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Management Options for Air Quality in Hamilton and Te Kuiti

An Assessment of Management Options to Achieve National Environmental Standards

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Executive Summary

Concentrations of PM_{10} measured in Hamilton and Te Kuiti have exceeded the national and Environment Waikato ambient air quality guideline for PM_{10} of 50 µg m^{-3} (24-hour average). A National Environmental Standard (NES) for PM_{10} has also been set at 50 µg m^{-3} (24-hour average) with one allowable exceedence per year. This standard comes into force in September 2005.

In Hamilton PM_{10} concentrations have exceeded the 50 µg m^{-3} guideline between 0-4 times per year since monitoring commenced in 1998. The maximum measured PM_{10} concentration is around 65 µg m^{-3} (24-hour average). Based on these data, the reduction in PM_{10} concentrations required to meet the NES is estimated to be around 12%

Air quality monitoring for PM_{10} in Te Kuiti has been carried out since January 2003. Concentrations measured during both years gave a maximum PM_{10} concentration of around 60 µg m^{-3} and there were five recorded breaches of the 50 µg m^{-3} guideline. Based on these data, the reduction required to meet the NES for PM_{10} in Te Kuiti is around 12%.

The main source of PM_{10} emissions in the urban areas of Hamilton and Te Kuiti is solid fuel burning for domestic home heating. In Hamilton the inventory indicates that domestic heating contributes around 72 % of the $PM_{10,}$ with motor vehicles contributing 11% and outdoor burning 13%. In Te Kuiti solid fuel burning is estimated to contribute around 89% of the PM_{10}, with motor vehicles contributing 6% and industry 5%. The inventories do not account for the potential contribution of natural sources such as dusts or industrial emissions from processes such as sanding.

The impact of management options to reduce PM_{10} concentrations in Hamilton and Te Kuiti is examined in this report for measures targeting domestic heating and outdoor burning. Results suggest that the implementation of the NES design standard for wood burners may be sufficient to achieve the NES in both areas, although additional measures are recommended if a higher degree of certainty is required.

1 Introduction

Hamilton is the largest urban area within the Waikato Region and the fourth largest city within New Zealand. It is located about 100 kilometres south-east of Auckland. The 2001 census gives a usually resident population for Hamilton of around 115,000. Te Kuiti is a small urban town located in the Waitomo District. It has a population of around 4,400.

Both Hamilton and Te Kuiti experience poor air quality on occasion during the winter months. The main air contaminant of concern is PM_{10} (particles in the air less than 10 microns in diameter). Air quality monitoring for PM_{10} has been carried out in Hamilton since November 1997. Concentrations of PM_{10} have been monitored in Te Kuiti continuously since January 2003. Prior to this, some monitoring had been carried out for PM_{10} during 1998.

The types of health effects associated with concentrations of PM_{10} include coughs, asthma symptoms, bronchitis, respiratory illness and premature mortality. Those most susceptible to the more serious impacts include the elderly, children and those with existing respiratory conditions such as cardio-obstructive pulmonary disease (COPD). A health impacts assessment indicates that around 970 premature deaths are likely to occur in New Zealand each year as a result of exposure to PM_{10} concentrations[1].

1.1 Air quality guidelines and standards

The first air quality guidelines for New Zealand were released by the Ministry for the Environment in 1994 and included an annual average guideline for PM_{10} of 50 µg m^{-3} and a 24-hour average guideline of 120 µg m^{-3}. In 2002, the Ministry for the Environment published a revised ambient air quality guideline document that included a PM_{10} guideline of 50 µg m^{-3} (24-hour average) as well as an annual average guideline for PM_{10} of 20 µg m^{-3}. In the lead up to the latter report, consideration had been given to the establishment of an interim guideline for $PM_{2.5}$ (the finer fraction of PM_{10}) as health studies suggested this size fraction was of greatest concern. This interim guideline was dropped prior to the establishment of the 2002 guidelines in favour of further investigations into the establishment of a formal guideline for this contaminant.

In 2004, the Ministry for the Environment introduced national environmental standards (NES) for air quality including an ambient air quality standard of 50 µg m^{-3} (24-hour average) for PM_{10}. The NES allows for one guideline exceedence per year. Should there be more than one exceedence, the NES expects that strategies will be put in place to ensure that there will be just one exceedence per year by 2013. The NES specifies that where ambient air standards are breached, no resource consents for air discharges for the offending contaminant may be granted.

The NES also include a design standard for the installation of new solid fuel burners. The standard specifies an emission limit of 1.5 grams of particulate per kilogram of fuel burnt (test method - NZS 4013) and an efficiency criteria of 65% (test method - NZS 4012). The standard applies to all dwellings on less than two hectares of land.

In addition to setting guideline values, the Ministry for the Environment's ambient air quality guidelines provide details on the application of the guideline values. They propose the use of Environmental Performance Indicator (EPI) categories (Table 1.1), in part to ensure that the guidelines are not treated as a level to pollute up to, and include a recommendation that councils aim to maintain air quality at existing levels where it is below 66% of the guideline value, and enhance it when it is above. While

[1] Fisher, G., Rolfe, K., Kjellstrom, T., Woodward, A., Hales, S., Sturman, A., Kingham, S., Peterson, J., Shrestha, R., King, D., 2002. *Health effects due to motor vehicle air pollution in New Zealand*. Report to the Ministry of Transport.

this provides a signal that levels below the guideline are desirable, in areas where the guideline is exceeded, achievement of the NES is an appropriate initial target.

Table 1-1: Ministry for the Environment EPI categories for air quality

Category	Value relative to guideline	Comment
Excellent	Less than 10% of the guideline	Of little concern: if maximum values are less than a tenth of the guideline, average values are likely to be much less
Good	Between 10% and 33% of the guideline	Peak measurements in this range are unlikely to affect air quality
Acceptable	Between 33% and 66% of the guideline	A broad category, where maximum values might be of concern in some sensitive locations but generally they are at a level which does not warrant urgent action
Alert	Between 66% and 100% of the guideline	This is a warning level, which can lead to exceedences if trends are not curbed
Action	More than 100% of the guideline	Exceedences of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

2 Air quality in Hamilton and Te Kuiti

Concentrations of PM_{10} measured in Hamilton have exceeded the 24-hour average guideline of 50 µg m^{-3} from 0 to 4 times per year since monitoring commenced. The maximum measured 24-hour average concentration in Hamilton is 67 µg m^{-3}. In Te Kuiti, concentrations have exceeded the guideline five times per year with a maximum measured PM_{10} concentration of 61 µg m^{-3}.

Tables 2.1 and 2.2 show summary statistics for PM_{10} monitoring at Hamilton and Te Kuiti. The number of exceedences has been adjusted to account for missing data. This extrapolation is based on the assumption that guideline exceedences occurred on days of missing data at the same rate as for the days monitored during the winter months. That is, if exceedences occurred on 20% of days monitored from May to August inclusive, then exceedences also occurred on 20% of the days during this time when concentrations were not measured.

