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Management of PM_{10} in Hamilton, Taupo, Te Kuiti and Tokoroa

An Assessment of Management Options to Achieve National Environmental Standards

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Abstract

Concentrations of PM_{10} exceed National Environmental Standards (NES) for PM_{10} in a number of urban areas of the Waikato. The NES is set at 50 µg m^{-3} (24-hour average) with one allowable exceedence per year. The Regional Air Plan sets a more stringent target for PM_{10} of 33 µg m^{-3} (24-hour average).

The main areas of concern are Taupo, Te Kuiti, Hamilton and Tokoroa. The maximum measured 24 hour PM_{10} concentrations in these areas are 89 µg m^{-3} (Taupo - 2006), 69 µg m^{-3} (Te Kuiti - 2006), 68 µg m^{-3} (Hamilton - 2006) and 75 µg m^{-3} (Tokoroa - 2001). Highest PM_{10} concentrations in all areas are measured during the winter months. Reductions in PM_{10} concentrations required to meet the NES are: 44% for Taupo, 33% for Tokoroa, 28 for Te Kuiti, 27% for Hamilton.

The main source of PM_{10} emissions in these areas is from solid fuel burning for domestic home heating. In Taupo domestic heating contributes around 88% of the daily winter PM_{10} with 9% from motor vehicles, 3% from outdoor burning and less than 1% from industry. Similar contributions are observed for Tokoroa with 89% domestic, 5% outdoor burning, 5% motor vehicles and 1% industry. In Te Kuiti solid fuel burning is estimated to contribute around 89% of the PM_{10}, with motor vehicles contributing 6% and industry 5%. In Hamilton the contribution from domestic heating is 72%, with motor vehicles contributing 11%, outdoor burning 13% and industry 4%. 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 Taupo, Te Kuiti, Hamilton and Tokoroa are examined in this report. Results suggest that the NES is unlikely to be met in any area without additional measures. A combination of incentives and regulations is likely to be required in all locations.

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1 Introduction

Air quality monitoring in the Waikato shows PM_{10} concentrations in Hamilton, Taupo, Tokoroa and Te Kuiti exceed the National Environmental Standard (NES) for PM_{10} on occasion during the winter months. The Ministry for the Environment requires the NES to be met by 2013 or the Council will be unable to grant resource consents for discharges to air in non-complying airsheds. The NES for PM_{10} is set at 50 µg m^{-3} (24-hour average). The Regional Air Plan specifies a lower target for PM_{10} of 33 µg m^{-3} (24-hour average).

In Hamilton, concentrations of PM_{10} 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 69 µg m^{-3} and was measured in June 2006. This compares with a highest measured PM_{10} concentration in Taupo of 89 µg m^{-3} and 68 µg m^{-3} in Te Kuiti. Highest concentrations in these locations were also measured in 2006.

For Tokoroa, the maximum measured PM_{10} concentrations is assumed to be a value of 75 µg m^{-3} recorded during 2001. Some more recent measurements have recorded higher values but significant concerns exist about the accuracy of the monitoring equipment during these times (Smith, 2006).

Monitoring data therefore show that the highest PM_{10} concentrations in the Waikato region were recorded at Taupo, followed by Tokoroa, Hamilton and Te Kuiti. Environment Waikato have calculated the reductions required in PM_{10} in each of these areas are: 44% for Taupo, 33% for Tokoroa, 27% for Hamilton and 28% for Te Kuiti.

An assessment of the management options required to meet the NES had been prepared for Hamilton and Te Kuiti (Wilton, 2005a) and for Tokoroa and Taupo (Wilton, 2005b). Since the preparation of these reports higher PM_{10} concentrations have been measured in three of the four areas. This has implications for the reductions in PM_{10} emissions required to meet the NES and consequently the effectiveness of different management options. Other changes in information on model input parameters will also impact on previous assessments. The purpose of this report is to update the analysis of the effectiveness of management options for reducing PM_{10} and consider the effectiveness of options relative to achieving the NES by 2013.

2 Sources of PM_{10}

2.1 Taupo Emission Inventory – 2004

An emission inventory was carried out for Taupo during 2004. The inventory quantified emissions to air of PM_{10}, CO, SOx, NOx and CO_2 and included domestic home heating, motor vehicles, outdoor burning and industry. The contribution of natural sources such as dusts and sea spray cannot be identified in a robust manner using an inventory approach.

Figure 2.1 shows the domestic heating contribution to daily winter PM_{10} emissions in Taupo is 88%, with motor vehicles producing around 9% of the PM_{10} emissions, outdoor burning 3% and industry less than 1%.

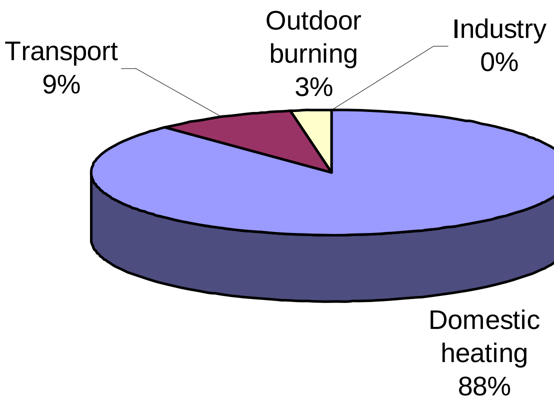

Figure 2-1: Sources of PM_{10} emissions in the urban areas of Taupo in 2004

2.2 Tokoroa Emission Inventory – 2005

An emission inventory for Tokoroa was completed in 2004. However, the domestic heating emissions were estimated again during 2005 and revised estimates of the relative contribution were made (Wilton, 2005c). Figure 2.2 shows the relative contribution to daily winter PM_{10} emissions based on the latter assessment. The industrial assessment excludes emissions from Kinleith pulp and paper mill, as these were considered unlikely to significantly impact on PM_{10} concentrations in Tokoroa (Wilton, 2005b).

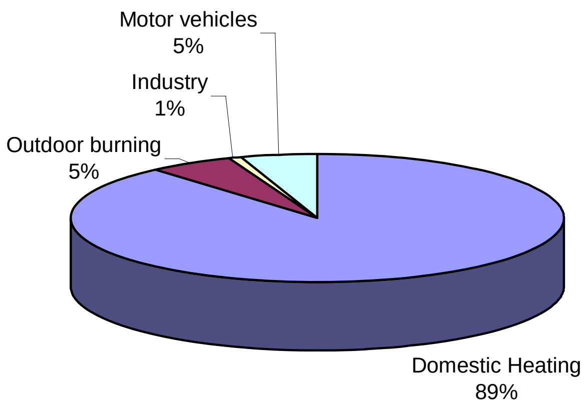

Figure 2-2: Sources of PM_{10} emissions in the urban areas of Tokoroa in 2005

2.3 Hamilton Emission Inventory - 2005

An emission inventory for Hamilton was carried out during 2005 (Wilton, 2005d). 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 2.3).

