | 134 | 138 | 8% | 2 | 2 | 19% | 0 | 0 | 6% | 40 | 41 | 8% | 2 | 2 | 7% | 13 | 14 | 8% |
| **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** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 6.2 | 32% | 68 | 70 | 41% | 680 | 702 | 41% | 3 | 3 | 27% | 1 | 1 | 29% | 204 | 210 | 41% | 10 | 10 | 31% | 68 | 70 | 41% |
| **1996-2001 wood burner** | 4.8 | 25% | 34 | 35 | 20% | 336 | 347 | 20% | 2 | 2 | 21% | 1 | 1 | 23% | 101 | 104 | 20% | 8 | 8 | 24% | 34 | 35 | 20% |
| **Post 2001 wood burner** | 5.8 | 30% | 35 | 36 | 21% | 350 | 361 | 21% | 3 | 3 | 25% | 1 | 1 | 27% | 105 | 108 | 21% | 9 | 10 | 30% | 35 | 36 | 21% |
| **Pellet Burner** | 0.1 | 0% | 0.1 | 0 | 0% | 1 | 1 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 1.1 | 6% | 14 | 14 | 8% | 140 | 145 | 8% | 1 | 1 | 5% | 0 | 0 | 5% | 42 | 43 | 9% | 2 | 2 | 5% | 14 | 14 | 8% |
| **Multi fuel burner – coal** | 0.1 | 0% | 3 | 3 | 2% | 11 | 11 | 1% | 0 | 0 | 1% | 0 | 0 | 6% | 1 | 1 | 0% | 0 | 0 | 1% | 1 | 1 | 1% |
| **Gas** | 0.1 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 0% |
| **Oil** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 3% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 19.3 | 99% | 164 | 169 | 98% | 1641 | 1694 | 99% | 11 | 11 | 97% | 4 | 4 | 90% | 492 | 508 | 100% | 31 | 32 | 98% | 164 | 169 | 99% |
| **Total Coal** | 0.1 | 0% | 3 | 3 | 2% | 11 | 11 | 1% | 0 | 0 | 1% | 0 | 0 | 6% | 1 | 1 | 0% | 0 | 0 | 1% | 1 | 1 | 1% |
| **Total** | **20** | | **167** | **172** | | **1652** | **1705** | | **11** | **12** | | **4** | **4** | | **494** | **510** | | **32** | **33** | | **166** | **171** | |

**Table 4-6: Monthly variations in contaminant emissions from domestic heating in Turangi**

| | $PM_{10}$ 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 | 5 | 0 | 0 | 1 | 0 | 0 |
| **April** | 8 | 77 | 0 | 0 | 23 | 1 | 8 |
| **May** | 102 | 1015 | 6 | 3 | 304 | 20 | 102 |
| **June** | 164 | 1622 | 11 | 4 | 485 | 31 | 163 |
| **July** | 167 | 1652 | 11 | 4 | 494 | 31 | 166 |
| **August** | 147 | 1452 | 10 | 4 | 434 | 27 | 146 |
| **September** | 47 | 471 | 3 | 1 | 141 | 9 | 47 |
| **October** | 7 | 65 | 0 | 0 | 20 | 1 | 7 |
| **November** | 0 | 4 | 0 | 0 | 1 | 0 | 0 |
| **December** | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Total (kg/ year)** | **19672** | **195119** | **1319** | **489** | **58325** | **3741** | **19552** |

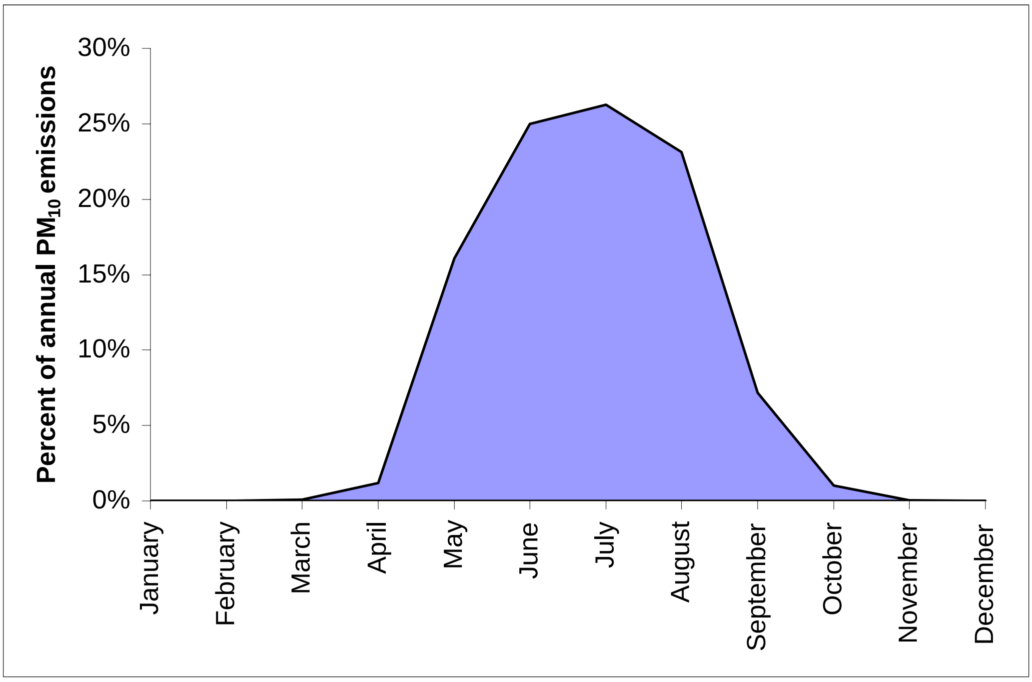


**Figure 4-8: Proportion of annual $PM_{10}$ emissions from domestic heating in Turangi by month of year**

# 4.3 Ngaruawahia

The greatest amount of $PM_{10}$ from domestic heating during the winter in Ngaruawahia comes from wood burning on multi fuel burners which contribute around 29% of the daily average wintertime $PM_{10}$ emissions. Older wood burners (23%) and multi fuel burners burning coal (19%) are the next greatest contributors. Overall wood burning contributes 81% of the $PM_{10}$ (Figure 4-9).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-7 and Table 4-8. The emission estimates indicate the following:

- Around 412 kilograms of domestic $PM_{10}$ are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime $PM_{10}$ emissions are less at around 329 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this $PM_{10}$ is in the finer $PM_{2.5}$ size fraction.
- The majority (81%) of the wintertime $PM_{10}$ emissions come from the burning of wood with 19% from the burning of coal.

Monthly variations in appliance use and average days per week used are shown in Figure 4-10 and Figure 4-11. Table 4-9 shows seasonal variations in contaminant emissions. The majority of the annual $PM_{10}$ from domestic home heating occur during the months June, July and August (Figure 4-12).

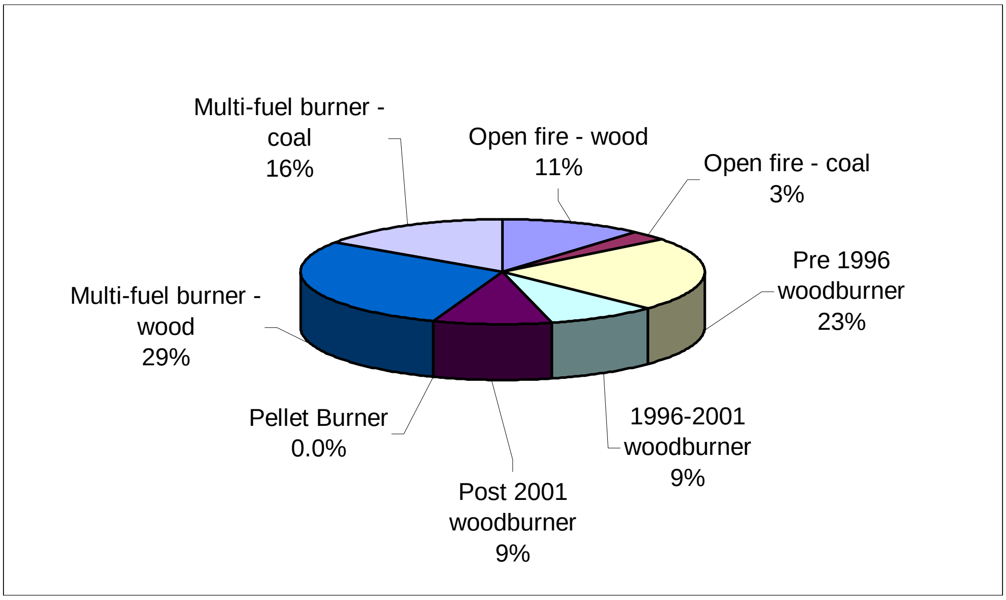


**Figure 4-9: Relative contribution of different heating methods to average daily $PM_{10}$ (July) from domestic heating in Ngaruawahia**