Table 2-1: Summary statistics for air quality monitoring in Hamilton from 2001 to 2004

	PM_{10} 2001	PM_{10} 2002	PM_{10} 2003	PM_{10} 2004
"Good" 0-33% of guideline	77%	61%	67%	56%
"Acceptable" 33-66% of guideline	21%	38%	29%	41%
"Alert" 66-100% of guideline	2%	1%	3%	3%
>Guideline	1%	0%	1%	<1%
Percentage of valid data	70%	93%	91%	94%
Annual average (µg m-3)	15	15	15	17
Guideline exceedences (extrapolated)	3	0	4	1
99.7 %ile concentration (µg m-3)	57	34	54	43
Annual maximum (µg m-3)	67	36	62	55

Table 2-2: Summary statistics for air quality monitoring in Te Kuiti

	PM_{10} 2003	PM_{10} 2004
"Good" 0-33% of guideline	48%	51%
"Acceptable" 33-66% of guideline	32%	40%
"Alert" 66-100% of guideline	17%	8%
>Guideline	2%	1%
Percentage of valid data	63%	95%
Annual average (µg m-3)	18	18
Guideline exceedences (extrapolated)	5	5
99.7 %ile concentration (µg m-3)	57	56
Annual maximum (µg m-3)	59	61

2.1 Reductions required in PM_{10} concentrations

The reduction required in PM_{10} concentrations to meet an air quality target of 50 μgm^{-3} (24-hour average), based on the maximum measured PM_{10} concentration, can be calculated using Equation 2.1.

$$R = 100(1 - \frac{t}{c}) \qquad \text{Equation 2.1}$$

where

R = the percentage reduction

t = the air quality target (e.g., 50 μgm^{-3})

c = the percentile concentration (e.g., 99.7 percentile for one allowable exceedence)

Based on Equation 2.1 the required reduction to meet the air quality target of 50 μgm^{-3} with one allowable exceedence is 12% for both Hamilton and Te Kuiti based on 2001-2004 data.

The Environment Waikato Regional Plan indicates that air quality is degraded if it exceeds 66% of the air quality guideline e.g., 50 µg m^{-3} for PM_{10}. The reduction required to meet a target of 50 µg m^{-3} with no annual exceedences is around 25% in Hamilton and 18% in Te Kuiti. If an air quality target were set at 66% of the guideline, the reduction in PM_{10} concentrations would be around 50% in Hamilton and 46% in Te Kuiti. The assessments of management options in subsequent sections of this report include an indication of the likelihood of different management scenarios relative to the NES target, with one allowable breach.

3 Sources of PM_{10} in Hamilton and Te Kuiti

3.1 Emission inventory

An emission inventory for Hamilton was carried out during 2005[2]The inventory quantified emissions to air of PM_{10}, CO, SOx, NOx and CO_2 in the urban areas of Hamilton. Sources included in the inventory were domestic home heating, motor vehicles, outdoor burning and industry. Emissions of PM_{10} from abrasive and sanding industrial processes were not included because of poor information on emission rates. The contribution of natural sources e.g., dusts, was also unable to be quantified.

Results indicated that the main source of PM_{10} in the urban areas of Hamilton during the winter was domestic heating (Figure 3.1).

In Te Kuiti, estimates of emissions from different sources have been made at different times. Industrial and motor vehicle emissions were estimated in 1997[3]. Domestic heating emissions were also estimated in 1997, in 2001 and more recently in 2004 as a part of the Ministry for the Environment's "warm homes" project. Estimates of emissions from outdoor burning were made for this study based on average burning rates per household for areas of New Zealand where these data were available. Combining these data with results of the 2004 domestic heating emissions and 1997 industry and motor vehicle emissions suggest domestic heating contributes around 82%, motor vehicles 8%, industry 6% and outdoor burning 4% of the PM_{10} emissions in Te Kuiti (Figure 3.2). Interestingly, emission estimates for domestic heating have decreased from 652 kg/day in 1997, to 412 kg/day in 2001, to 282 kg/day for 2004. The main reasons for the decrease from 1997 to 2001 appears to be a reduction in the number of households using multi fuel burners from 28% in 1997 to 11% in 2001. From 2001 to 2004 the proportion of households using open fires appears to decrease from around 24% to 9%. It is possible that some of these households have converted to wood burners as the proportion of households using this method increases from 36% in 2001 to 49% in 2004.

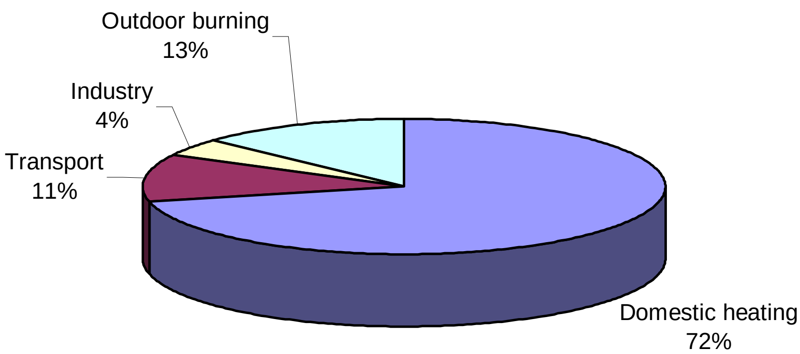


Figure 3-1: Sources of PM10 emissions in the urban areas of Hamilton in 2005

[2] Wilton, E., 2005, Hamilton Emission Inventory 2005. Unpublished report prepared for Environment Waikato.
[3] Noonan, M., 1997, *Environment Waikato Industrial emissions inventory*. Unpublished Environment Waikato Report.

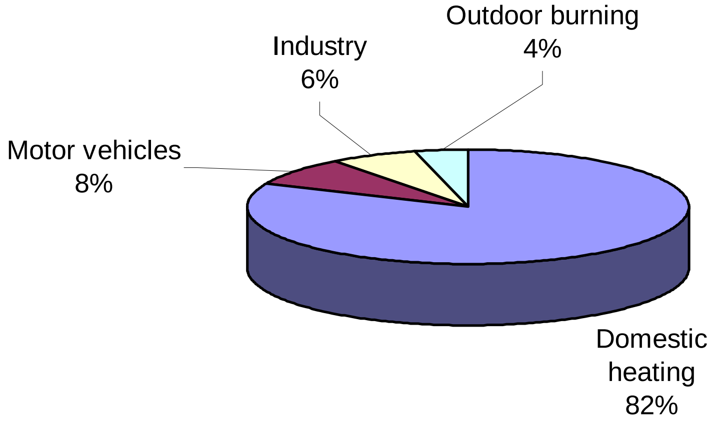
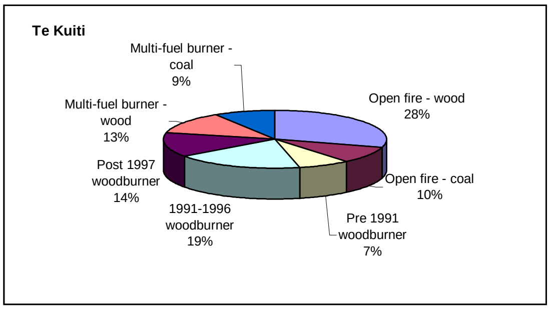


Figure 3-2: **Estimates of sources of PM10 emissions in the urban areas of Te Kuiti**

Figure 3.3 shows the breakdown of domestic heating emissions by appliance type and fuel in Hamilton for 2005 and Te Kuiti for 2001. The distribution across different appliance types is similar for both areas although Hamilton appears to have a greater proportion of older wood burners.