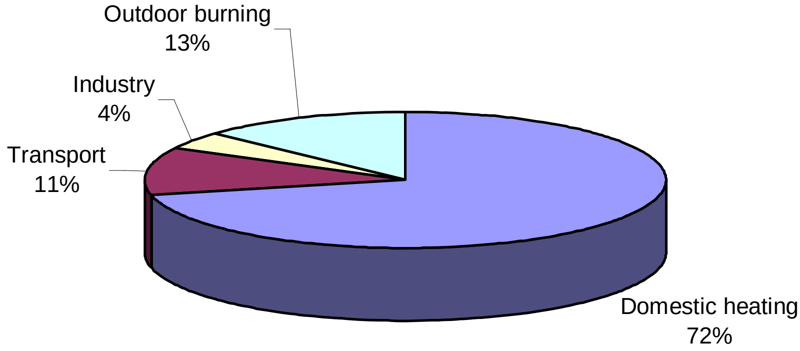

Figure 2-3: Sources of PM_{10} emissions in the urban areas of Hamilton in 2005

2.4 Te Kuiti Emissions Assessment

In Te Kuiti, estimates of emissions from different sources have been made at different times. Industrial and motor vehicle emissions were estimated in 1997 (Noonan, 1997). 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 2.4). 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.

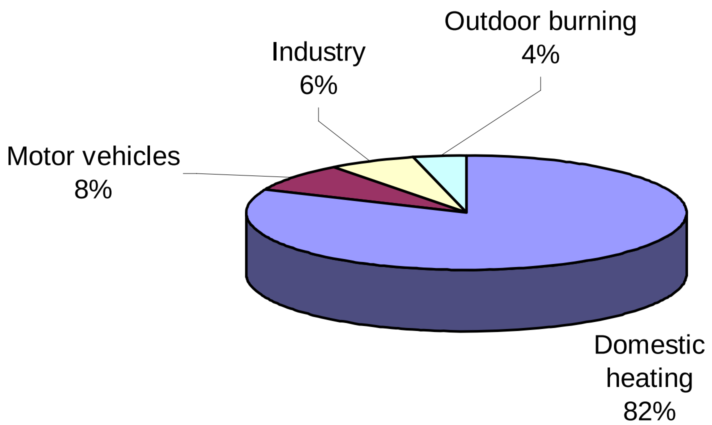

Figure 2-4: Estimates of sources of PM_{10} emissions in the urban areas of Te Kuiti

3 Managing air quality to meet the NES

A number of improvements in information on model input parameters have occurred since the preparation of the previous management options assessments. The most significant factor impacting on projections is the decision to use a more conservative emission factor for burners meeting the NES wood burner design criteria. This emission factor was revised from 3 grams of particulate per kilogram of fuel burnt to 6 g/kg (Wilton, Smith and Scott – personal meeting October 2005) based on the results of "real life" emission testing of a range of older (pre 1994) burners and a small number of NES compliant burners (Wilton & Smith 2005; Scott, 2005). Further emission testing of NES compliant burners is to be carried out during 2007 and may result in further modifications to this factor.

Other differences in assumptions applying to projections in all areas include:

- The use of a lower emission factor for pre-1995 woodburners (11 g/kg) than used in the previous projections model (13 g/kg).
- The assumption of a background PM_{10} concentration of around 3 μg m^{-3}.
- The phasing out of solid fuel burners 20 years after installation.
- The use of 2006 as a base year for assessing changes in PM_{10} emissions.

3.1 Tokoroa

3.1.1 Assumptions

In addition to the changes outlined previously, the projections model for Tokoroa was updated to incorporate the results of a domestic home heating survey, which was carried out for Tokoroa during 2005. The model was updated for these changes in September 2006 and for the background PM_{10}, the 20-year burner phase out and 2006 base year assumptions in December 2006. Table 3.1 outlines the average fuel use and emission factors used for different appliance and fuel type categories. Table 3.2 compares the assumptions underlying the original projections (Wilton 2005b) and the revised model projections.

Table 3-1: Revised fuel use and emission factors for 2006 model upgrade

	Fuel Use kg	Emission Factor g/kg
Open fire - wood	18	10
Open fire - coal	18	21
Wood burner -pre 1994	26	11
Wood burner - 1994-1999	26	8
Wood burner -Post 1999	26	7
Pellet	8	2
Woodburner 1.5 g/kg	26	6
Multifuel – wood	16	13
Multifuel – coal	9	28
Oil	4	0.03
Gas	1	0.03

Note for Tokoroa alone, the emission rate for the 1995-2000 and post 2000 burner age categories are slightly higher than in other areas. This is because burner installation information for this area indicates around 10% of newly installed burners are second hand.

Table 3-2: Changes in assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions (Adapted from Table 4.2 - Wilton, 2005b)

1	A decrease in PM_{10} emissions from motor vehicles of around 60% by 2021. This is likely to be conservative, i.e., a greater reduction is probable given the NZTER predictions for PM_{10} emissions as a result of improvements in vehicle technology. **Revised Note 2006: These may not be conservative as previously indicated.**
2	The industry contribution to PM_{10} emissions is less than 2% and there is no change in emissions from industry with time.
3	Current outdoor burning emissions occur throughout the week and weekend.
4	Emission factors for burners as per the 2004 Tokoroa emission inventory **Revised Note 2006: Emission factors for burners as per Table 3.1.**
5	Average fuel use for 1.5 g/kg burners of 28 kg per night as per the post 1999 burners in the 2004 emission inventory survey. **Revised Note 2006: Average fuel use for 1.5 g/kg burners of 26 kg per night as per the 2005 emission inventory survey (average for all burners).**
6	Average fuel use for other burners as per the 2004 Tokoroa emission inventory survey. **Revised Note 2006: Average fuel use for other burners as per the 2005 Tokoroa domestic heating survey (Table 3.1)**
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	No change in the number of households in Tokoroa from 2001 to 2021
11	Unless otherwise stated, 100% of households replacing open fires or older solid fuel burners will install solid fuel burners. **Revised Note 2006: Only 50% of households replacing open fires, if prohibited, will install solid fuel burners*.**
12	An emission factor for 1.5 g/kg burners of 3 g/kg. **Revised Note 2006: An emission factor for 1.5 g/kg burners of 6 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	All wood and multi fuel burners are phased out 15 years following installation. **Revised Note 2006: All wood and multi fuel burners are phased out 20 years following installation.**

*This is based on an evaluation of heating methods in households that use open fires which show a reasonable proportion also have an alternative solid fuel burner.

Other assumptions included in the analysis are:

- A 5% reduction in the number of open fires from 2005 to 2021.
- The size of an average outdoor rubbish fire is 150 kilograms per burn.
- No conversions of existing houses using other heating methods to solid fuel burners.
- For options including a ban on open fires, this is effective from 2009.
- For options including a ban on the installation of multi fuel burners this is effective from 2009.
- 4% of new burner installations will be multi fuel burners.
- For options including a pilot incentives programme encouraging clean heat alternatives at the end of a burner's useful life, the incentives are assumed to be effective from 2008.

Unlike Hamilton, Te Kuiti and Taupo, the starting point for Tokoroa has been estimated based on 2001 air quality monitoring data. There are some uncertainties around the starting point for the straight-line path for Tokoroa. In particular it is possible that reductions in PM_{10} emissions have occurred between 2001 and 2007. This includes closure of industry as well as changes in domestic heating emissions. It is possible that the reduction required is less than the 33% shown in subsequent graphs.