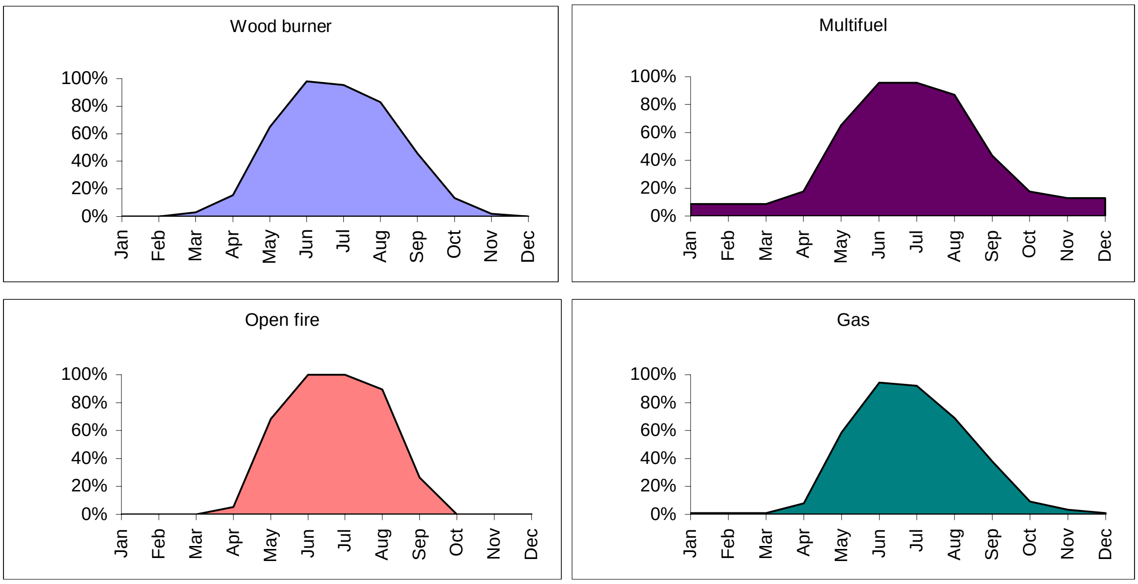


**Figure 4-10: Monthly variations in appliance use in Ngaruawahia**

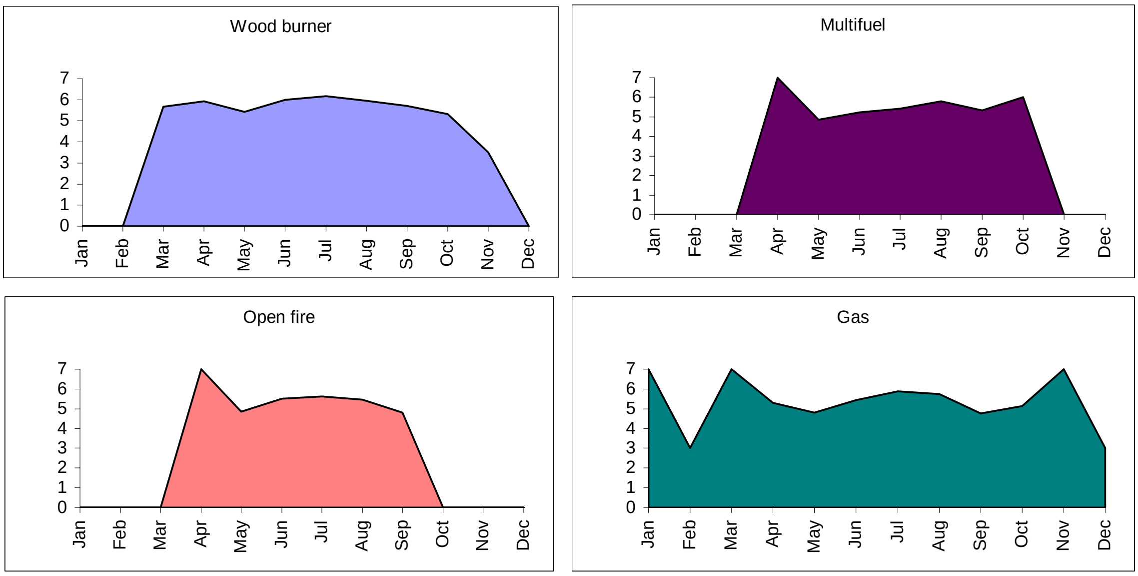


**Figure 4-11: Average number of days per week appliances are used in Ngaruawahia per month**

**Table 4-7: Ngaruawahia worst-case winter daily domestic heating emissions by appliance type**

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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** | 4.2 | 11% | 42 | 56 | 10% | 423 | 559 | 12% | 7 | 9 | 24% | 1 | 1 | 5% | 127 | 168 | 12% | 7 | 9 | 11% | 42 | 56 | 11% |
| **Open fire - coal** | 0.5 | 1% | 10 | 14 | 3% | 39 | 52 | 1% | 2 | 3 | 7% | 2 | 3 | 14% | 7 | 10 | 1% | 1 | 2 | 2% | 6 | 8 | 2% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 8.1 | 22% | 89 | 117 | 22% | 887 | 1173 | 24% | 4 | 5 | 15% | 2 | 2 | 9% | 266 | 352 | 25% | 13 | 17 | 20% | 89 | 117 | 23% |
| **1996-2001 wood burner** | 5.0 | 13% | 35 | 46 | 9% | 351 | 464 | 10% | 3 | 3 | 9% | 1 | 1 | 6% | 105 | 139 | 10% | 8 | 11 | 13% | 35 | 46 | 9% |
| **Post 2001 wood burner** | 6.1 | 16% | 37 | 48 | 9% | 366 | 484 | 10% | 3 | 4 | 11% | 1 | 2 | 7% | 110 | 145 | 11% | 10 | 13 | 15% | 37 | 48 | 10% |
| **Pellet Burner** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 10.1 | 27% | 131 | 173 | 32% | 1307 | 1729 | 36% | 5 | 7 | 18% | 2 | 3 | 12% | 392 | 519 | 38% | 16 | 21 | 25% | 131 | 173 | 35% |
| **Multi fuel burner – coal** | 2.4 | 7% | 68 | 90 | 17% | 293 | 387 | 8% | 3 | 4 | 10% | 7 | 10 | 42% | 37 | 48 | 4% | 6 | 8 | 10% | 39 | 51 | 10% |
| **Gas** | 0.7 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 3% | 0 | 0 | 0% | 0 | 0 | 0% | 2 | 2 | 3% | 0 | 0 | 0% |
| **Oil** | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 2% | 1 | 1 | 5% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% |
| **Total Wood** | 33 | 90% | 333 | 441 | 81% | 3334 | 4410 | 91% | 21 | 28 | 77% | 7 | 9 | 38% | 1000 | 1323 | 96% | 54 | 71 | 84% | 333 | 441 | 88% |
| **Total Coal** | 3 | 8% | 79 | 104 | 19% | 332 | 439 | 9% | 5 | 6 | 17% | 10 | 13 | 56% | 44 | 58 | 4% | 8 | 10 | 12% | 45 | 59 | 12% |
| **Total** | **37** | | **412** | **545** | | **3666** | **4849** | | **28** | **37** | | **17** | **23** | | **1044** | **1381** | | **64** | **84** | | **378** | **500** | |

**Table 4-8: Ngaruawahia average winter daily domestic heating emissions by appliance type**

| | 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** | 3.8 | 12% | 38 | 50 | 11% | 376 | 497 | 13% | 6 | 8 | 27% | 1 | 1 | 6% | 113 | 149 | 13% | 6 | 8 | 12% | 38 | 50 | 12% |
| **Open fire - coal** | 0.5 | 2% | 10 | 14 | 3% | 39 | 52 | 1% | 2 | 3 | 9% | 2 | 3 | 18% | 7 | 10 | 1% | 1 | 2 | 3% | 6 | 8 | 2% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1996 wood burner** | 6.8 | 23% | 75 | 99 | 23% | 745 | 986 | 25% | 3 | 4 | 15% | 1 | 2 | 10% | 224 | 296 | 27% | 11 | 14 | 21% | 75 | 99 | 25% |
| **1996-2001 wood burner** | 4.2 | 14% | 29 | 39 | 9% | 295 | 390 | 10% | 2 | 3 | 9% | 1 | 1 | 6% | 88 | 117 | 11% | 7 | 9 | 13% | 29 | 39 | 10% |
| **Post 2001 wood burner** | 5.1 | 17% | 31 | 41 | 9% | 308 | 407 | 10% | 3 | 3 | 11% | 1 | 1 | 8% | 92 | 122 | 11% | 8 | 11 | 16% | 31 | 41 | 10% |
| **Pellet Burner** | 0.0 | 0% | 0.0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 7.3 | 24% | 95 | 126 | 29% | 953 | 1261 | 32% | 4 | 5 | 16% | 1 | 2 | 11% | 286 | 378 | 34% | 12 | 16 | 23% | 95 | 126 | 31% |
| **Multi fuel burner – coal** | 1.8 | 6% | 51 | 68 | 16% | 220 | 291 | 7% | 2 | 3 | 9% | 5 | 7 | 41% | 27 | 36 | 3% | 5 | 6 | 9% | 29 | 39 | 10% |
| **Gas** | 0.5 | 2% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 3% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 2 | 2% | 0 | 0 | 0% |
| **Oil** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 27.2 | 90% | 268 | 354 | 81% | 2677 | 3541 | 91% | 18 | 23 | 78% | 5 | 7 | 40% | 803 | 1062 | 96% | 44 | 58 | 85% | 268 | 354 | 88% |
| **Total Coal** | 2.3 | 8% | 62 | 82 | 19% | 259 | 343 | 9% | 4 | 5 | 18% | 8 | 11 | 59% | 35 | 46 | 4% | 6 | 8 | 12% | 35 | 46 | 12% |
| **Total** | **30** | | **329** | **436** | | **2936** | **3884** | | **23** | **30** | | **14** | **18** | | **838** | **1108** | | **51** | **67** | | **303** | **401** | |

**Table 4-9: Monthly variations in contaminant emissions from domestic heating in Ngaruawahia**

| | $PM_{10}$ 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 | 5 | 0 | 0 | 1 | 0 | 1 |
| February | 1 | 5 | 0 | 0 | 1 | 0 | 1 |
| March | 1 | 5 | 0 | 0 | 1 | 0 | 1 |
| April | 9 | 72 | 0 | 0 | 19 | 1 | 8 |
| May | 152 | 1397 | 10 | 6 | 405 | 25 | 143 |
| June | 332 | 2941 | 22 | 14 | 836 | 51 | 304 |
| July | 329 | 2936 | 23 | 13 | 838 | 51 | 303 |
| August | 283 | 2511 | 19 | 12 | 715 | 43 | 259 |
| September | 60 | 503 | 4 | 3 | 139 | 10 | 53 |
| October | 4 | 29 | 0 | 0 | 7 | 1 | 3 |
| November | 2 | 9 | 0 | 0 | 2 | 0 | 1 |
| December | 2 | 8 | 0 | 0 | 1 | 0 | 1 |
| Total (kg/ year) | 36050 | 319506 | 2412 | 1498 | 90875 | 5571 | 33004 |