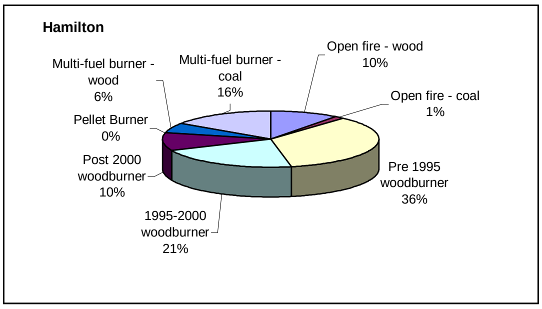


Figure 3-3: **Domestic heating emissions for Hamilton for 2005 and Te Kuiti for 2001 by heating method**

4 Managing air quality in Hamilton

The main factors contributing to poor air quality in most areas include meteorological conditions conducive to elevated pollution, emissions from within the area, the transportation of pollutants from other areas and atmospheric reactions between contaminants. Options for air quality management of PM_{10} in Hamilton include targeting primary emissions from within the area.

4.1 Sources within Hamilton

The Hamilton emissions inventory shows the main source of emissions from within the area during the winter months is domestic home heating (72%, Figure 3.1). Outdoor burning and motor vehicles contribute 13% and 11% of PM_{10} emissions. Figure 4.3 shows estimated trends in emissions from domestic heating, outdoor burning, industry and motor vehicles. These are based on the following assumptions:

- An increase in the number of occupied dwellings in Hamilton of 26% from 2001 to 2021 (Appendix B).
- The replacement of older solid fuel burners 15 years following installation.
- Improvements in vehicle engine technology as per the Ministry of Transport's Transport Emission Model (NZTER).

- Increases in outdoor burning emissions associated with predicted increases in population.
- A 10% increase in 2005 industrial PM10 emissions by 2021.
- Around 16% of new solid fuel burners being installed are multi fuel burners and all other wood burners installed from 2006 meet the NES design standard for new installations of solid fuel burners.

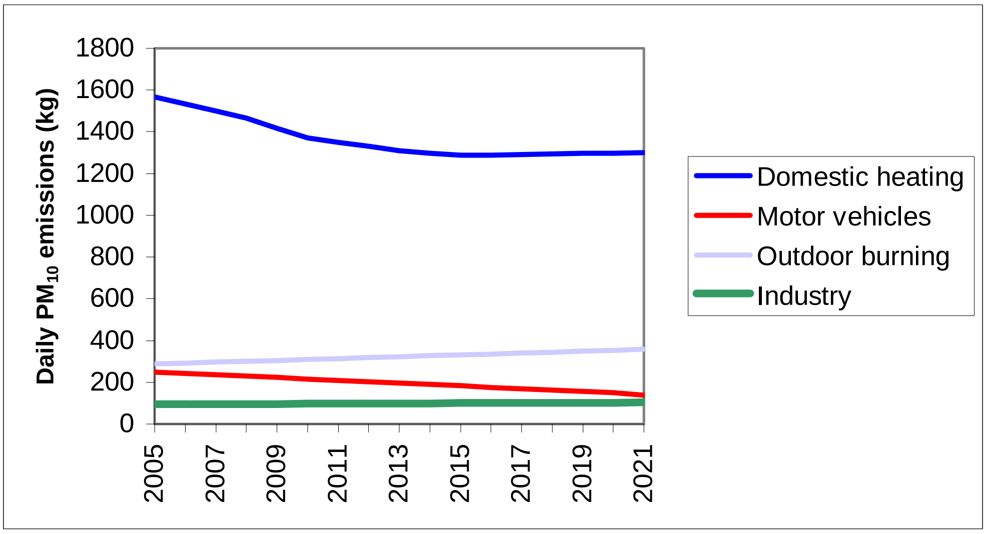


Figure 4-1: Projections in emissions from all sources in Hamilton

The effectiveness of different management options in reducing PM_{10} concentrations also depends on the relationship between emissions and concentrations in Hamilton. This includes the impact of the time of day emissions occur relative to meteorological conditions and how reductions in PM_{10} emissions influence reductions in PM_{10} concentrations.

The time of day impact relates to how emissions occurring at different times of the day influence the 24-hour average concentration. For example, emissions that occur when wind speeds are lowest and temperature inversions are present (typically evening and early morning) will have a greater impact on 24-hour average concentrations.

Although the relationship between emissions and concentrations at different times of the day has not been established for Hamilton, it is most likely that emissions that occur in the evening and early morning will have the greatest impact on 24-hour average PM_{10} concentrations. Table 4.1 shows an estimate of daily variations in emissions sources from the 2005 Hamilton emissions inventory. This shows that about 65% of the domestic heating emissions occur in the evening (4pm-10pm) period, compared to one third of motor vehicle PM_{10} emissions and about one quarter of industrial PM_{10} emissions. Based on these data, it is likely that the time of day impact may result in a slightly higher contribution to PM_{10} concentrations from domestic home heating.

Table 4-1: Source contributions to PM10 emissions at different times of the day

	6am-10am kg	10am-4pm kg	4pm-10pm kg	10pm-6am kg	Total kg
Domestic heating	124	189	1018	237	1569
Motor vehicles	61	94	81	12	249
Outdoor burning	17	24	23	31	94
Industry	72	215			287
Total	274	523	1123	281	2200

The other impact of meteorology is how reductions in PM_{10} emissions influence reductions in PM_{10} concentrations. In Christchurch, modelling work carried out by NIWA suggests that this relationship is linear, indicating a proportional reduction in concentrations for a reduction in emissions[4]. That is, if emissions were reduced evenly across all time periods.

In the absence of modelling of the relationship between emissions and concentrations for Hamilton, the assessment of effects has been based on the assumption of a linear relationship between emissions and concentrations and no impact of time of day emissions occurring relative to meteorological conditions. The impact of the latter assumption is likely to be a conservative estimate of the effectiveness of management options for domestic heating (i.e., the assessment will slightly under predict the impact of options targeting domestic heating PM_{10} emissions).