3.1.2 Projections

Figure 3.1 shows the status quo projections including the NES design criteria for new installations of woodburners. Based on this assessment, it is unlikely that PM_{10} concentrations in Tokoroa will meet the NES without additional management intervention.

Figure 3.2 shows the additional impact of a ban on outdoor rubbish burning in Tokoroa.

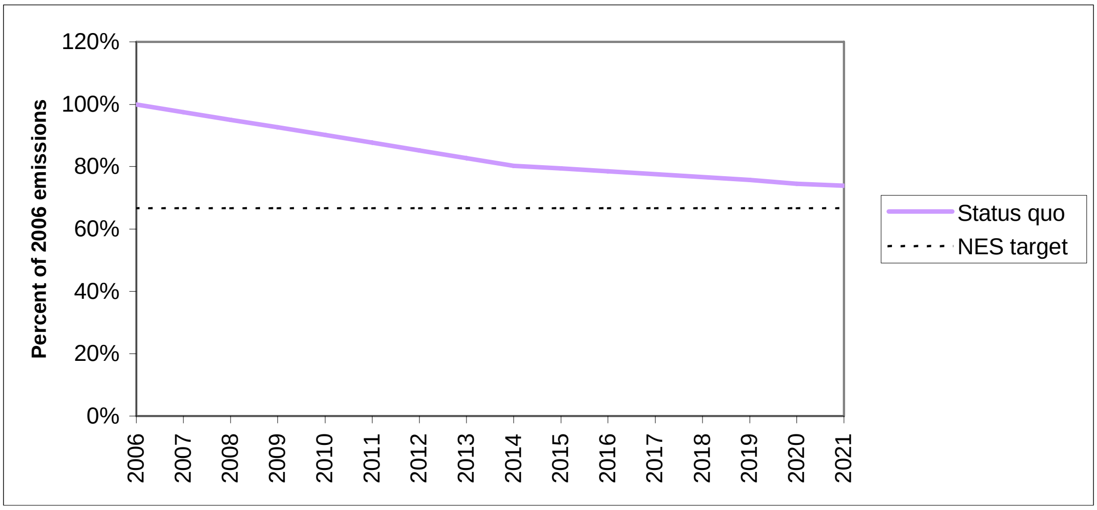

Figure 3-1: Status quo PM_{10} emission projections for Tokoroa

Figure 3-2: Effect on emission projections of banning outdoor rubbish burning in Tokoroa

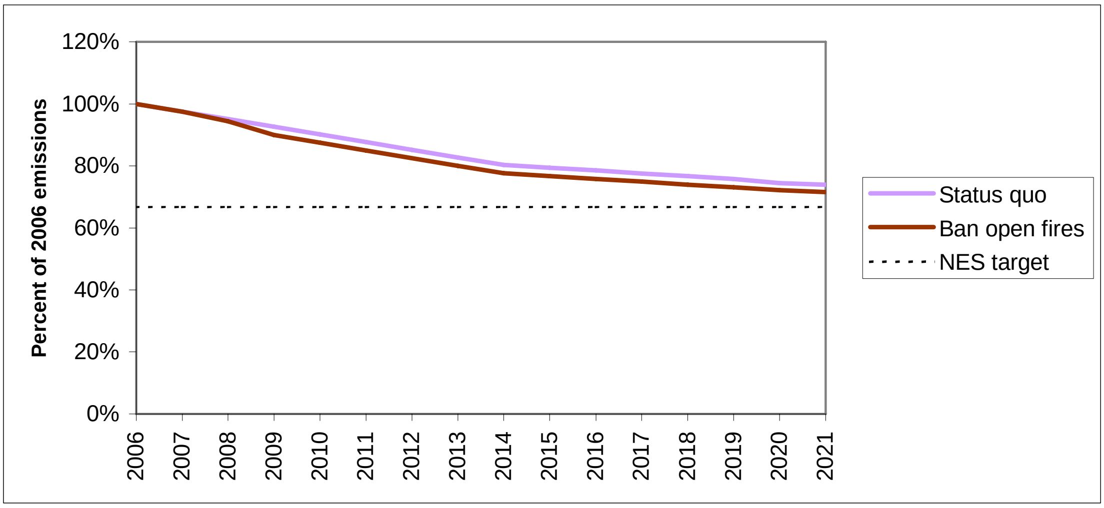

Figure 3-3: Effect of banning open fires on emission projections for Tokoroa

Figures 3.3 and 3.4 show the impact of a ban on the use of open fires and a combination of an open fire ban and restrictions on the installation of new multi fuel burners to those that comply with the NES design criteria for wood burners. Note that based on the current burner technology, this is effectively a ban on the installation of multi fuel burners.

Figure 3.5 shows the effectiveness of an incentives programme that encourages 50% of households replacing burners at the end of their useful life to choose non-solid fuel alternatives. An additional option of restricting the useful life of a burner to 15 years is also shown. While these two options show similar reductions by 2021, the latter appears better in terms of meeting the NES by 2013.

A further evaluation into the effectiveness of an end of life incentives programme found that even if all burners were converted to non-solid fuel at the end of their useful life, the maximum reduction achievable was estimated to be 35% for an assumed burner life of 20 years.

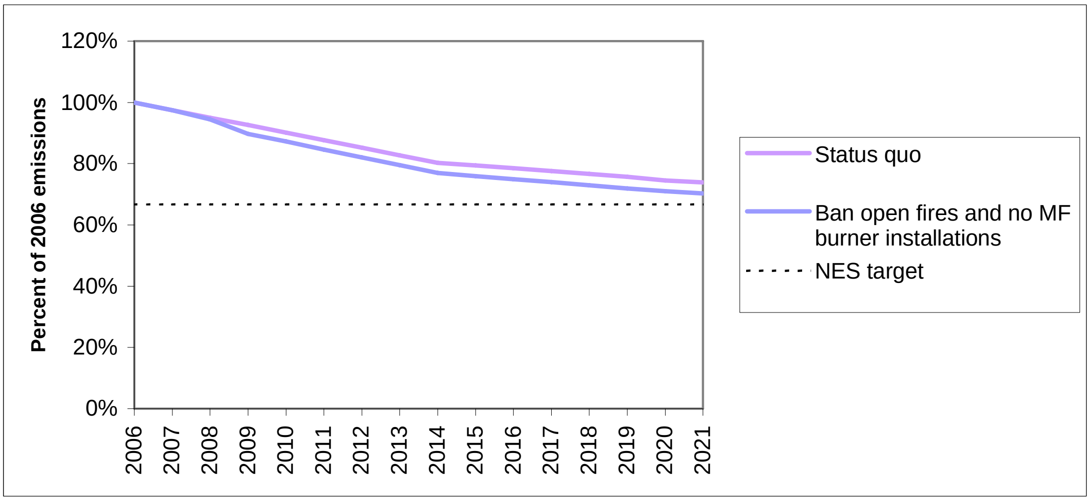

Figure 3-4: PM_{10} emission projections in Tokoroa, showing effect of banning open fires and no new multi fuel burner installations