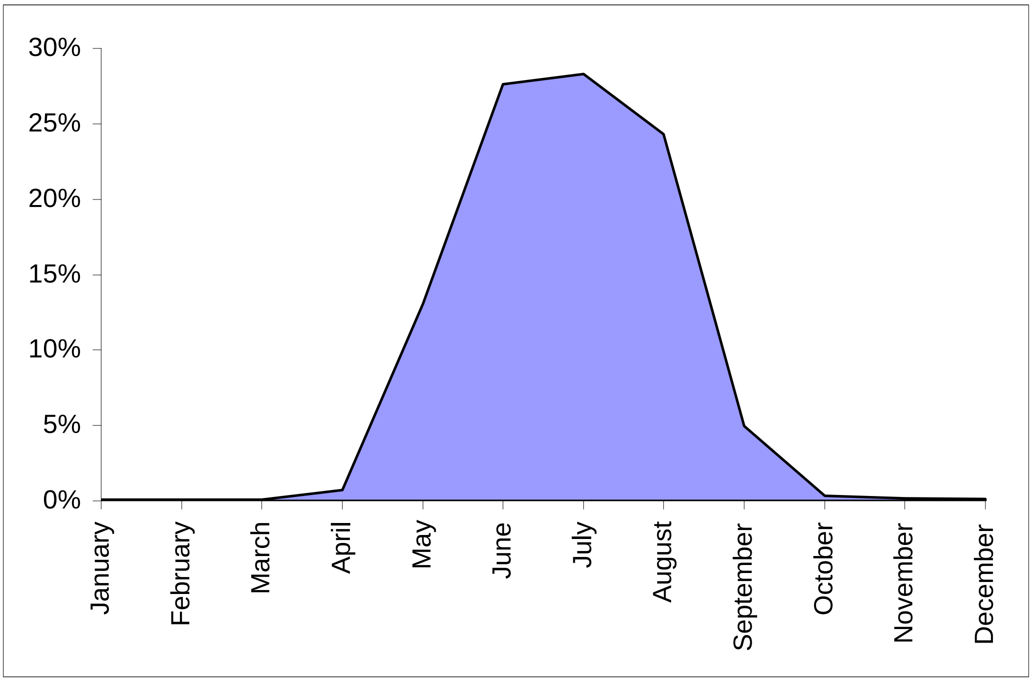


**Figure 4-12: Proportion of annual $PM_{10}$ emissions from domestic heating in Ngaruawahia by month of year**

# 5 Motor vehicles

Estimates of emissions from motor vehicles in New Zealand typically involve collecting data on vehicle kilometres travelled (VKT) per day under different levels of congestion. Emission factors are then applied to these data to give estimates of emissions for a likely range of congestion conditions.

In the larger urban centres, estimates of VKTs are often made using local road network models. No road network models have been developed for Te Awamutu, Turangi or Ngaruawahia. Estimates of VKTs for this inventory were therefore based on the ratio of VKTs to households for other urban areas of New Zealand (Table 5-1).

Estimates of emissions were made for the lower end of the range (33 VKT per household) and the higher end of the range (68 VKT per household). The likely upper and lower range of VKT estimates for each of the study areas is shown in Table 5-2. Upper limit estimates are likely to be more appropriate for Turangi and Ngaruawahia, as both have State Highway One running through them to increase traffic volumes. The ratio of VKTs to households in Te Awamutu may be more similar to low ratio areas such as Napier and Hastings.

**Table 5-1: Ratios of daily VKT to households for urban areas in New Zealand**

| | VKT/ day | No. of households | VKT/HH /day |
|---|---|---|---|
| **Nelson** | 916,007 | 14340 | 64 |
| **Hamilton** | 2,463,143 | 40698 | 60 |
| **Taupo** | 446,258 | 6973 | 64 |
| **Kaiapoi** | 215,509 | 3188 | 68 |
| **Timaru - excluding Washdyke** | 348,742 | 10696 | 33 |
| **Christchurch** | 4,764,837 | 100470 | 47 |
| **Napier** | 878,629 | 19521 | 45 |
| **Havelock North** | 142,046 | 3927 | 36 |
| **Hastings** | 472,747 | 10746 | 44 |
| **Flaxmere** | 88,816 | 2733 | 33 |

**Table 5-2: Daily VKT estimates**

| | Daily VKT - upper estimate | Daily VKT - lower estimate |
|---|---|---|
| **Te Awamutu** | 253708 | 123123 |
| **Turangi** | 87924 | 42669 |
| **Ngaruawahia** | 109140 | 52965 |

The emission factors used to estimate motor vehicle emissions for $PM_{10}$, CO, NOx and VOC were taken from the New Zealand Traffic Emission Rates (NZTER) database based on a vehicle fleet profile for the Hamilton 2005 inventory. Further details of the basis for all motor vehicle emission rates are given in Wilton (2005).

Emissions from motor vehicles increase significantly when traffic is congested. Thus different emission rates are used for kilometres travelled when traffic is congested or semi congested. The three different levels of congestion/ driving conditions typically used in emission inventory studies are free flow conditions, interrupted flow conditions and congested flow conditions. A fourth category representing emissions under cold running conditions may also be included. Because of the relative free flowing nature of vehicle movements in Te Awamutu, Turangi and Ngaruawahia all VKTs were treated as free flowing. The emission factors for each contaminant are shown in Table 5-3. These are based on the assumption that 30% of the VKTs occur under cold running conditions.

**Table 5-3: Emission factors for Te Awamutu, Turangi and Ngaruawahia based on a suburban driving regime and free flow conditions**

| | CO g/VKT | $CO_2$ g/VKT | VOC g/VKT | NOx g/VKT | SOx g/VKT | $PM_{10}$ g/VKT | $PM_{2.5}$ g/VKT |
|---|---|---|---|---|---|---|---|
| **Free flow conditions** | 11.2 | 363 | 1.8 | 1.3 | 0.2 | 0.07 | 0.04 |

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

Emissions (g) = Emission Rate (g/km) x VKT

Separate estimates of emissions were made for $PM_{10}$ and $PM_{2.5}$ from brake and tyre wear.

# 5.1 Motor vehicle emissions

# 5.2 Te Awamutu

The number of VKTs for Te Awamutu is likely to be around 123,000 per day for 2006, based on the more probable lower limit VKT to households ratio. Based on these data, 11 kilograms per day is likely to be indicative of the amount of $PM_{10}$ from motor vehicles in Te Awamutu. Around 25% of the daily $PM_{10}$ emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Te Awamutu include around 1.3 tonnes of CO, 163 kilograms of NOx and 26 kilograms of SOx. In comparison, in Christchurch, where CO concentrations exceed ambient air quality guidelines at least once during most winters, motor vehicles emit around 109 tonnes of CO within the main urban area.

Table 5-4 shows emissions from motor vehicles in Te Awamutu by weight and grams per hectare.

# 5.3 Turangi

The number of VKTs for Turangi is estimated to be nearer the upper limit estimate of 88,000 per day for 2006. Based on these data, 8 kilograms per day is likely to be indicative of the amount of $PM_{10}$ from motor vehicles in Turangi. Around 25% of the daily $PM_{10}$ emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Turangi include around 981 kilograms of CO, 116 kilograms of NOx and 19 kilograms of SOx.

Table 5-4 shows emissions from motor vehicles in Turangi by weight and grams per hectare.

# 5.4 Ngaruawahia

The number of VKTs for Ngaruawahia is estimated to be nearer the upper limit estimate of 109,000 per day for 2006. Based on these data, 10 kilograms per day is likely to be indicative of the amount of $PM_{10}$ from motor vehicles in Ngaruawahia. Around 25% of the daily $PM_{10}$ emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Ngaruawahia include around 1.2 tonnes of CO, 144 kilograms of NOx and 23 kilograms of SOx.

Table 5-4 shows emissions from motor vehicles in Ngaruawahia by weight and grams per hectare.

**Table 5-4: Summary of daily motor vehicle emissions in Te Awamutu, Turangi and Ngaruawahia**

| | | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|---|
| | Hectares | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Te Awamutu | 731 | 11 | 15 | 1374 | 1880 | 163 | 223 | 26 | 36 |
| Turangi | 969 | 8 | 8 | 981 | 1013 | 116 | 120 | 19 | 19 |
| Ngaruawahia | 756 | 10 | 13 | 1218 | 1611 | 144 | 191 | 23 | 30 |
| | | VOC | | $CO_2$ | | $PM_{2.5}$ | | | |
| | Hectares | kg | | t | kg/ha | kg | g/ha | | |
| Te Awamutu | 731 | 220 | 301 | 159 | 218 | 6 | 8 | | |
| Turangi | 969 | 157 | 162 | 114 | 117 | 4 | 4 | | |
| Ngaruawahia | 756 | 195 | 258 | 141 | 187 | 5 | 7 | | |

# 6 Industrial and Commercial

## 6.1 Methodology

Industrial discharges to air located within Te Awamutu, Turangi and Ngaruawahia were identified by Environment Waikato staff using a combination of resource consent information and searches of particular activity types such as schools and hospitals. A small number of activities held resource consents for air discharges in Te Awamutu. No resource consents had been issued in Turangi or Ngaruawahia for air discharges that are relevant to this emission inventory. Schools in these areas were identified using lists provided by the Ministry of Education.

The selection of industries for inclusion in the inventory was primarily based on potential for $PM_{10}$ emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily volatile organic compounds (VOC) were not included in the assessment. 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. Activities such as open mine quarrying were excluded from the analysis because of uncertainties in emission rates.

Emissions from one consented activity and several non-consented school boilers were included in the assessment for Te Awamutu. Emissions from this activity were estimated by season using steam data provided to Environment Waikato by Kingett Mitchell Ltd (2006). In Turangi and Ngaruawahia the industrial emissions assessment was limited to a small number of school boilers.

For the school boilers, the combustion emissions were estimated using emission factor data as indicated in Equation 6.1.

Equation 6.1 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

Emissions for the consented industry (Fonterra) located in Te Awamutu were estimated based on emissions test data from the site for $PM_{10}$, NOx and SOx. Emissions of $PM_{2.5}$ were estimated based on the $PM_{10}$ results using USEPA AP-42 size distribution data for a coal fired boiler with baghouse filter. Emissions of CO, VOC and $CO_2$ were estimated based on fuel consumption data and emission factors for gas and for a chain grate coal fired boiler as outlined in Table 6-1.