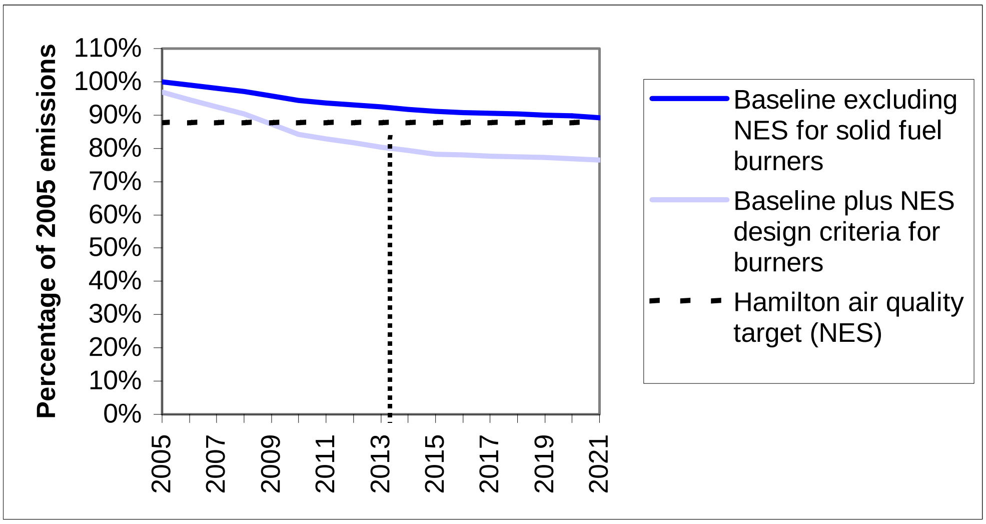


Table 4-2: Projections for PM10 emissions in Hamilton with and without the NES design criteria for solid fuel burners

Figure 4.2 shows the combined impact of estimated trends in PM_{10} emissions within Hamilton. This suggests that the introduction of the design criteria for new installations of solid fuel burners may be sufficient to achieve the NES by 2013 on its own. Additional obstacles that may limit achievement of the NES include:

- An increase in the proportion of households using open fires or solid fuel burners.
- Non-compliance with the NES design standard for solid fuel burners.
- Households not replacing solid fuel burners at the end of their anticipated useful life (15 years).
- An increase in the quantity of fuel burnt on existing burners or open fires.
- The contribution of sources from outside of the urban areas of Hamilton or non-anthropogenic sources within Hamilton.
- Meteorological conditions more conducive to air pollution than those occurring from 1998 to 2004.

Other assumptions underlying the projections are outlined in Table 4.2. There are uncertainties associated with these assumptions and those related to the underlying data, e.g., the emission inventory and air quality monitoring. Where assumptions are made about human behaviour there is the potential for variations in the associated emissions: for example, changes in electricity prices, electricity shortages or concerns about gas supplies can influence heating choices. Other factors such as economic conditions or uncertainties, income levels, or interest and mortgage rates, can also

[4] Gimson, N; Fisher, G (1997): "The Relationship Between Emissions to Air and Measured Ambient Air Concentrations of Contaminants in Christchurch", Report U97(67), Environment Canterbury.

affect the choices that people make about their heating methods and consequently affect the real life emissions from solid fuel burning.

Table 4-3: Assumptions underlying the assessment of the effectiveness of management options for reducing PM10 emissions

1	A decrease in PM_{10} emissions from motor vehicles of around 55% by 2021. This is based on motor vehicle modelling work carried out by Gabites Porter and NZTER emission rates.
2	**The industry contribution to PM_{10} emissions is less than 5% and increases by 10% from 2005 to 2021.**
3	Current outdoor burning emissions occur throughout the week and weekend.
4	Emission factors for burners as per the 2005 Hamilton emission inventory.
5	Average fuel use for 1.5 g/kg burners of 21 kg per night as per the post 2000 burners in the 2005 emission inventory survey.
6	Average fuel use for other burners as per the 2005 Hamilton emission inventory survey.
7	A proportional reduction in concentrations for any given reduction in emissions.
8	No variations in the impact of emissions occurring at different times of the day.
10	An increase in the number of dwellings in Hamilton of 26% from 2001 to 2021.
11	Unless otherwise stated, 100% of households replacing older solid fuel burners will install solid fuel burners.
12	An emission factor for 1.5 g/kg burners of 3 g/kg.
13	All new installations of wood burners from 2005 will meet an emission criterion of 1.5 g/kg when tested to NZS 4013.

Additional management measures for reducing PM_{10} concentrations in Hamilton include:

- A ban on outdoor rubbish burning.
- A ban on the use of open fires.
- Applying the NES design criteria for wood burners to multi fuel burners.
- Economic incentives for households to replace older solid fuel burners.
- Further prohibitions on the use of solid fuel burners.

In many urban areas of New Zealand outdoor rubbish burning is already prohibited because of the nuisance effects of smoke and odour. Figure 4.3 shows the estimated impact on PM_{10} concentrations in Hamilton if outdoor burning were prohibited by 2006. The costs associated with implementing this option include enforcement and costs to households and orchards in finding alternative disposal methods.

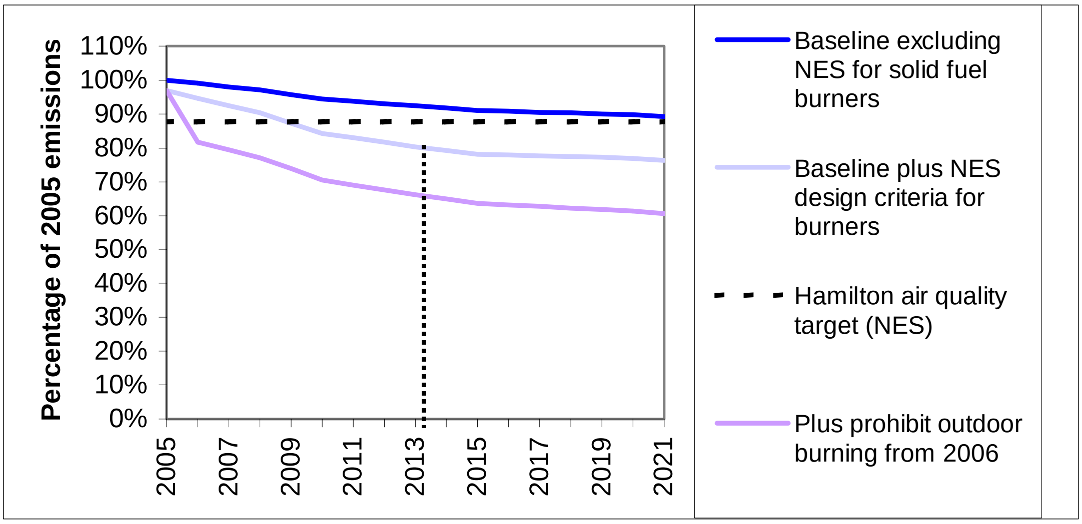


Figure 4-2: **Projections for PM10 emissions in Hamilton if outdoor burning is prohibited by 2006**

An additional management option to reduce emissions from domestic home heating is a ban on the use of open fires. Open fires contribute about 11% of PM_{10} emissions from domestic heating in Hamilton and are an inefficient method of home heating. However, a reasonable proportion (78%) of households using open fires also have other heating methods in their main living area. Figure 4.4 suggests that this combination of options may also be sufficient to achieve the air quality target by 2013.