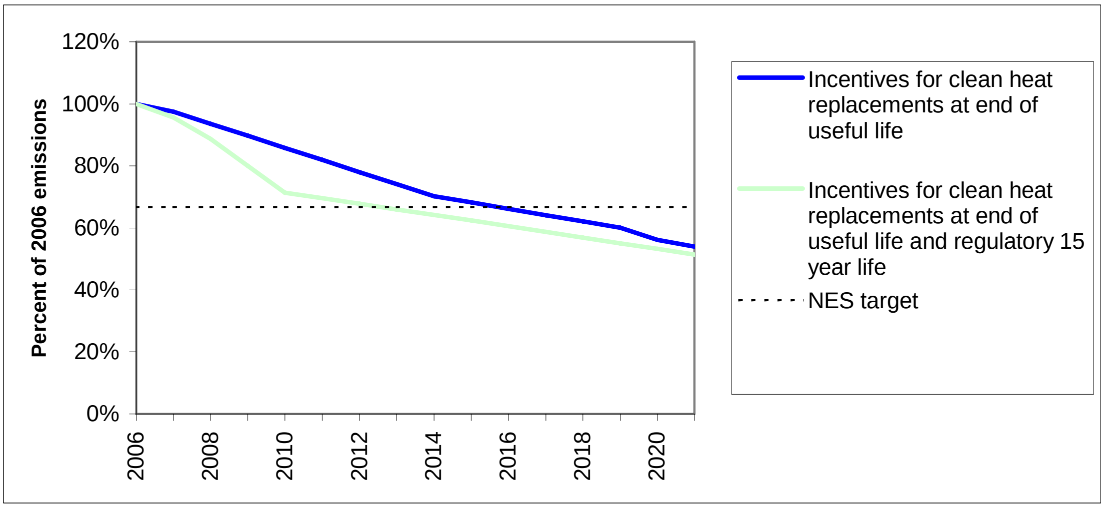

Figure 3-5: PM_{10} emission projections in Tokoroa, showing effect of incentives for clean heat replacements at the end of the useful life of a burner and the same incentives plus restricting the use of a burner to 15 years post installation

The effectiveness of an alternative (more expensive) incentives programme was also evaluated. Figure 3.6a shows the impact of replacing 30% of the existing burners to non-solid fuel heating methods prior to the end of their useful life. In addition, this method allows for uptake of the programme by 50% of households replacing burners at the end of their useful life. It is likely that around 1036 households would need to be funded between 2007 and 2013 to achieve the reductions illustrated in Figure 3.6a[1].

The same incentives programme is shown in Figure 3.6b with the addition of a ban on open fires and the installation of new multi fuel burners. Because of the impact of the latter regulation the replacement rate for 3.6b has been assumed to be 10% instead of 30%. Under this scenario, it is likely that around 920 households would need to be funded between 2007 and 2103 to achieve the reductions illustrated in Figure 3.6b.

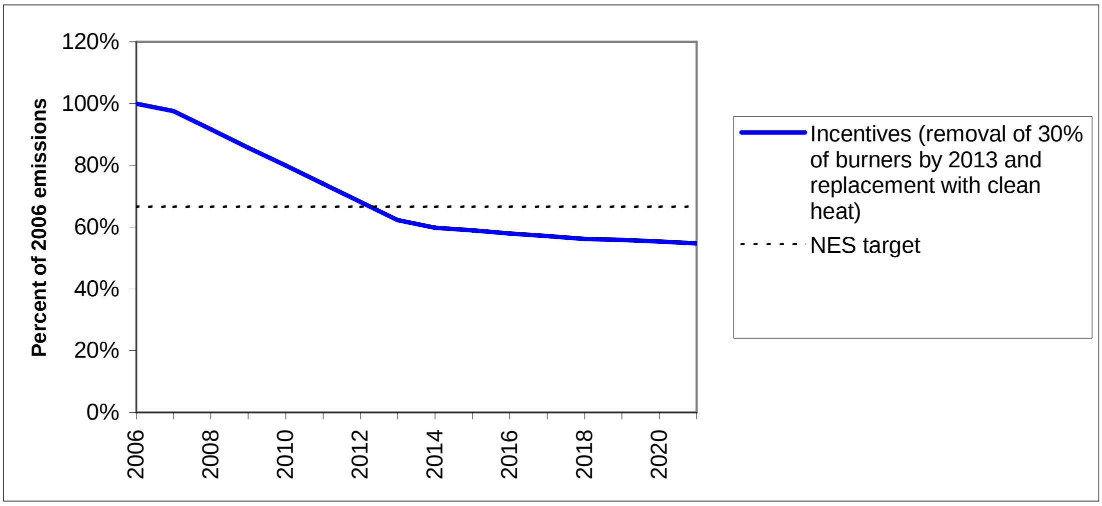

Figure 3-6(a): PM_{10} emission projections in Tokoroa, showing effect of alternative incentives programme targeting burners prior to the end of their useful life (removal of 30% of burners by 2013 and replacement with clean heat alternatives)

[1] Note that while the conversion could happen anytime from 2007 to 2013, Figures 3.6a and 3.6b assumes an incentives programme (and therefore any consequent conversions) would not be effective until 2008.

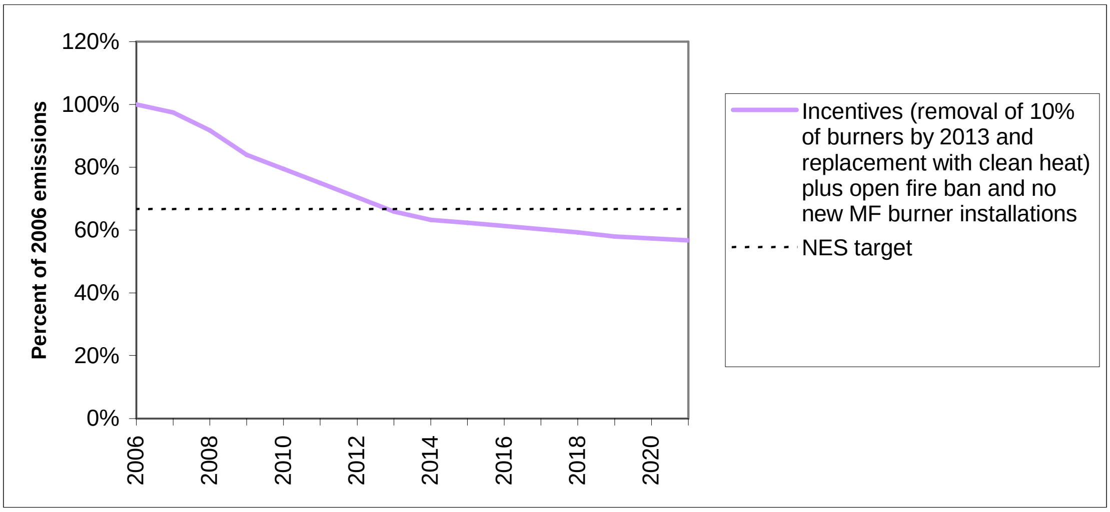

Figure 3.6(b): **PM_{10} emission projections in Tokoroa, showing effect of banning open fires, no new multi fuel burner installations and an alternative incentives programme targeting burners prior to the end of their useful life (removal of 10% of burners by 2013 and replacement with clean heat alternatives)**

Figure 3.7 shows a combination of a ban on open fires, a restriction on the installation of multi fuel burners to those meeting the NES design criteria for wood burners and incentives (aimed at a 50% non-solid fuel conversion at the end of the useful life of a burner).