The emission factors used to estimate the quantity of emissions discharged are shown in Table 6-1. The coal fired boiler emission factors for $PM_{10}$ are based on CRL Energy Ltd emission factors. Emission factors for $PM_{2.5}$ are based on the USEPA AP42 database[1] particle size distribution factors, as are emission factors for CO, NOx and SOx. The VOC and $CO_2$ and all gas emission factors are based on factors derived by NIWA for the Christchurch 1996 emission inventory (NIWA, 1998).

**Table 6-1: Emission factors for industrial discharges**

| | $PM_{10}$ g/kg | $PM_{2.5}$ g/kg | CO g/kg | NOx g/kg | $SO_2$ g/kg | VOC g/kg | $CO_2$ g/kg |
|---|---|---|---|---|---|---|---|
| **Coal boiler (underfeed stoker)** | 3.1 | 1.9 | 5.5 | 4.8 | 13.5 | 0.1 | 2400 |
| **Coal boiler - chaingrate** | 1.8 | 0.7 | 3.0 | 3.8 | 18.0 | 0.1 | 2400 |
| | $g/m^3$ | $g/m^3$ | $g/m^3$ | $g/m^3$ | $g/m^3$ | $g/m^3$ | $g/m^3$ |
| **Natural gas** | 0.12 | 0.12 | 1.34 | 1.6 | 0.0096 | 0.088 | 1920 |

# 6.2 Industrial and commercial emissions

## 6.2.1 Te Awamutu

Around 63 kilograms of $PM_{10}$ per day are estimated to be emitted to air in Te Awamutu from industrial and commercial activities during the winter months (Table 6-2)[2].

The amount of $PM_{10}$ from industry increases to 306 kilograms per day during the summer months (Figure 6-1). The main sources of these emissions are combustion activities (187 kg per day) from the Fonterra gas co-generation plant and coal-fired boiler and the milk powder drying facilities at the same plant (118 kg per day). While it is uncertain whether $PM_{10}$ from milk powder would result in the same type and extent of health impacts as combustion particulate, all sources are included in the inventory because the NES does not discriminate between different types of particulate. Around 25% of the combustion $PM_{10}$ emissions come from the burning of gas, with the remainder occurring as a result of coal burning.

Industry also contributes over 700 kilograms of NOx and over 500 kilograms of SOx per day during the winter and 3.8 tonnes of NOx and 2.6 tonnes of SOx in Te Awamutu during the summer.

The industrial contribution to ambient contaminant concentrations is likely to be much less than the contribution to emissions because industrial discharge is via high stacks that promote more effective dispersion of contaminants. For example, while industry contributes 15% of winter time $PM_{10}$ emissions at Te Awamutu, the industrial contribution to ambient $PM_{10}$ concentrations will be lower. This is because the industrial stacks are up to 62m high and will disperse $PM_{10}$ emissions farther and wider than emissions from domestic sources.

## 6.2.2 Turangi

The amount of industrial and commercial emissions to air within Turangi is negligible with estimates of less than one kilogram of $PM_{10}$ per day (Table 6-2). Similarly emissions of other contaminants are estimated to be negligible.

[1] http://www.epa.gov/ttn/chief/ap42/index.html
[2] Emission estimates based on July values

### 6.2.3 Ngaruawahia

Around one kilogram of $PM_{10}$ is estimated to be emitted to air from industrial and commercial activities within Ngaruawahia per day (Table 6-2). This arises from the burning of coal in school boilers but is negligible relative to other sources. Emissions of other contaminants from industrial and commercial activities in Ngaruawahia are also estimated to be negligible.

**Table 6-2: Summary of Te Awamutu, Turangi and Ngaruawahia winter time industrial/ commercial emissions**

| | | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hectares** | **kg** | **g/ha** | **Kg** | **g/ha** | **kg** | **g/ha** | **kg** | **g/ha** |
| **Te Awamutu** | 731 | 63 | 86 | 191 | 261 | 771 | 1055 | 530 | 725 |
| **Turangi** | 969 | 0 | 0 | 1 | 1 | 1 | 1 | 3 | 3 |
| **Ngaruawahia** | 756 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 5 |
| | | **VOC** | | $CO_2$ | | $PM_{2.5}$ | | | |
| | **Hectares** | **kg** | **g/ha** | **Kg** | **g/ha** | **kg** | **g/ha** | | |
| **Te Awamutu** | 731 | 12 | 16 | 297 | 407 | 26 | 36 | | |
| **Turangi** | 969 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| **Ngaruawahia** | 756 | 0 | 0 | 0 | 1 | 0 | 1 | | |

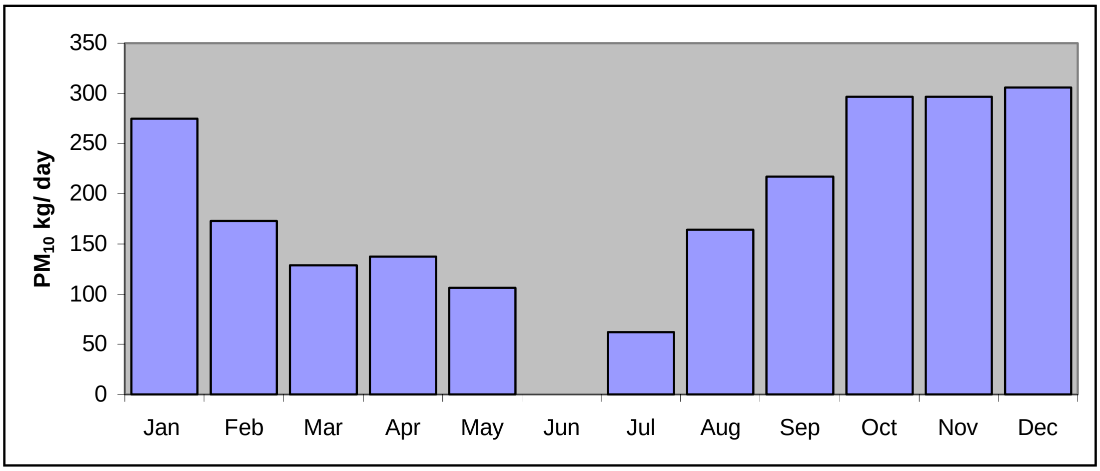


**Figure 6-1 Monthly variations in $PM_{10}$ emissions from industry in Te Awamutu**

# 7 Outdoor burning

The burning of household or garden wastes in a drum, incinerator or in the open air can result in significant emissions to air of key air contaminants, including $PM_{10}$. Emissions from outdoor burning can contribute to ambient concentrations of these contaminants and cause localised health and nuisance problems. In some urban areas of New Zealand outdoor burning is prohibited because of these impacts. Presently there are no regulations restricting outdoor burning in Te Awamutu, Turangi or Ngaruawahia. Section 17 of the Resource Management Act (1991) or section 29 of the Health Act could be used to control these emissions if individual discharges were causing adverse effects.

## 7.1 Methodology

Data on the frequency and extent of outdoor rubbish burning in Te Awamutu, Turangi and Ngaruawahia was collected using the household survey described in section 3.1. Survey results showed that outdoor burning was carried out by around 17% of households in Te Awamutu, 6% of households in Turangi and 20% of households in Ngaruawahia.

On average there are around 52 fires per day during the winter in Te Awamutu, 7 per day in Turangi and 25 per day in Ngaruawahia. The proportion of green waste (60%) versus household rubbish burnt (40%) was based on data collected in Otago (ESR, 1999). Emissions were calculated based on the assumption of an average weight of material per burn of 150 kg and using the emission factors in Table 7-1.

**Table 7-1: Outdoor burning emission factors (USEPA AP42, 2001)**

| | $PM_{2.5}$ g/kg | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | SOx g/kg | VOC g/kg | $CO_2$ g/kg |
|---|---|---|---|---|---|---|---|
| Garden rubbish | 8 | 8 | 42 | 3 | 0.5 | 4 | 1470 |
| Household rubbish | 17 | 19 | 42 | 3 | 0.5 | 4.278 | 1470 |
| **Emission factor** | 11.7 | 12.5 | 42.0 | 3.0 | 0.5 | 4.3 | 1470 |

## 7.2 Emissions from outdoor burning

## 7.3 Te Awamutu

During the winter it is likely that around 97 kilograms of $PM_{10}$ per day is emitted from outdoor burning in Te Awamutu (Table 7-2). Of this, the majority (93%) is within the finer, $PM_{2.5}$ size fraction. Outdoor burning also produces around 325 kg of carbon monoxide and around 11 tonnes of carbon dioxide per day during winter.

It should be noted, however, that there are a number of uncertainties relating to this estimation. In particular it is assumed that burning is carried out evenly throughout the winter, whereas it is likely that a disproportionate amount of burning is carried out during weekend days. Thus on some days no $PM_{10}$ from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

**Table 7-2: Seasonal variations in outdoor burning emissions in Te Awamutu**

| Outdoor burning | $PM_{10}$ | CO | NOx | SOx | VOC | $CO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|
| | kg/day | kg/day | kg/day | kg/day | kg/day | t/day | kg/day |
| January | 94 | 317 | 23 | 4 | 32 | 11 | 88 |
| February | 94 | 317 | 23 | 4 | 32 | 11 | 88 |
| March | 96 | 324 | 23 | 4 | 33 | 11 | 90 |
| April | 96 | 324 | 23 | 4 | 33 | 11 | 90 |
| May | 96 | 324 | 23 | 4 | 33 | 11 | 90 |
| June | 97 | 325 | 23 | 4 | 33 | 11 | 91 |
| July | 97 | 325 | 23 | 4 | 33 | 11 | 91 |
| August | 97 | 325 | 23 | 4 | 33 | 11 | 91 |
| September | 100 | 335 | 24 | 4 | 34 | 12 | 93 |
| October | 100 | 335 | 24 | 4 | 34 | 12 | 93 |
| November | 100 | 335 | 24 | 4 | 34 | 12 | 93 |
| December | 94 | 317 | 23 | 4 | 32 | 11 | 88 |
| **Total (kg/ year)** | **35332** | **118716** | **8480** | **1413** | **12154** | **4155** | **33071** |

## 7.4 Turangi

In Turangi, outdoor burning is estimated to contribute around 12 kilograms of $PM_{10}$ per day during the winter months (Table 7-3).