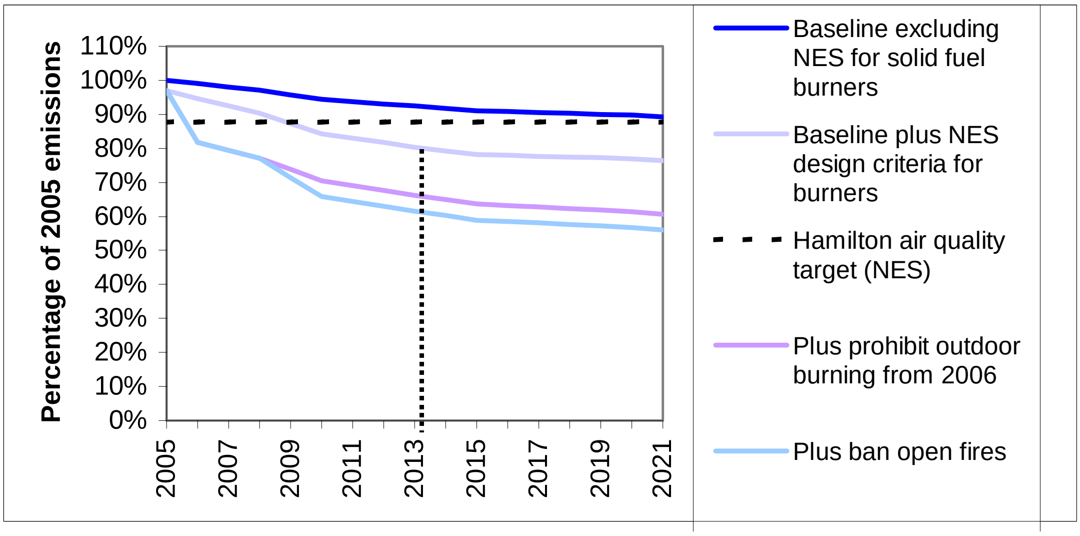


Figure 4-3: **Projections for PM10 emissions in Hamilton if outdoor burning is prohibited by 2006 and open fires by 2010**

5 Managing air quality in Te Kuiti

5.1 Sources within Te Kuiti

The main source of emissions from within the urban area of Te Kuiti during the winter months is domestic home heating (82%). Motor vehicles contribute 8% of PM_{10} emissions, with outdoor burning resulting in 4% and industry 6%. Figure 5.3 shows estimated trends in emissions from domestic heating, outdoor burning, industry and motor vehicles. These are based on the following assumptions:

- A decrease in the number of occupied dwellings in Te Kuiti of around 10% from 2001 to 2021 (Appendix two).
- The replacement of solid fuel burners 15 years after installation.
- Improvements in vehicle engine technology as per the Ministry of Transport's Transport Emission Model (NZTER).
- A 10% decrease in emissions from outdoor burning in accordance with projected population decreases.
- No significant changes in industrial emissions.
- Around 10% of new installations of solid fuel burners are multi fuel burners that do not meet the NES design criteria for wood burners.
- The NES design standard for new installations of wood burners is effective from September 2005 so all new installations of wood burners from 2006 are assumed to meet the NES emission criteria.

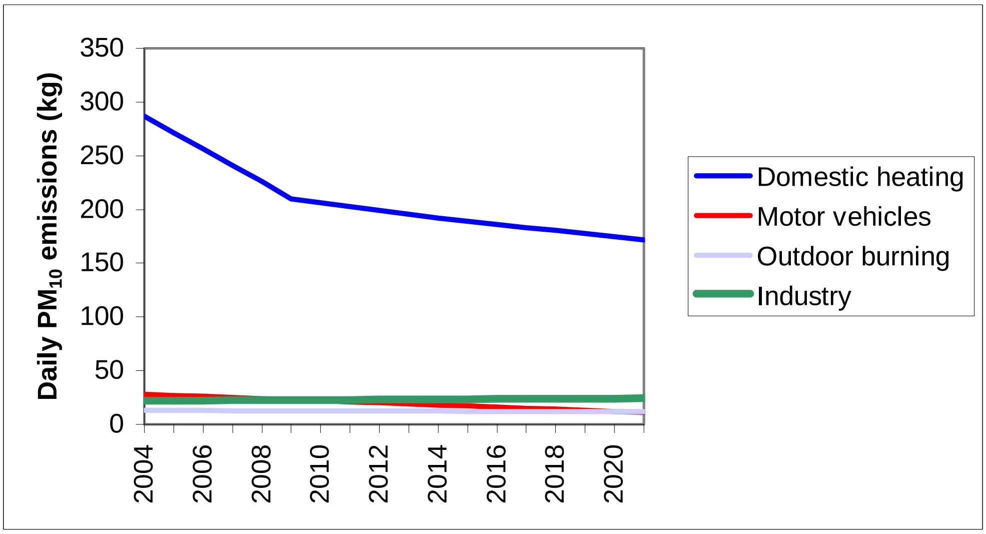


Figure 5-1: Projections in emissions from all sources in Te Kuiti

The effectiveness of different management options in reducing PM_{10} concentrations also depends on the relationship between emissions and concentrations in Te Kuiti. This includes the impact of the time of day emissions occur relative to meteorological conditions and how reductions in PM_{10} emissions influence reductions in PM_{10} concentrations.

The time of day impact relates to how emissions occurring at different times of the day influence the 24-hour average concentration. For example, emissions that occur when wind speeds are lowest and temperature inversions are present (typically evening and early morning) will have a greater impact on 24-hour average concentrations.

Although the relationship between emissions and concentrations at different times of the day has not been established for Te Kuiti, it is most likely that emissions that occur in the evening and early morning will have the greatest impact on 24-hour average PM_{10} concentrations. Table 5.1 shows an estimate of daily variations in emissions sources from the 2001 domestic heating inventory and 1997 motor vehicle and industrial emissions inventories[5]. This shows that about 54% of the domestic heating emissions occur in the evening (4pm-10pm) period, compared to 31% of motor vehicle PM_{10} emissions. Based on these data, it is likely that the time of day impact may result in a slightly higher contribution to PM_{10} concentrations from domestic home heating relative to motor vehicles.

[5] As no time of day breakdowns were available for industry for Te Kuiti, it was assumed that emissions from this source were spread evenly throughout the day.

Table 5-1: Source contributions to PM10 emissions at different times of the day

	6am-10am kg	10am-4pm kg	4pm-10pm kg	10pm-6am kg	Total kg
Domestic heating	29	51	152	50	282
Motor vehicles	6	12	9	2	28
Outdoor burning	3	10			13
Industry	4	6	6	7	22
Total	42	79	166	58	345

The other impact of meteorology is how reductions in PM_{10} emissions influence reductions in PM_{10} concentrations. In Christchurch, modelling work carried out by NIWA suggests that this relationship is linear, indicating a proportional reduction in concentrations for a reduction in emissions (Gimson & Fisher, 1997). That is, if emissions were reduced evenly across all time periods.