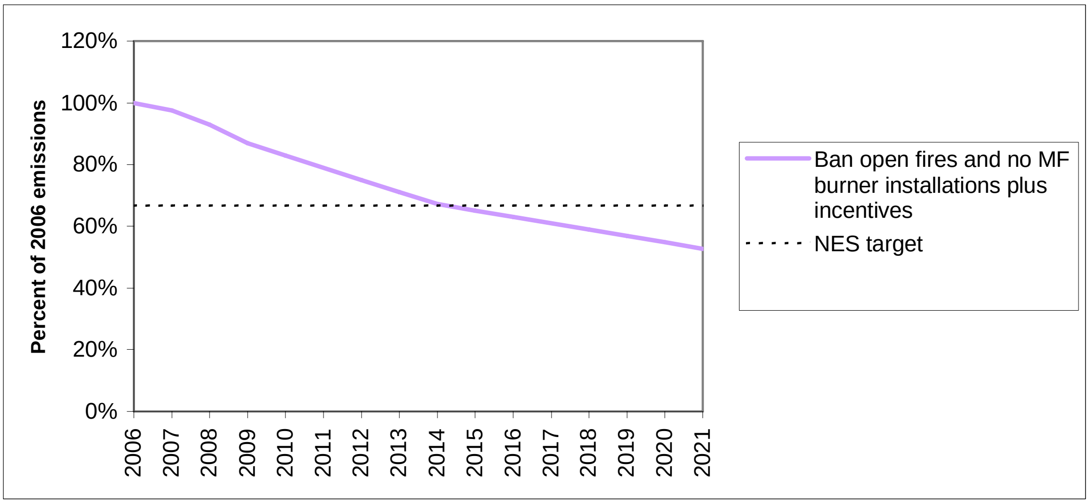

Figure 3-7: **PM_{10} emission projections in Tokoroa, showing effect of an open fire ban and no installations of multi fuel burners, plus incentives for clean heat replacements at the end of the useful life of the burner**

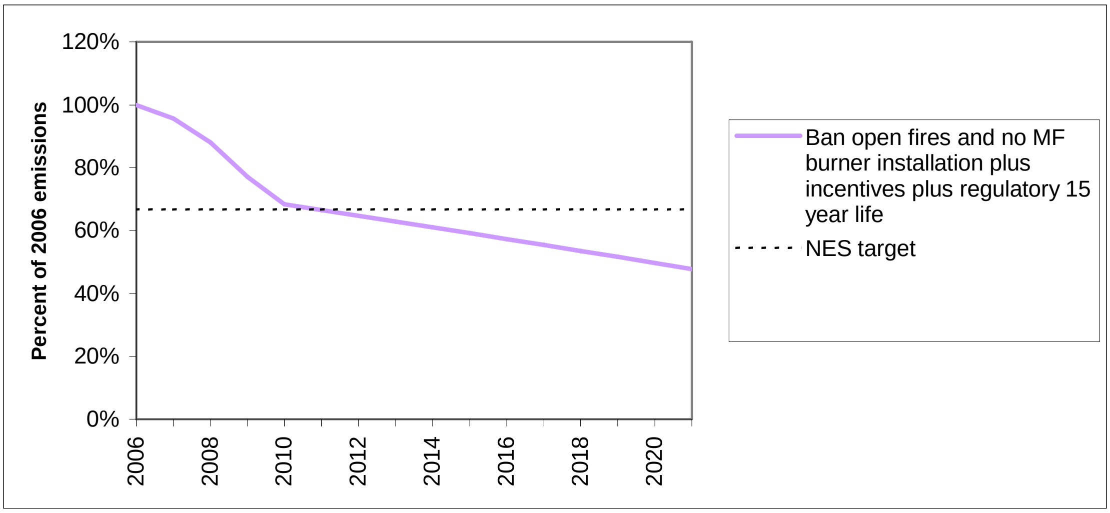

Figure 3-8: PM_{10} emission projections in Tokoroa, showing effect of an open fire ban and no installations of multi fuel burners, compulsory replacement of burners at the end of a 15-year life, plus incentives for clean heat replacements at the end of the useful life of the burner

Figure 3.8 shows a ban on open fires, no installations of multi fuel burners, compulsory phase out of burners 15 years after installation and incentives for clean heat replacements being up taken by 50% of households replacing burners. Under a 15-year replacement scenario, the number of burners reaching the end of their useful life is higher for each year. This has implications for the cost of an incentives programme. For example for the assumption of a 20-year useful life, the number of burners being replaced with clean heating methods each year from 2008 to 2013 based on a 50% up take is around 89, on average, compared with 123 households for a 15-year burner life.

Projections illustrated in Figures 3.2 to 3.8 are based on regulatory implementation dates of 2009 and incentives implementation dates of 2008. As these implementation dates may be optimistic, Figure 3.9 shows the impact of the regulatory and incentives options shown in Figure 3.6b but based on implementation of incentives in 2010 and regulatory measures in 2011. The delay is likely to result in a reduced number of conversions before 2013 (690) and this in turn reduces the probability that this combination would achieve the NES by 2013.

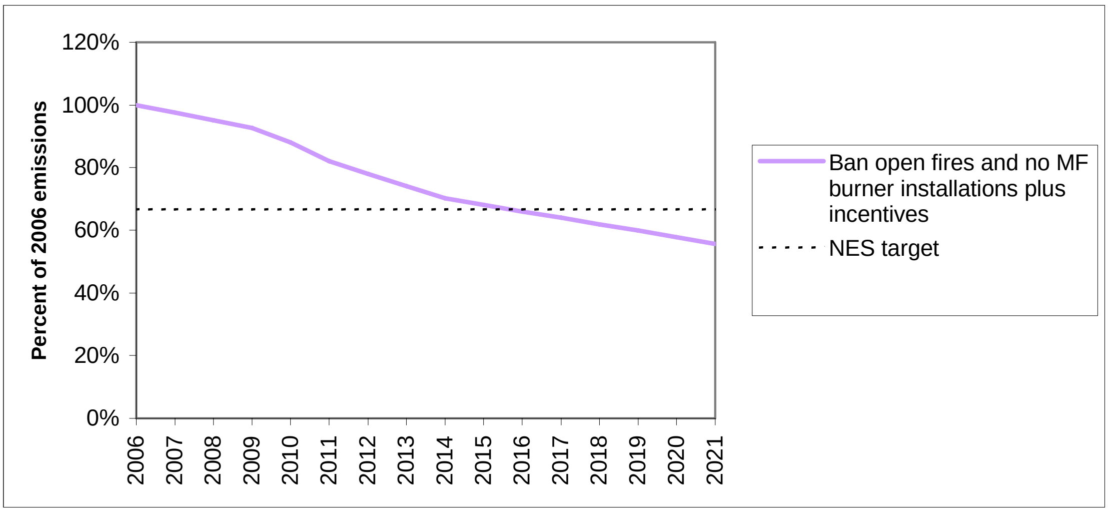

Figure 3-9: PM_{10} emission projections in Tokoroa, with implementation of management options delayed by two years. The plot shows combined impact of open fire prohibition and no installations of multi fuel burners, compulsory replacement of burners at the end of a 15-year life, plus incentives for clean heat replacements at the end of the useful life of the burner