As with Te Awamutu, there are a number of uncertainties relating to this estimation. In particular it is assumed that burning is carried out evenly throughout the winter, whereas it is likely that a disproportionate amount of burning is carried out during weekend days. Thus on some days no $PM_{10}$ from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

**Table 7-3: Seasonal variations in outdoor burning emissions in Turangi**

| Outdoor burning | $PM_{10}$ | CO | NOx | SOx | VOC | $CO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|
| | kg/day | kg/day | kg/day | kg/day | kg/day | t/day | kg/day |
| January | 9 | 29 | 2 | 0 | 3 | 1 | 8 |
| February | 9 | 29 | 2 | 0 | 3 | 1 | 8 |
| March | 10 | 35 | 2 | 0 | 4 | 1 | 10 |
| April | 10 | 35 | 2 | 0 | 4 | 1 | 10 |
| May | 10 | 35 | 2 | 0 | 4 | 1 | 10 |
| June | 12 | 41 | 3 | 0 | 4 | 1 | 12 |
| July | 12 | 41 | 3 | 0 | 4 | 1 | 12 |
| August | 12 | 41 | 3 | 0 | 4 | 1 | 12 |
| September | 9 | 30 | 2 | 0 | 3 | 1 | 8 |
| October | 9 | 30 | 2 | 0 | 3 | 1 | 8 |
| November | 9 | 30 | 2 | 0 | 3 | 1 | 8 |
| December | 9 | 29 | 2 | 0 | 3 | 1 | 8 |
| **Total (kg/ year)** | **3648** | **12256** | **875** | **146** | **1255** | **429** | **3414** |

## 7.5 Ngaruawahia

Outdoor burning is estimated to contribute around 46 kilograms of $PM_{10}$ per day in Ngaruawahia during the winter months on average (Table 7-4). However, as with Te Awamutu and Turangi, there are a number of uncertainties relating to this estimation. Most noteworthy is the assumption that burning is carried out evenly throughout the winter. In reality it is likely that a disproportionate amount of burning is carried out during weekend days. Thus on some days no $PM_{10}$ from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

**Table 7-4: Seasonal variations in outdoor burning emissions in Ngaruawahia**

| Outdoor burning | $PM_{10}$ | CO | NOx | SOx | VOC | $CO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|
| | kg/day | kg/day | kg/day | kg/day | kg/day | t/day | kg/day |
| January | 28 | 93 | 7 | 1 | 9 | 3 | 26 |
| February | 28 | 93 | 7 | 1 | 9 | 3 | 26 |
| March | 33 | 112 | 8 | 1 | 11 | 4 | 31 |
| April | 33 | 112 | 8 | 1 | 11 | 4 | 31 |
| May | 33 | 112 | 8 | 1 | 11 | 4 | 31 |
| June | 46 | 154 | 11 | 2 | 16 | 5 | 43 |
| July | 46 | 154 | 11 | 2 | 16 | 5 | 43 |
| August | 46 | 154 | 11 | 2 | 16 | 5 | 43 |
| September | 33 | 110 | 8 | 1 | 11 | 4 | 31 |
| October | 33 | 110 | 8 | 1 | 11 | 4 | 31 |
| November | 33 | 110 | 8 | 1 | 11 | 4 | 31 |
| December | 28 | 93 | 7 | 1 | 9 | 3 | 26 |
| **Total (kg/ year)** | **12763** | **42883** | **3063** | **511** | **4390** | **1501** | **11946** |

## 7.6 Other sources of emissions

This inventory includes all likely major sources of $PM_{10}$ that can be adequately estimated using inventory techniques. Other potentially significant sources of emissions not included in the inventory include dusts ($PM_{10}$) and sea spray.

Another source not included in the inventory is vegetation, which can emit VOC and NOx. Neither of these latter contaminants is likely to be an air quality concern and vegetation is unlikely to be a significant source in the predominantly urban areas. A natural emissions inventory for the Waikato Region was prepared in 1999 and includes estimates of emissions from vegetative sources (NIWA, 1999).

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 1 kilogram per day[3].

[3] 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 Te Awamutu

Less than half a tonne of $PM_{10}$ is discharged to air in Te Awamutu on an average winter's[4] day. The proportion of $PM_{10}$ that is from the burning of solid fuel for domestic home heating is less than most areas of the Waikato (59%), which typically show at least 80% from domestic home heating. Outdoor rubbish burning contributes 23% and industry 15%. Motor vehicles are the smallest contributor at around 3% (Figure 8-1). The main source of industrial $PM_{10}$ emissions in Te Awamutu is the burning of gas (25%) and coal (75%) and milk powder emissions from Fonterra.

Another point of difference to other areas of the Waikato is the small difference between summertime and winter daily emissions. Because of an increased industrial contribution during the summer months, emissions during the summer are estimated at around 90% of the daily winter time emissions. This compares to around 8% in Turangi, for example.

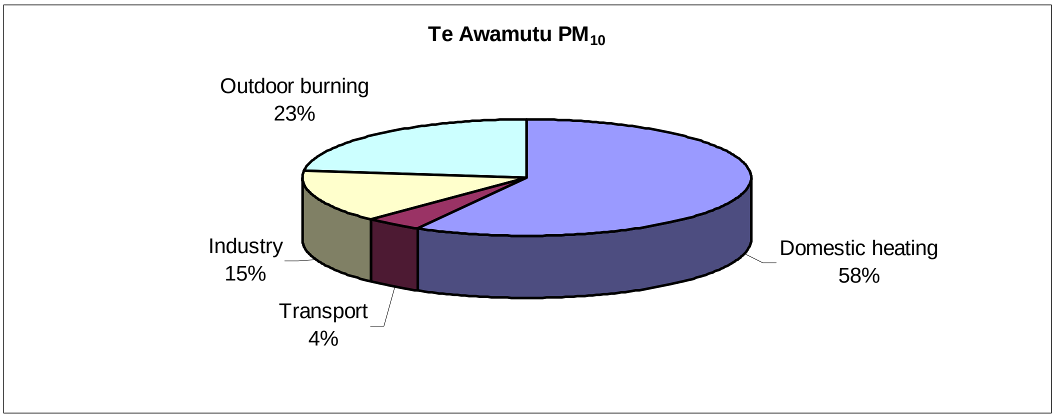


**Figure 8-1: Relative contribution of sources to daily winter $PM_{10}$ emissions in Te Awamutu**

Domestic home heating and motor vehicles are the main sources of CO and industry is the main source of NOx, SOx and $CO_2$ in Te Awamutu (Figure 8-2).

[4] Winter emission estimates are based on July values

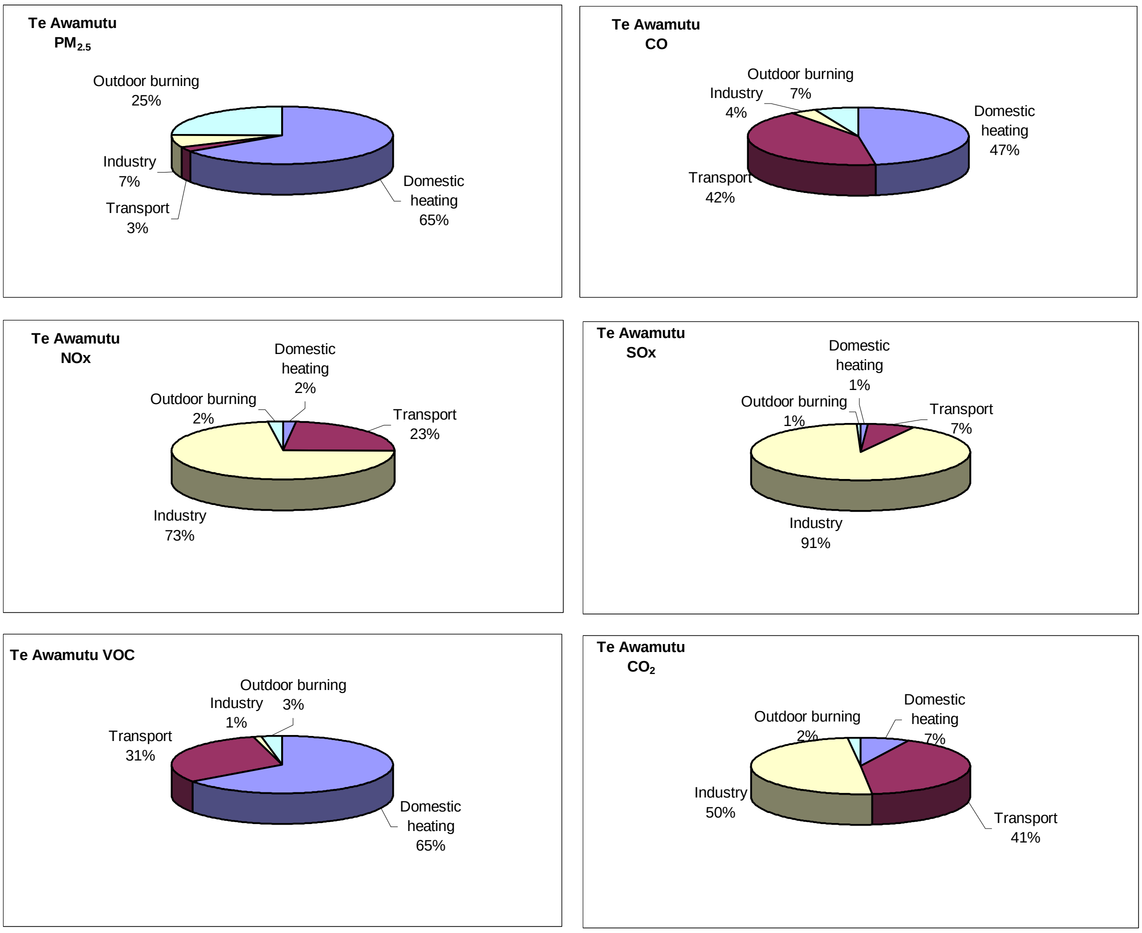


**Figure 8-2: Relative contribution of sources to winter time contaminant emissions in Te Awamutu**

Because the survey was not designed to collect time of day distributions of fuel use, an assumption has been made that Hamilton daily emission profiles are representative of Te Awamutu contaminant emissions. Based on this assumption being met, the daily variations of emissions for Te Awamutu are estimated in Table 8-1.