In the absence of modelling of the relationship between emissions and concentrations for Te Kuiti, the assessment of effects has been based on the assumption of a linear relationship between emissions and concentrations and no impact of time of day emissions occurring relative to meteorological conditions. The impact of the latter assumption is likely to be a conservative estimate of the effectiveness of management options for domestic heating (i.e., the assessment will slightly under predict the impact of options targeting domestic heating PM_{10} emissions).

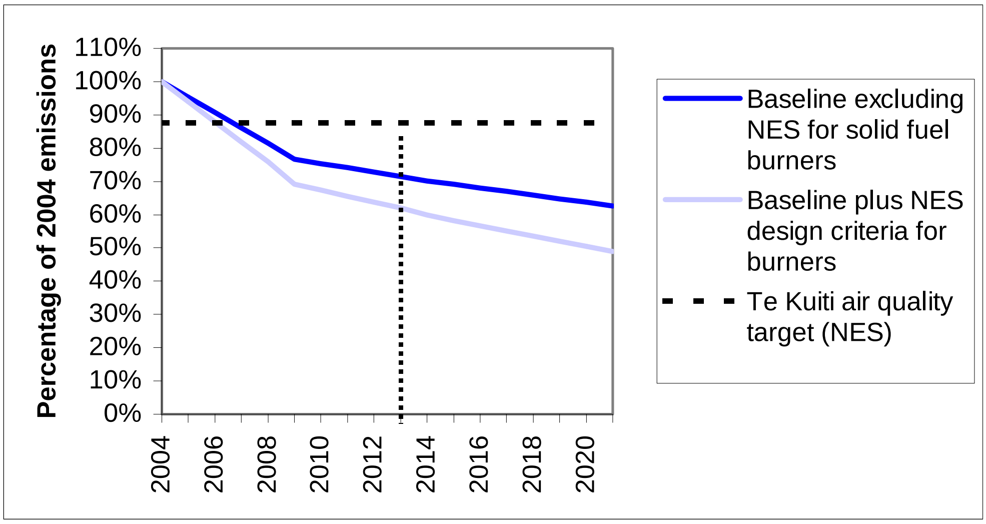


Figure 5-2: Projections for PM10 emissions in Te Kuiti with and without the NES design criteria for solid fuel burners

Based on the projected PM_{10} concentrations shown in Figure 5.2 it is likely that the introduction of the NES for solid fuel burners should result in achievement of the ambient air target by around 2007. Factors that may contribute to the target not being met include:

- Older solid fuel burners not being phased out within 15 years of installation.
- An increase in the proportion of households using open fires or older solid fuel burners.
- Non-compliance with the NES design standard for wood fuel burners.
- An increase in the proportion of households installing new multi fuel burners instead of wood burners complying with the NES.
- An increase in the quantity of fuel burnt on existing burners or open fires.
- The contribution of sources from outside of the urban areas of Te Kuiti.

- If sources other than those considered, e.g., natural dusts, are a major contributor to PM_{10} concentrations in Te Kuiti.

Estimates of PM_{10} shown in Figure 5.2 are also based on a number of assumptions, which are outlined in Table 5.2. There are uncertainties associated with these assumptions and those associated with the underlying data, e.g., the emission inventory and air quality monitoring. Where assumptions are made about human behaviour there is the potential for variations in the associated emissions, for example, changes in electricity prices, electricity shortages or concerns about gas supplies can influence heating choices. Other factors such as economic conditions or uncertainties, income levels, or interest and mortgage rates, can also affect the choices that people make about their heating methods and consequently affect the real life emissions from solid fuel burning.

Table 5-2: Assumptions underlying the assessment of the effectiveness of management options for reducing PM10 emissions

1	A decrease in PM_{10} emissions from motor vehicles of around 60% by 2021. This is based on reductions estimated for other urban areas of the Waikato such as Hamilton and Taupo and depends largely on the NZTER emission rates for 2021, which are significantly lower than 2005 rates because of the estimated impact of changes in engine technology.
2	**The industry contribution to PM_{10} emissions is 8% and increases by around 10% from 2001 to 2021.**
3	Current and future outdoor burning emissions occur throughout the week and weekend.
4	**Emission factors for burners as per the 2004 Te Kuiti domestic heating emissions assessment (Appendix A).**
5	Average fuel use for 1.5 g/kg burners of 30 kg per night as per the post 1999 burners in the 2004 emission inventory survey.
6	**Average fuel use for other burners as per the 2004 Te Kuiti emission inventory survey.**
7	A proportional reduction in concentrations for any given reduction in emissions.
8	No variations in the impact of emissions occurring at different times of the day.
10	**A decrease in occupied dwellings in Te Kuiti of around 10% from 2001 to 2021.**
11	Unless otherwise stated, 100% of households replacing open fires or older solid fuel burners will install solid fuel burners.
12	An emission factor for 1.5 g/kg burners of 3 g/kg.
13	All new installations of wood burners from 2005 will meet an emission criterion of 1.5 g/kg when tested to NZS 4013.
14	Around 10% of households installing solid fuel burners will install a multi fuel burner that does not comply with the NES design criteria for wood burners.

Although the projections for Te Kuiti suggest that the NES for PM_{10} is likely to be met by 2013, Environment Waikato may also want to consider the option of banning outdoor burning in the urban areas of Te Kuiti as an additional measure. This practice is already prohibited in many urban areas of New Zealand because of the nuisance effects of smoke and odour. Currently outdoor burning contributes around 4% of PM_{10} emissions in Te Kuiti. Figure 5.3 shows the estimated impact on PM_{10} concentrations in Te Kuiti if outdoor burning were prohibited in 2005. Additional benefits include a reduction in smoke and odour nuisance occurring as a result of this practice. The costs associated with implementing this option include enforcement and costs to households and orchards in finding alternative disposal methods.