3.1.3 Summary

The three most effective options for achieving the NES in Tokoroa (assuming outdoor rubbish burning will continue) appear to be:

1. An incentives programme aimed at converting 10% of existing solid fuel burners to clean heating methods prior to the end of their useful life and 50% of households replacing burners through natural attrition to non-solid fuel heating. Total conversions to be funded under this scenario are around 920.
2. An open fire ban, no installations of multi fuel burners, plus an incentives programme aimed at converting 25% of existing solid fuel burners to clean heating methods prior to the end of their useful life and 50% of households replacing burners through natural attrition to non-solid fuel heating. Total conversions to be funded under this scenario are around 1073.
3. A ban on open fires, no installations of multi fuel burners, the compulsory replacement of burners at the end of a 15 year life and incentives for clean heat replacements for burners at the end of the 15 year burner life. Total conversions to be funded under this scenario are around 875.

Additional projections showing the impact of delays in option one indicate a reasonable probability that the NES would not be met in Tokoroa if incentives were not implemented until 2010 and regulations until 2011. Projections also suggest that a ban on open fires, no installations of multi fuel burners and incentives for clean heat replacements for burners at the end of their life (without the 15 year phase out) is unlikely to meet the air quality target. However, it is recommended that the effectiveness of this option be re-evaluated post winter 2007, as it is possible that revisions to the reduction required may be warranted for Tokoroa.

3.2 Hamilton

3.2.1 Assumptions

The main changes to the management options assessment for 2005 for Hamilton is the increased PM_{10} concentrations, and therefore greater required reduction and the assumption of an emission rate for NES compliant burners of 6 g/kg of PM_{10}. The reduction required in PM_{10} concentrations in Hamilton has been estimated at around 27%. Table 3.3 outlines the average fuel use and emission factors used for different appliance and fuel type categories. Table 3.4 compares the assumptions underlying the original projections (Wilton 2005a) and the revised model projections.

Table 3-3: Revised fuel use and emission factors for 2006 model upgrade

	Fuel Use kg	Emission Factor g/kg
Open fire - wood	13	10
Open fire - coal	4	21
Wood burner -pre 1994	20	11
Wood burner - 1994-1999	20	7
Wood burner -Post 1999	20	6
Pellet	8	2
Woodburner 1.5 g/kg	20	6
Multifuel – wood	10	13
Multifuel – coal	36	28
Oil	5	0.03
Gas	1	0.03

Table 3-4: Changes in assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions (Adapted from Table 4.2 - Wilton, 2005b)

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. Emissions from this source increase with projection population growth.
4	Emission factors for burners as per the 2005 Hamilton emission inventory. **Revised Note 2006: Emission factors for burners as per Table 3.3**
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. **Revised Note 2006: Average fuel use 1.5 g/kg burners of 20 kilograms based on the average for all burners for the 2005 Hamilton inventory (Table 3.3).**
6	Average fuel use for other burners as per the 2005 Hamilton emission inventory survey. **Revised Note 2006: Same source used but fuel use averaged across all burner age categories.**
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 open fires or older solid fuel burners will install solid fuel burners. **Revised Note 2006: Only 50% of households replacing open fires, if prohibited, will install solid fuel burners*.**
12	An emission factor for 1.5 g/kg burners of 3 g/kg. **Revised Note 2006: An emission factor for 1.5 g/kg burners of 6 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	All wood and multi fuel burners are phased out 15 years following installation. **Revised Note 2006: All wood and multi fuel burners are phased out 20 years following installation.**

*This is based on an evaluation of heating methods in households that use open fires which show a reasonable proportion also have an alternative solid fuel burner.

Other assumptions included in the analysis are:

- A 10% reduction in the number of open fires from 2005 to 2021.
- The size of an average outdoor rubbish fire is 150 kilograms per burn.
- Around 0.5% of existing houses using other heating methods (11 household per year) convert to solid fuel burners each year.
- 10% of new dwellings install a wood burner.
- 20% of new burner installations are multi fuel burners.
- For options including a ban on open fires, this is effective from 2009
- For options including a ban on the installation of new multi fuel burners this is effective from 2009.
- For options including an incentives programme encouraging clean heat alternatives at the end of a burners useful life, the incentives are assumed to be effective from 2009.

3.2.2 Projections

In the absence of additional regulations for Hamilton, PM_{10} concentrations are not likely to change significantly from 2006 to 2021. Figure 3.10 shows a 13% decrease until 2014 followed by a 7% increase to 2021. Overall the status quo projections show a 4% decrease by 2021 and a trend of increasing emissions from 2014, which is likely to continue beyond 2021. The decrease until 2014 occurs because the phase out of older burners offsets the increase in population and dwellings during this period. Post 2014, however, the worst polluting burners have been removed and increases in population are no longer offset.

Figure 3.11 shows the impact of a ban on outdoor rubbish burning in Hamilton. A similar trend of emissions is observed once the impact of the ban on this burning is effective.