Table 8-2 shows seasonal variations in $PM_{10}$ emissions. Although domestic home heating is the dominant source of $PM_{10}$ emissions during the winter months, during the summer, industry and outdoor burning are the dominant contributors to $PM_{10}$ emissions. Note industrial contributions are based on average seasonal rather than monthly fluctuations.

**Table 8-1: Total daily wintertime emissions by time of day for Te Awamutu**

| Total emissions (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $PM_{10}$ kg | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $PM_{2.5}$ kg | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total CO (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total NOx (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Domestic heating** | 20 | 29 | 159 | 37 | 245 | 19 | 29 | 156 | 36 | 240 | 191 | 286 | 1551 | 334 | 2363 | 1 | 2 | 13 | 4 | 20 |
| **Motor vehicle** | 3 | 4 | 4 | 1 | 11 | 1 | 2 | 2 | 0 | 6 | 336 | 521 | 449 | 68 | 1374 | 40 | 62 | 53 | 8 | 163 |
| **Industry** | 11 | 16 | 15 | 21 | 63 | 5 | 7 | 7 | 9 | 26 | 33 | 48 | 47 | 63 | 191 | 129 | 193 | 192 | 257 | 771 |
| **Outdoor burning** | 24 | 73 | | | 97 | 23 | 68 | | | 91 | 81 | 244 | | | 325 | 6 | 17 | | | 23 |
| **Total** | **57** | **122** | **179** | **58** | **416** | **48** | **106** | **165** | **45** | **364** | **641** | **1099** | **2048** | **465** | **4253** | **176** | **274** | **259** | **268** | **977** |

| Total emissions (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total SOx (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total VOC (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $CO_2$ (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Domestic heating** | 0 | 1 | 4 | 2 | 7 | 57 | 85 | 468 | 99 | 708 | 3 | 5 | 28 | 7 | 44 |
| **Motor vehicle** | 6 | 10 | 9 | 1 | 26 | 54 | 83 | 72 | 11 | 220 | 39 | 60 | 52 | 8 | 159 |
| **Industry** | 91 | 132 | 131 | 175 | 530 | 2 | 3 | 3 | 4 | 12 | 50 | 74 | 74 | 99 | 297 |
| **Outdoor burning** | 1 | 3 | | | 4 | 8 | 25 | | | 33 | 3 | 9 | | | 11 |
| **Total** | **99** | **146** | **144** | **178** | **567** | **121** | **196** | **543** | **114** | **974** | **95** | **148** | **154** | **114** | **511** |

**Table 8-2: Monthly variations in daily $PM_{10}$ emissions in Te Awamutu**

| | Domestic Heating | | Outdoor burning | | Industry | | Motor vehicles | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | kg/day | % | kg/day | % | kg/day | % | kg/day | % | |
| January | 0 | 0% | 94 | 25% | 275 | 72% | 11 | 3% | 380 |
| February | 0 | 0% | 94 | 34% | 173 | 62% | 11 | 4% | 278 |
| March | 0 | 0% | 96 | 41% | 128 | 54% | 11 | 5% | 236 |
| April | 4 | 2% | 96 | 39% | 137 | 55% | 11 | 5% | 249 |
| May | 161 | 43% | 96 | 26% | 107 | 29% | 11 | 3% | 375 |
| June | 230 | 68% | 97 | 29% | 1 | 0% | 11 | 3% | 339 |
| July | 245 | 59% | 97 | 23% | 63 | 15% | 11 | 3% | 416 |
| August | 195 | 42% | 97 | 21% | 165 | 35% | 11 | 2% | 468 |
| September | 74 | 18% | 100 | 25% | 217 | 54% | 11 | 3% | 402 |
| October | 12 | 3% | 100 | 24% | 297 | 71% | 11 | 3% | 419 |
| November | 0 | 0% | 100 | 24% | 297 | 73% | 11 | 3% | 408 |
| December | 0 | 0% | 94 | 23% | 306 | 74% | 11 | 3% | 411 |
| **Total kg year** | **28241** | | **35332** | | **65915** | | **4094** | | |

## 8.2 Turangi

Around 186 kilograms of $PM_{10}$ is discharged to air in Turangi on an average winter's day. The main source is solid fuel burning for domestic home heating, which contributes around 89% of the daily $PM_{10}$ (Figure 8-3). Outdoor burning contributes 7% and motor vehicles 4%. The contribution of industry to $PM_{10}$ emissions in Turangi is negligible.

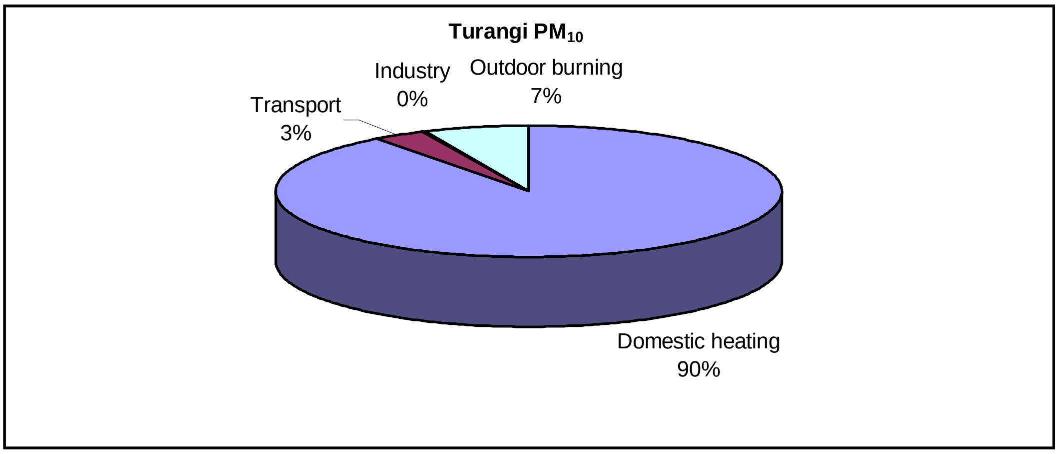


**Figure 8-3: Relative contribution of sources to daily winter $PM_{10}$ emissions in Turangi**

Domestic heating is also the main contributor to CO, $PM_{2.5}$, and VOC emissions in Turangi ( Figure 8-4). Motor vehicles are the main source of NOx, SOx and $CO_2$.

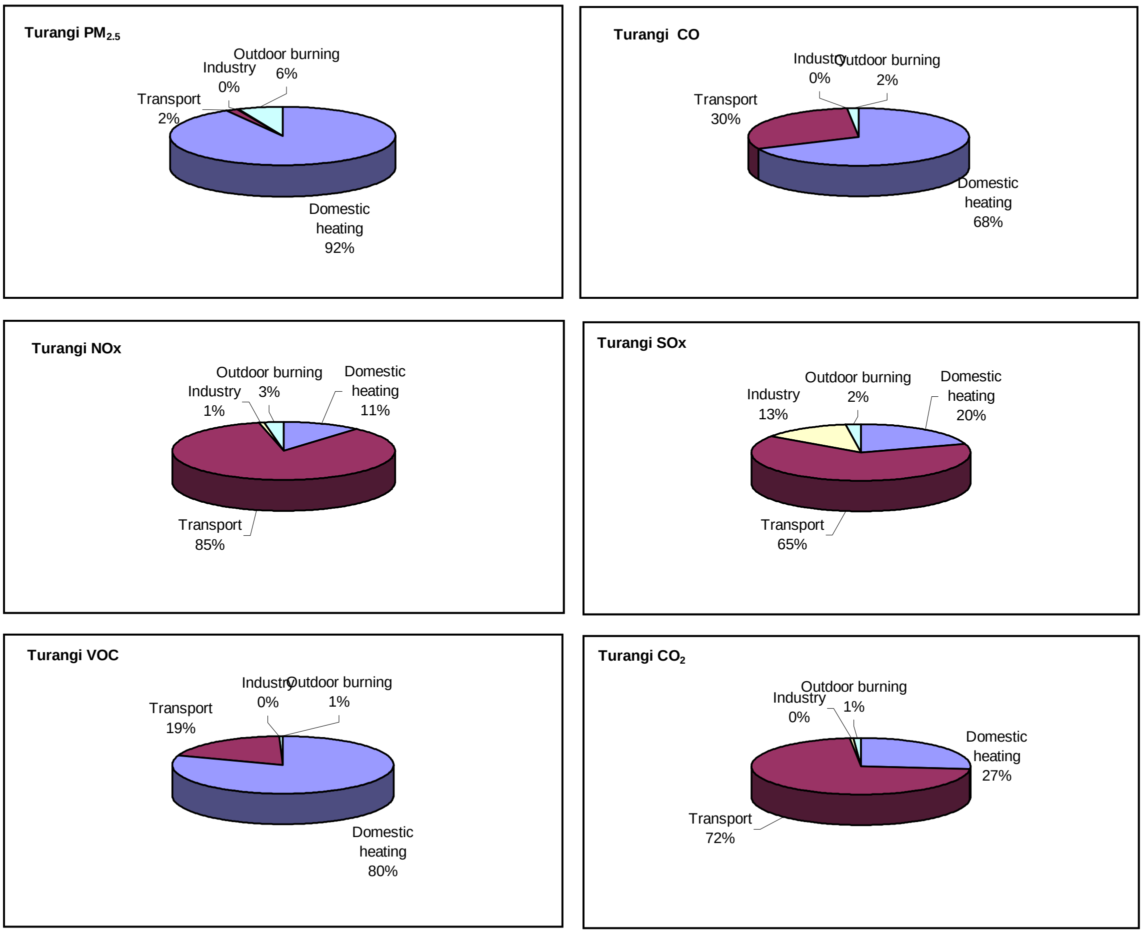


**Figure 8-4: Relative contribution of sources to contaminant emissions in Turangi**

Because the survey was not designed to collect time of day distributions of fuel use, an assumption has been made that Hamilton daily emission profiles are representative of Turangi contaminant emissions. Based on this assumption, the daily variations of emissions for Turangi are estimated in Table 8-3.