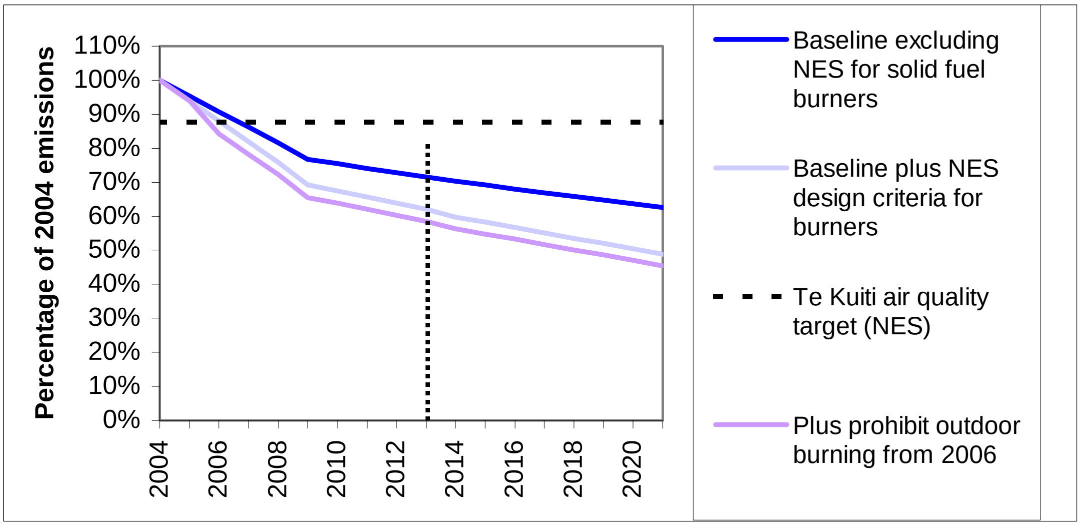


Figure 5-3: **Projections for PM10 emissions in Te Kuiti if outdoor burning is prohibited by 2006**

Open fires contribute about 6% of PM_{10} emissions from domestic heating in Te Kuiti and are an inefficient method of home heating. Figure 5.4 shows the additional impact on PM_{10} concentrations in Te Kuiti if all open fires were removed and 50% were replaced with low emission solid fuel burners or multi fuel burners.

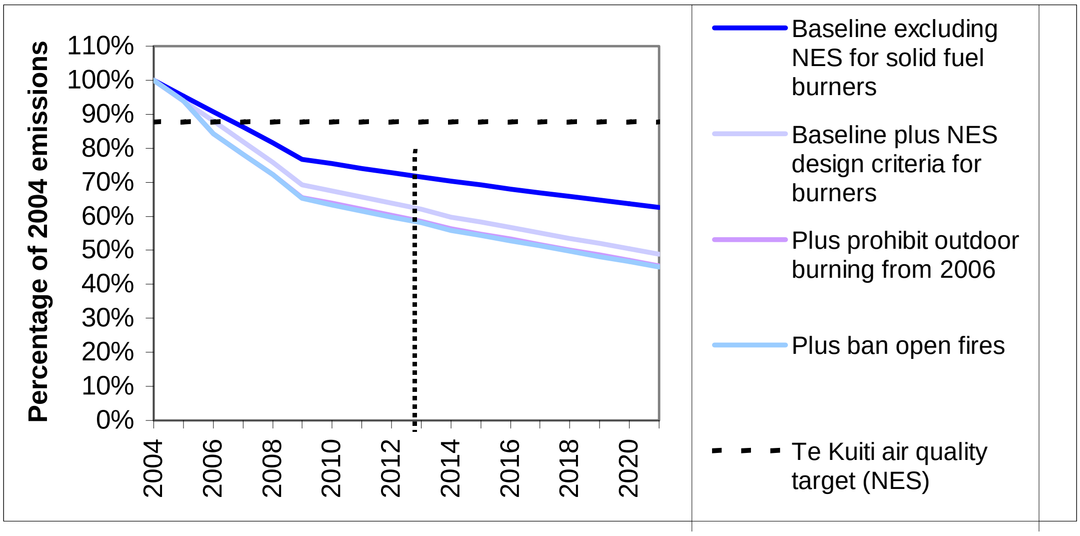


Figure 5-4: **Projections for PM10 emissions in Te Kuiti if outdoor burning is prohibited by 2006 and open fires are replaced with low emission burners by 2010**

6 Conclusions

Concentrations of PM_{10} measured in Hamilton have exceeded the National Environmental Standard of 50 µg m^{-3} (24-hour average) from 0 to 4 times per year since monitoring commenced in 1997. Reductions in PM_{10} concentrations required to meet the NES in Hamilton are around 12%. This is based on one allowable breach per year. If an air quality target of 50 µg m^{-3} with no allowable breaches were to be achieved, a reduction of around 25% would be required.

In Te Kuiti, PM_{10} concentrations have breached the 50 µg m^{-3} guideline on five occasions per year for both 2003 and 2004. Based on these data, a reduction of around 10% would be required to meet the NES. If an air quality target of 50 µg m^{-3} with no allowable breaches were to be achieved, a reduction of around 18% would be required. However, it is possible that meteorological conditions during 2003 and 2004 did not represent the worst case situation, and therefore higher PM_{10} concentrations could occur.

The main source of PM_{10} in both locations is solid fuel burning for domestic home heating.

An analysis of the effectiveness of measures to reduce PM_{10} concentrations suggests that in both areas the NES may be met by 2013 in the absence of additional regulations. This is because the Ministry for the Environment has included in the NES a design standard for new installations of solid fuel burners, requiring them to meet an emission limit of 1.5 grams of particulate per kilogram of fuel burnt and a thermal efficiency of 65%. Emissions of PM_{10} are predicted to decrease as older more polluting burners are replaced with efficient low emission burners meeting an emission limit of 1.5 g/kg. This conclusion is dependent on the assumption that the real life operating emissions from NES compliant burners are significantly lower than for older non-complying burners.

The projections are based on a number of uncertainties, however, and additional measures may be considered to increase the probability of compliance. It is proposed that the banning of outdoor rubbish burning be considered in both areas because of the contribution to ambient PM_{10} concentrations as well as the localised smoke and odour nuisance.

The main barriers to achievement of the air quality target are the potential for contribution from non-anthropogenic sources and the occurrence of meteorological conditions more conducive to elevated pollution than those experienced from 1997 to 2004 for Hamilton and 2003 and 2004 for Te Kuiti. In addition, non-replacement of solid fuel burners within 15 years of installation may delay achievement of the NES.

Appendix A: PM_{10} emission factors

Table A.1: PM_{10} emission factors for solid fuel burning

	Hamilton PM_{10} g/kg	Te Kuiti PM_{10} g/kg
Open fire - wood	10	10
Open fire - coal	21	21
Category 1 woodburner[1]	11	11
Category 2 woodburner	7	7
Category 3 woodburner	6	6
Multi-fuel[2] **– wood**	13	13
Multi-fuel[2] **– coal**	28	28
1.5 g/kg wood burner	3	3

[1] – Category 1 burners = pre 1994 for Te Kuiti and pre 1995 for Hamilton, Category 2 = 1994 – 1999 for Te Kuiti and 1995 – 2000 for Hamilton, Category 3 = Post 1999 for Te Kuiti and Post 2000 for Hamilton

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

Appendix B: Population projections

The population projection for Hamilton is based on New Zealand Statistics population projections for medium growth of 26% from 2001 to 2021 for Hamilton City. The same data source indicates a 10% decrease in the population of the Waitomo District. It is assumed that this figure applies to the urban area of Te Kuiti. In the absence of better information, it is assumed that the population projections also apply to the number of occupied dwellings.