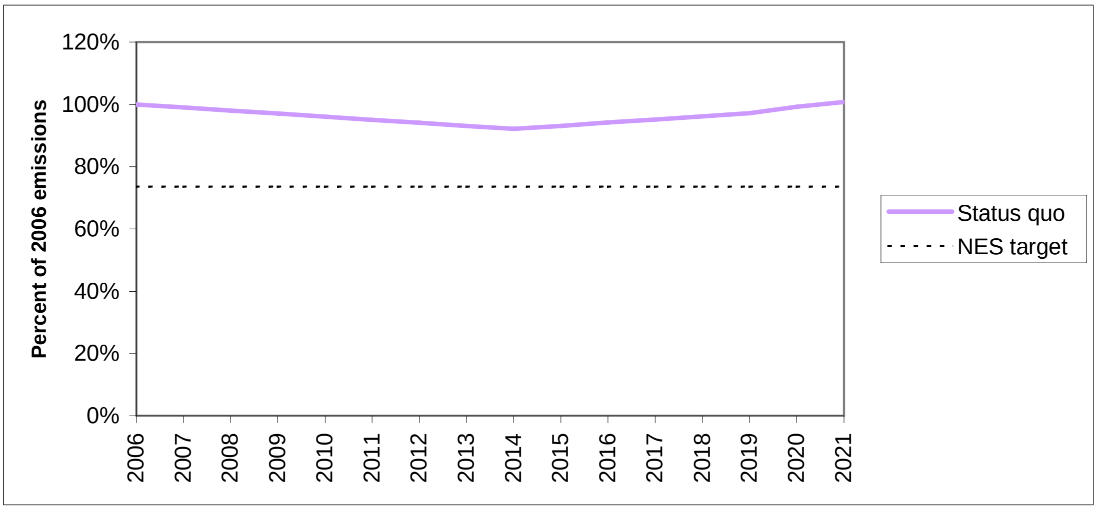

Figure 3-10: Status quo PM_{10} emission projections for Hamilton

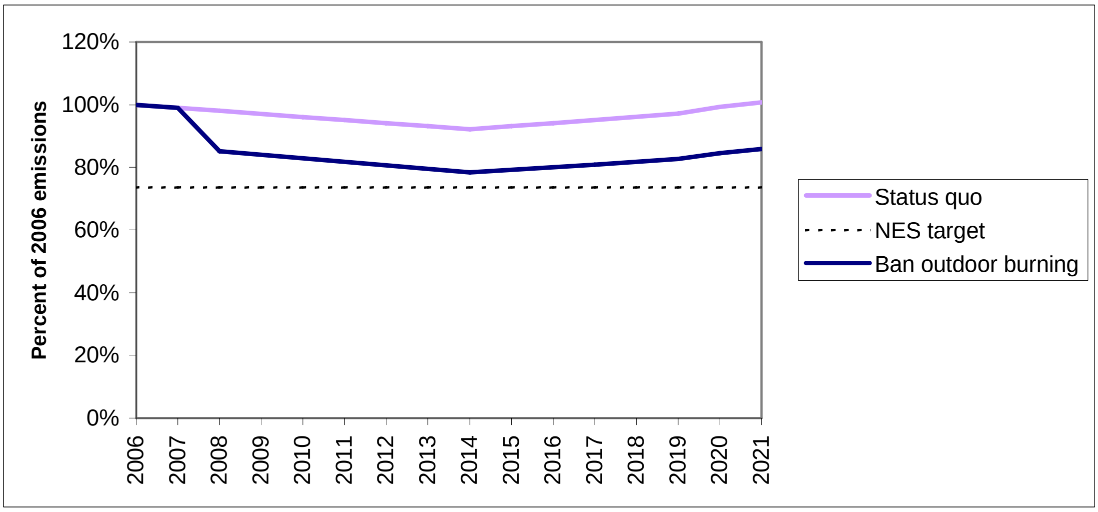

Figure 3-11: Effect on emission projections of banning outdoor rubbish burning in Hamilton

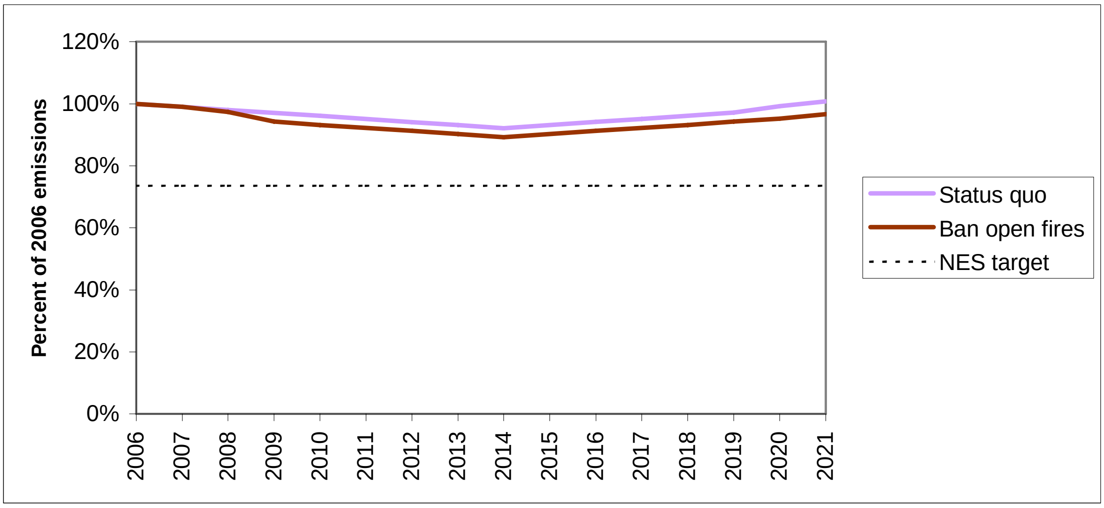

Figure 3-12: **PM_{10} emission projections in Hamilton, showing effect of banning open fires in Hamilton**

Figure 3-13: **PM_{10} emission projections in Hamilton, showing effect of banning open fires and no new multi fuel burner installations**

Figures 3.12 and 3.13 show the impact of a ban on the use of open fires and a combination of an open fire ban and restrictions on the installation of new multi fuel burners to those that comply with the NES design criteria for wood burners. As indicated previously, based on the current burner technology, this is effectively a ban on the installation of multi fuel burners. The impact of the additional regulations on the installation of multi fuel burners is very effective in reducing emissions in Hamilton.

Figure 3.14 shows the effectiveness of an incentives programme that encourages 50% of households replacing burners at the end of their useful life to choose non-solid fuel alternatives. An additional option of restricting the useful life of a burner to 15 years is also shown.

The effectiveness of an alternative (more expensive) incentives programme was also evaluated. Figure 3.15 shows the impact of replacing 30% of the existing burners to non-solid fuel heating methods prior to the end of their useful life. In addition, this method allows for uptake of the programme by 50% of households replacing burners at the end of their useful life. It is likely that around 2840 households would need to be converted between 2007 and 2013 to achieve the reductions illustrated in Figure 3.15.

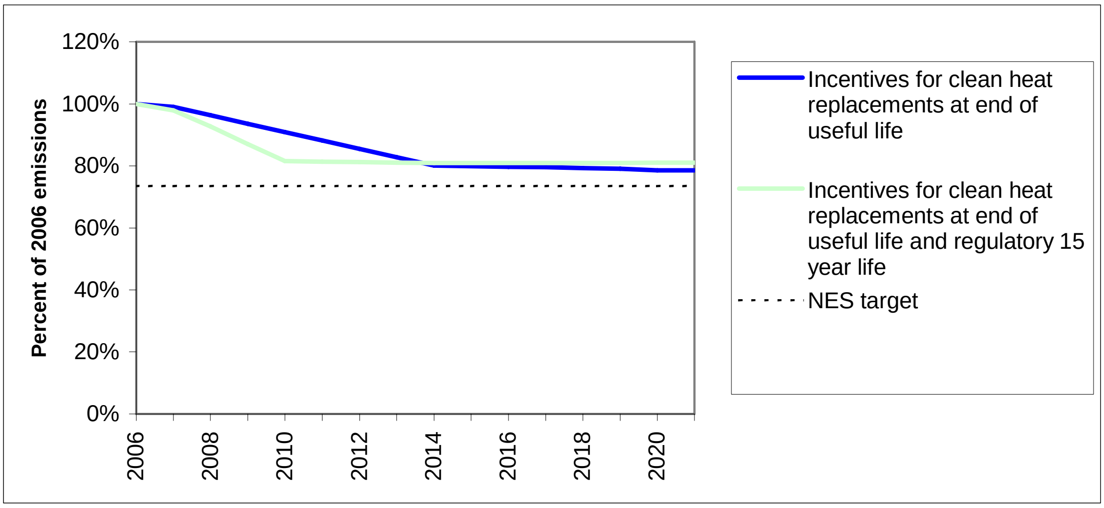

Figure 3-14: PM_{10} emission projections in Hamilton, showing effect of incentives for clean heat replacements at the end of the useful life of a burner, and the same incentives plus restricting the use of a burner to 15 years post installation