Table 8-4 shows seasonal variations in $PM_{10}$ emissions.  Although domestic home heating is the dominant source of $PM_{10}$ emissions during the winter months, during the summer, motor vehicles and outdoor burning are the dominant contributors to $PM_{10}$ emissions.

Table 8-3: Total daily wintertime emissions by time of day for Turangi

| Total emissions (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $PM_{10}$ kg | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $PM_{2.5}$ kg | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total CO (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total NOx (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic heating | 13 | 20 | 108 | 25 | 167 | 13 | 20 | 108 | 25 | 166 | 132 | 198 | 1074 | 231 | 1636 | 1 | 1 | 7 | 2 | 11 |
| Motor vehicle | 2 | 3 | 3 | 0 | 8 | 1 | 2 | 1 | 0 | 4 | 240 | 372 | 321 | 48 | 981 | 28 | 44 | 38 | 6 | 116 |
| Industry | 0.4 | 0.1 | 0.0 | 0.0 | 0.5 | 0.2 | 0.1 | 0.0 | 0.0 | 0.3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| Outdoor burning | 3 | 9 | | | 12 | 3 | 9 | | | 12 | 10 | 31 | | | 41 | 1 | 2 | | | 3 |
| Total | 19 | 32 | 111 | 25 | 188 | 17 | 30 | 109 | 25 | 182 | 383 | 601 | 1395 | 280 | 2659 | 31 | 48 | 46 | 8 | 132 |

| Total emissions (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total SOx (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total VOC (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $CO_2$ (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic heating | 0 | 0 | 3 | 1 | 4 | 39 | 59 | 326 | 69 | 494 | 3 | 4 | 20 | 5 | 32 |
| Motor vehicle | 5 | 7 | 6 | 1 | 19 | 39 | 60 | 51 | 8 | 157 | 28 | 43 | 37 | 6 | 114 |
| Industry | 2 | 1 | 0 | 0 | 3 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.3 | 0.1 | 0.0 | 0.0 | 0.4 |
| Outdoor burning | 0 | 0 | | | 0 | 1 | 3 | | | 4 | 0 | 1 | | | 1 |
| **Total** | **7** | **8** | **9** | **2** | **26** | **79** | **122** | **377** | **77** | **655** | **31** | **48** | **57** | **11** | **147** |

**Table 8-4: Monthly variations in daily $PM_{10}$ emissions in Turangi**

| | Domestic Heating | | Outdoor burning | | Industry | | Motor vehicles | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | kg/day | % | kg/day | % | kg/day | % | kg/day | % | |
| January | 0.0 | 0% | 9 | 51% | 0.0 | 0% | 8 | 49% | 17 |
| February | 0.0 | 0% | 9 | 51% | 0.0 | 0% | 8 | 48% | 17 |
| March | 0.5 | 3% | 10 | 55% | 0.0 | 0% | 8 | 43% | 19 |
| April | 8 | 29% | 10 | 39% | 0.0 | 0.0% | 8 | 31% | 26 |
| May | 102 | 84% | 10 | 8% | 0.5 | 0.4% | 8 | 7% | 121 |
| June | 164 | 89% | 12 | 7% | 0.5 | 0.3% | 8 | 4% | 185 |
| July | 167 | 89% | 12 | 7% | 0.5 | 0.3% | 8 | 4% | 188 |
| August | 147 | 88% | 12 | 7% | 0.5 | 0.3% | 8 | 5% | 168 |
| September | 47 | 73% | 9 | 14% | 0.5 | 0.7% | 8 | 13% | 64 |
| October | 7 | 27% | 9 | 37% | 0.5 | 2% | 8 | 34% | 24 |
| November | 0.4 | 2% | 9 | 51% | 0.0 | 0% | 8 | 47% | 17 |
| December | 0.1 | 0% | 9 | 51% | 0.0 | 0% | 8 | 48% | 17 |
| **Total kg year** | **19672** | | **3648** | | **88** | | **2950** | | |

## 8.3 Ngaruawahia

Around 383 kilograms of $PM_{10}$ is discharged to air in Ngaruawahia on an average winter's day. Solid fuel burning for domestic home heating is the main source contributing around 85% of the daily $PM_{10}$ ( Figure 8-5). Outdoor burning contributes 12% and motor vehicles 3%. The contribution of industry to $PM_{10}$ emissions in Ngaruawahia is negligible.

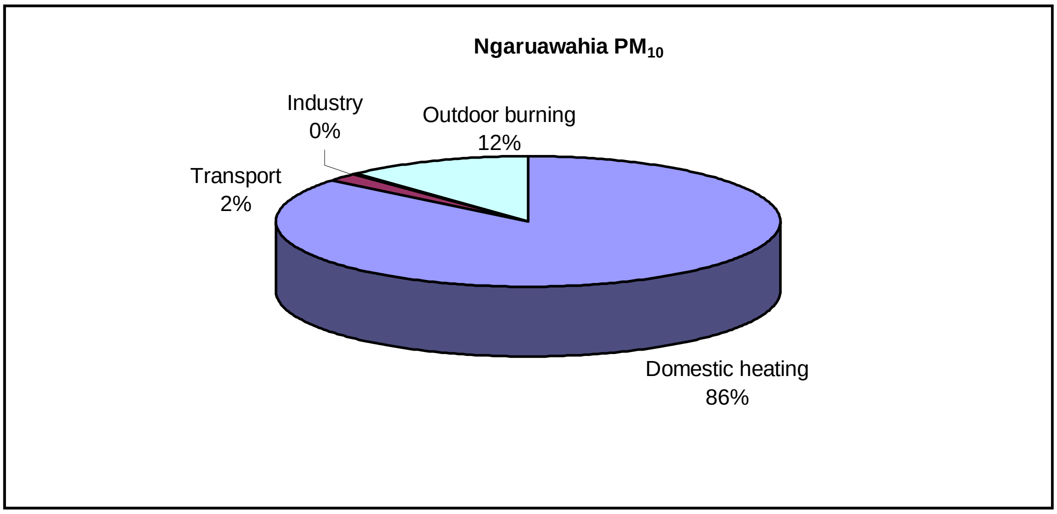


**Figure 8-5: Relative contribution of sources to daily winter $PM_{10}$ emissions in Ngaruawahia**

Domestic heating is also the main contributor to CO, $PM_{2.5}$, and VOC emissions in Ngaruawahia (Figure 8-6). Motor vehicles are the main source of NOx, SOx and $CO_2$.

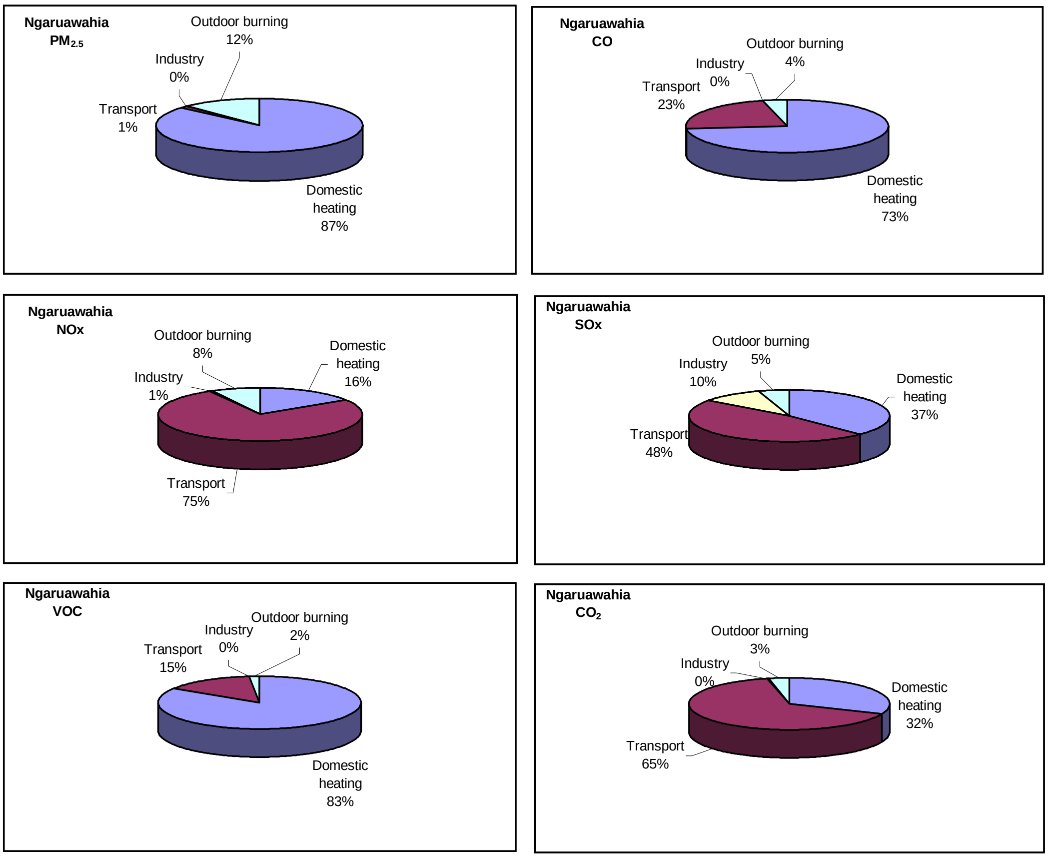


**Figure 8-6: Relative contribution of sources to contaminant emissions in Ngaruawahia**

Because the survey was not designed to collect time of day distributions of fuel use, an assumption has been made that Hamilton daily emission profiles are representative of Ngaruawahia contaminant emissions. Based on this assumption, the daily variations of emissions for Ngaruawahia are estimated in Table 8-5.