The following is an excerpt from the New Zealand statistics website http://www.stats.govt.nz/domino/external/omni/omni.nsf/outputs/Demographic+Projections#SPP) which provides some explanation for the derivation of population projections.

Subnational Population Projections

Projections (2001-base to 2021 at five-year intervals) of the population usually living in the 16 regional council areas and 74 territorial authority areas (cities and districts) of New Zealand were released via a Hot Off the Press (Cat 03.507) on 21 November 2002.

Base Population

These projections have as a base the estimated resident population of each area at 30 June 2001. This population was based on the census usually resident population count of each area at 6 March 2001, with adjustments for:

a. net census undercount
b. residents temporarily overseas on census night
c. births, deaths and net migration between census night (6 March 2001) and 30 June 2001
d. reconciliation with demographic estimates at ages 0–9 years.

For more information about the base population, refer to Population Estimates.

Alternative Series

Three alternative series (designated low, medium and high) have been produced for each area using different fertility, mortality and migration assumptions. At the time of release, the medium projection series is considered the most suitable for assessing future population change and is consistent with series 4 of the 2001-base National Population Projections released on 24 October 2002. The medium projection series uses medium fertility, medium mortality and medium net migration for each area.

The low and high projection series are independent of any series of national population projections as they represent plausible alternative scenarios for each area rather than at the collective national level. The low projection series uses low fertility, high mortality and low net migration for each area. The high projection series uses high fertility, low mortality and high net migration for each area.

Appendix C: Uncertainty Analysis

As outlined in the body of the report, the estimates of projections in PM_{10} emissions for different management options are based on a number of assumptions. The uncertainty surrounding each of these assumptions can be combined statistically to give an overall uncertainty indication for the projections.

Figure A1 shows the air plan and incentives projections based on a combination of management options for Hamilton with additional estimates of the uncertainty surrounding the projections. The management options include prohibition of outdoor rubbish burning as well as the use of open fires. The uncertainty estimates are a statistical extrapolation based on the formulae described in Topping[6] for a 95% confidence interval. Uncertainty estimates are based on the following assumptions:

- 100% uncertainty associated with emission factors for solid fuel burning.
- 50% uncertainty associated with fuel use factors for solid fuel burning.
- Varying uncertainty associated with estimated household numbers starting at 20% for 2002 and increasing to 56% for 2021.
- 6% variability associated with the assumptions relating to the impact of meteorology.
- Varying uncertainty associated with estimates of emissions from motor vehicles and industry starting at 20% in 2002 and increasing to 40% by 2021.

Figure A1 shows the uncertainty surrounding the PM_{10} projections for Hamilton and indicates a high probability that the NES for PM_{10} will be achieved in Hamilton for the management options proposed.

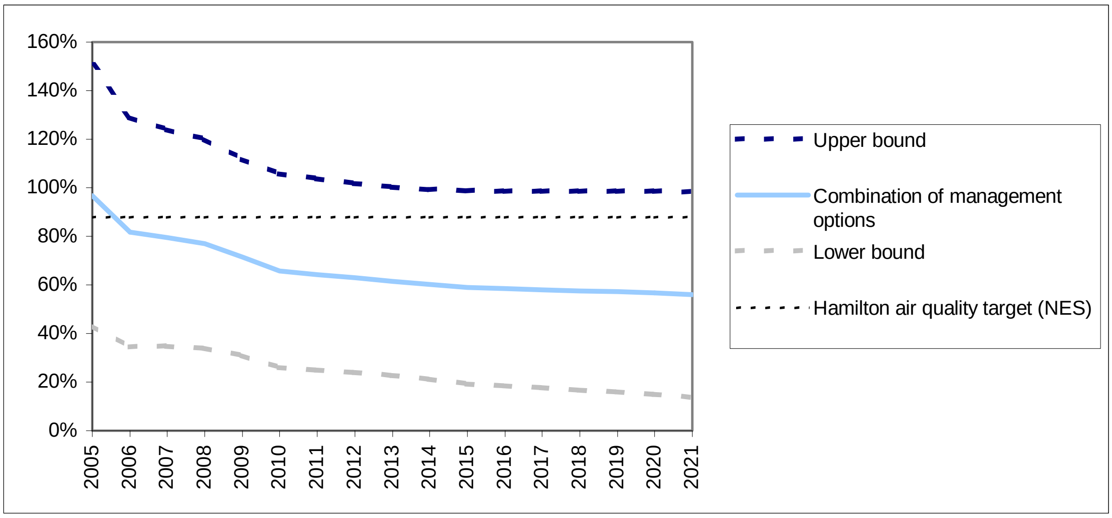


Figure A1: Estimates of uncertainty for PM_{10} projections for Hamilton

Figure A2 shows the uncertainty estimates for Te Kuiti for the management option, which includes a ban on outdoor rubbish burning as well as the use of open fires. This suggests a reasonable probability that the NES for PM_{10} might be met by 2013.

[6] Topping, J. 1971, Errors of observation and their treatment (3rd Edition) Chapman and Hall Ltd, England.

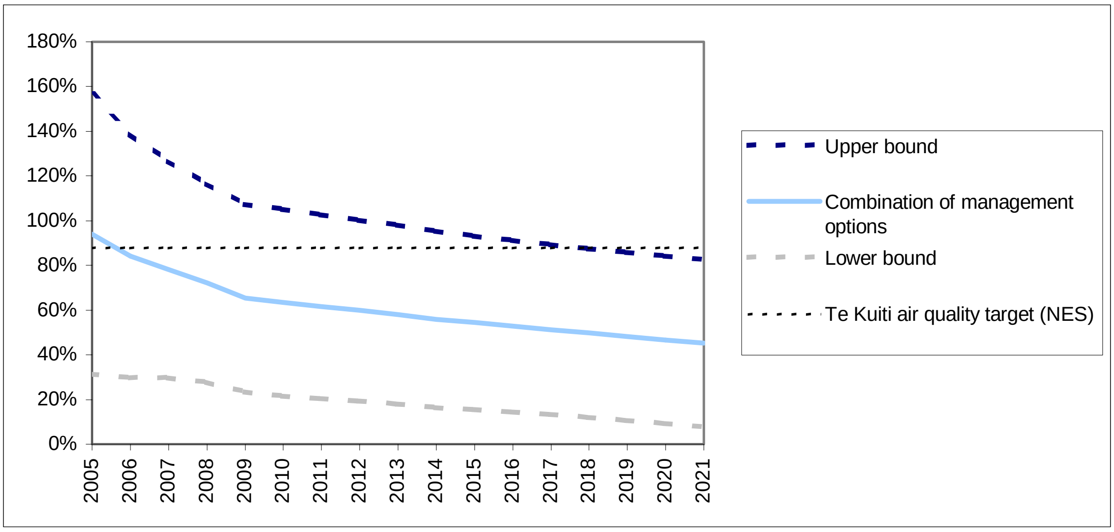


Figure A2: Estimates of uncertainty for PM_{10} projections for Te Kuiti