Seasonal variations in $PM_{10}$ emissions are shown in Table 8-6. Although domestic home heating is the dominant source of $PM_{10}$ emissions during the winter months, during the summer, motor vehicles and outdoor burning are the dominant contributors to $PM_{10}$ emissions.

**Table 8-5: Total daily wintertime emissions by time of day for Ngaruawahia**

| Total emissions (kg) | 6am-10am | 10am -4pm | 4pm-10pm | 10pm -6am | Total $PM_{10}$ kg | 6am-10am | 10am -4pm | 4pm-10pm | 10pm -6am | Total $PM_{2.5}$ kg | 6am-10am | 10am -4pm | 4pm-10pm | 10pm -6am | Total CO (kg) | 6am-10am | 10am -4pm | 4pm-10pm | 10pm -6am | Total NOx (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Domestic heating** | 26 | 40 | 214 | 49 | 329 | 24 | 36 | 197 | 45 | 303 | 235 | 352 | 1908 | 411 | 2907 | 2 | 2 | 15 | 4 | 23 |
| **Motor vehicle** | 2 | 4 | 3 | 0 | 10 | 1 | 2 | 2 | 0 | 5 | 298 | 462 | 398 | 60 | 1218 | 35 | 55 | 47 | 7 | 144 |
| **Industry** | 0.5 | 0.1 | 0.0 | 0.0 | 0.6 | 0.3 | 0.1 | 0.0 | 0.0 | 0.4 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| **Outdoor burning** | 11 | 34 | | | 46 | 11 | 32 | | | 43 | 39 | 116 | | | 154 | 3 | 8 | | | 11 |
| **Total** | **41** | **78** | **217** | **50** | **386** | **37** | **71** | **199** | **46** | **352** | **572** | **930** | **2307** | **471** | **4280** | **40** | **65** | **62** | **11** | **179** |

| Total emissions (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total SOx (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total VOC (kg) | 6am-10am | 10am-4pm | 4pm-10pm | 10pm-6am | Total $CO_2$ (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Domestic heating** | 1 | 1 | 8 | 3 | 14 | 67 | 101 | 553 | 117 | 838 | 4 | 6 | 33 | 8 | 51 |
| **Motor vehicle** | 6 | 9 | 8 | 1 | 23 | 48 | 74 | 64 | 10 | 195 | 35 | 53 | 46 | 7 | 141 |
| **Industry** | 3 | 1 | 0 | 0 | 4 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.4 | 0.1 | 0.0 | 0.0 | 0.5 |
| **Outdoor burning** | 0 | 1 | | | 2 | 4 | 12 | | | 16 | 1 | 4 | | | 5 |
| **Total** | **10** | **12** | **16** | **4** | **42** | **119** | **186** | **617** | **127** | **1049** | **40** | **64** | **79** | **15** | **198** |

**Table 8-6: Monthly variations in daily $PM_{10}$ emissions in Ngaruawahia**

| | Domestic Heating | | Outdoor burning | | Industry | | Motor vehicles | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | kg/day | % | kg/day | % | kg/day | % | kg/day | % | |
| January | 1 | 3% | 28 | 71% | 0.0 | 0% | 10 | 26% | 39 |
| February | 1 | 3% | 28 | 71% | 0.0 | 0% | 10 | 26% | 39 |
| March | 1 | 3% | 33 | 75% | 0.0 | 0% | 10 | 22% | 44 |
| April | 9 | 17% | 33 | 64% | 0.0 | 0% | 10 | 19% | 52 |
| May | 152 | 78% | 33 | 17% | 0.6 | 0% | 10 | 5% | 196 |
| June | 332 | 85% | 46 | 12% | 0.6 | 0% | 10 | 3% | 389 |
| July | 329 | 85% | 46 | 12% | 0.6 | 0% | 10 | 3% | 386 |
| August | 283 | 83% | 46 | 14% | 0.6 | 0% | 10 | 3% | 339 |
| September | 60 | 58% | 33 | 32% | 0.6 | 1% | 10 | 10% | 103 |
| October | 4 | 9% | 33 | 69% | 0.6 | 1% | 10 | 21% | 48 |
| November | 2 | 4% | 33 | 74% | 0.0 | 0% | 10 | 22% | 45 |
| December | 2 | 4% | 28 | 70% | 0.0 | 0% | 10 | 25% | 39 |
| Total kg year | 36050 | | 12763 | | 114 | | 3640 | | |

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# Appendix One: Home Heating Questionnaire

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

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

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

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

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

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

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

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

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

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

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

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

(f) What size gas bottle do you use?

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

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

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

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

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

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

(d) How old is your log burner?

(e) In a typical year, how many pieces of wood do you use on an average winters day? Interviewers note: winter is defined as May to August inclusive.

(f) Ask only If they used their log burner during non winter months How many pieces of wood do you use per day during the other months? Interviewers note: winter is defined as May to August inclusive.

(g) In a typical year, how much wood would you use per year on your log burner? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks, one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

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

(i) What proportion would be bought?

5.(a) Do you use an enclosed burner which burns coal as well as wood – i.e., a multi fuel burner in your MAIN living area during a typical year? (This includes incinerators, pot belly stoves, McKay space heaters etc but does not include open fires.) (If No then question 6)

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

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

(c) How many days per week would you use your multi fuel burner during?

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

(d) How old is your multi fuel burner?
(e) What type of multi fuel burner is it?
(f) In a typical year, how much wood do you use on your multi fuel burner per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as May to August inclusive
(g) ask only If they used their multi fuel burner during non winter months How much wood do you use per day during the other months?
(h) In a typical year, how much wood would you use per year on your multi fuel burner?_____ (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with
(i) Do you use coal on your multi fuel burner?
(j) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day) Interviewer: Winter is defined as May to August inclusive.
(k) Ask only If they used their multi fuel burner during non winter months How much coal do you use per day during the other months?
(l) Do you buy wood for your multi fuel burner, or do you receive it free of charge?
(m) What proportion would be bought?

6.(a) Do you use an open fire (includes a visor fireplace which is one enclosed on three sides but open to the front) in your MAIN living area during a typical year? *(If No then question 7)*
(b) Which months of the year do you use your open fire

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

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

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

(d) Do you use wood on your open fire?
(e) On a typical year, how much wood do you use per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as may to August inclusive
(f) Ask only If they used their open fire during non winter months How much wood do you use per day during the other months?
(g) In a typical year, how much wood would you use per year on your open fire? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)
(h) Do you use coal on your open fire?
(i) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day)____ Interviewer: Winter is defined as may to August inclusive
(j) Ask only If they used their open fire during non winter months How much coal do you use per day during the other months?
(k) Do you buy wood for your open fire, or do you receive it free of charge?
(l) What proportion would be bought?

7.(a) Do you use a pellet burner in your MAIN living area during a typical year? *(If No then question 8)*
(b) Which months of the year do you use your pellet burner

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

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

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

(d) How old is your pellet burner?
(e) What make and model is your pellet burner? First, can you tell me the make?
(e) and what model is your pellet burner?
(f) In a typical year, how many kilograms of pellets do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.
(g) Ask only If they used their pellet burner during non winter months How many kgs of pellets do you use per day during the other months? Interviewers note: winter is defined as May to August inclusive.
(h) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?

8.(a) Do you use any other heating system in your MAIN living area during a typical year? *(If No then question 9)*
(b) What type of heating system do you use (if they respond with diesel or oil burner go to question c otherwise go to Q8)
(c) Which months of the year do you use your oil burner

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

(d) How many days per week would you use your diesel/oil burner during?

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

(e) How much oil do you use per year?

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

How many days would you burn rubbish outdoors during

a) winter (June, July, August)

b) spring (September, October, November)

c) summer (December, January, February)

d) autumn (March, April, May)

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

10. Does you home have insulation?

Ceiling

Under floor

Wall

Cylinder wrap

Double glazing

None

Don't know

Other

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

D1. Would you mind telling me in what year you were born?

D2. Which of the following describes you and your household situation?

Single person below 40 living alone

Single person 40 or older living alone

Young couple without children

Family with oldest child who is school age or younger

Family with an adult child still at home

Couple without children at home

Flatting together

Boarder

D3 With which ethnic group do you most closely relate?

Interviewer: tick gender.

How many people live at your address?

Do you own your home or rent it?

D5 What is your employment status:

Thank you for your time today. Your answers will be very helpful. In case you missed it, my name is ---------- from DigiPoll in Hamilton. Have a nice day/evening.

# Appendix B: Emission factors for domestic heating.

Emission factors for domestic heating were those used in the Ministry for the Environment's (2005) assessment of burner removals to meet the NES in 31 urban areas of New Zealand. With the exception of gas, oil and post 1990 wood burners, these were based largely on the review of New Zealand emission rates carried out for the Christchurch 1999 emission inventory with adaptations made for different burner age categories. The latter review resulted in revised factors for open fires burning wood and the burning of coal on open fires and multi fuel burners. The open fire wood emission factor was reduced from 15 g/kg (used in previous inventories) to 10 g/kg. This was based on a combination of overseas literature, in particular the studies by Stern (1992) and Dasch (1982), and the results of a limited number of tests carried out in New Zealand. The New Zealand tests were carried out by Applied Research and gave emission rates of around 7 g/kg.

An emission factor of 22 g/kg was selected for coal burning on an open fire and was based on the average of the tests carried out in New Zealand, weighted for the more predominant use of bituminous coals, based on the 80% to 20% figures quoted by Hennessy (1999). Previous emission factors were around 33 g/kg. An emission factor for $PM_{10}$ for multi fuel burners burning coal of 28 g/kg was selected based on a weighted average of the test results available for different appliance types.

Emission factors for the post 1995 wood burner categories were based on data collected in Nelson on burner types in different age categories. Gas and oil emission factors were based on factors derived by Angie Scott (pers comm., 2004) based on more recent testing of these appliances.

Domestic heating emission factors for CO, NOx, SOx and $CO_2$ for all but post 1995 burners were also based on the Christchurch 1999 emission factor revisions.

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