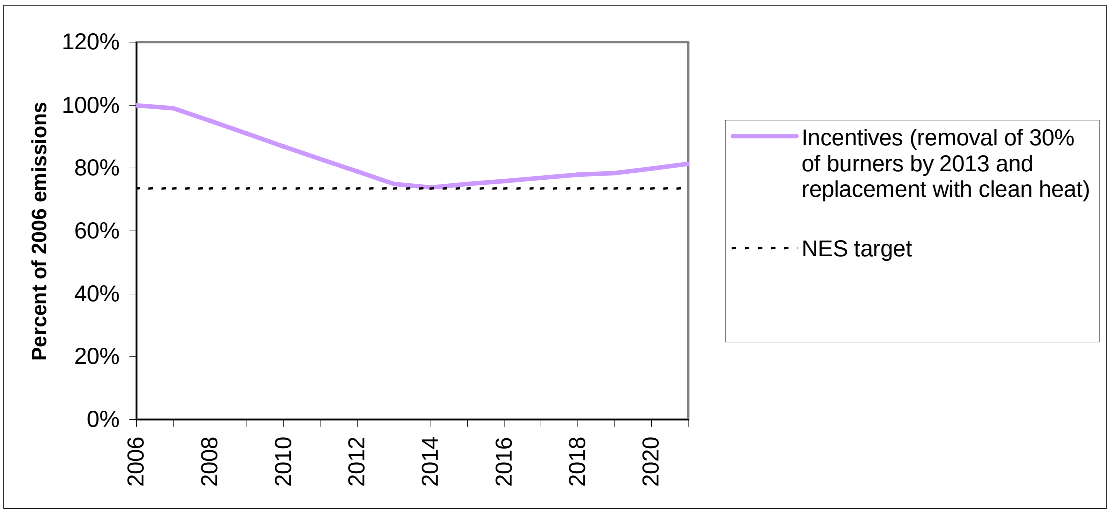

Figure 3-15: PM_{10} emission projections in Hamilton, showing effect of an alternative incentives programme, targeting burners prior to the end of their useful life (removal of 30% of burners by 2013 and replacement with clean heat alternatives)

Figure 3.16 shows a combination of a ban on open fires, a restriction on the installation of multi fuel burners to those meeting the NES design criteria for wood burners and incentives (aimed at a 50% non-solid fuel conversion at the end of the useful life of a burner). This involves the conversion of around 1830 burners by 2013, around 305 per year.

The impact of an open fire ban, a restriction on the installation of multi fuel burners to those meeting the NES design criteria for wood burners and a prohibition on the installation of any solid fuel burners in new dwellings or existing dwellings using other heating methods is shown in Figure 3.17. The addition of an incentives programme such as that described for Figure 3.16 is also shown. With an incentives programme, the NES for PM_{10} is likely to be met by 2013.

Figure 3.18 shows the impact of delayed implementation dates for incentives to 2010 and for regulatory options to 2011. Under this scenario, the NES is unlikely to be met by 2013.

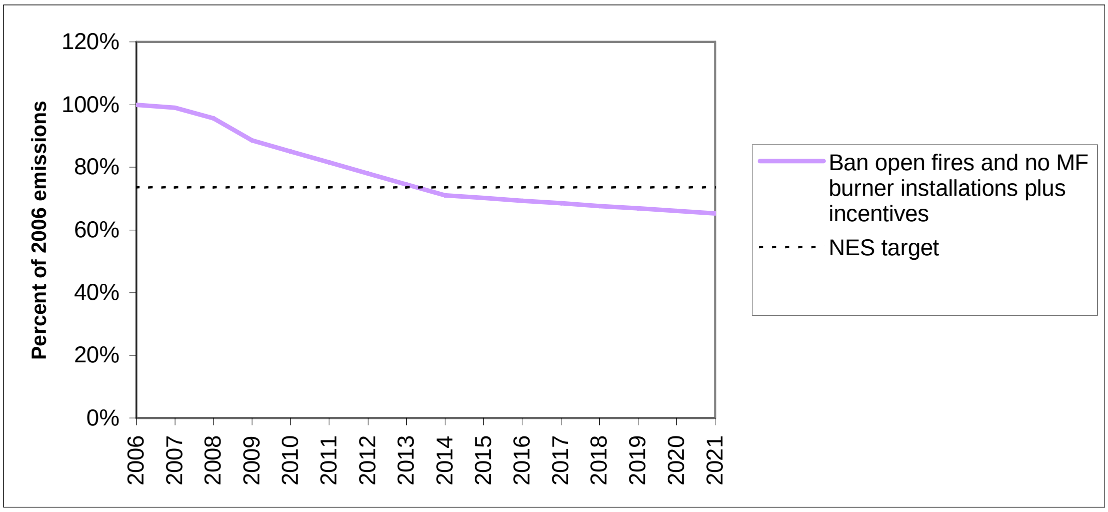

Figure 3-16: PM_{10} emission projections in Hamilton, showing effect of banning open fires, no installations of multi fuel burners, plus incentives for clean heat replacements at the end of the useful life of the burner

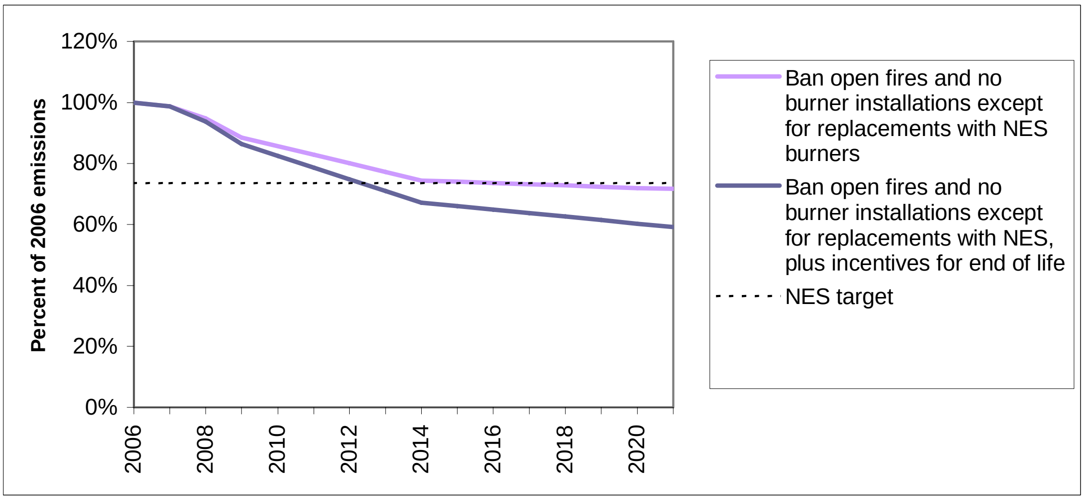

Figure 3-17 PM_{10} emission projections in Hamilton, showing effect of banning open fires, no burner installations in new dwellings or existing dwellings using other methods and no multi fuel burner installations – with and without an incentives programme that converts 50% of households replacing heating methods at the end of their useful life with non solid fuel alternatives

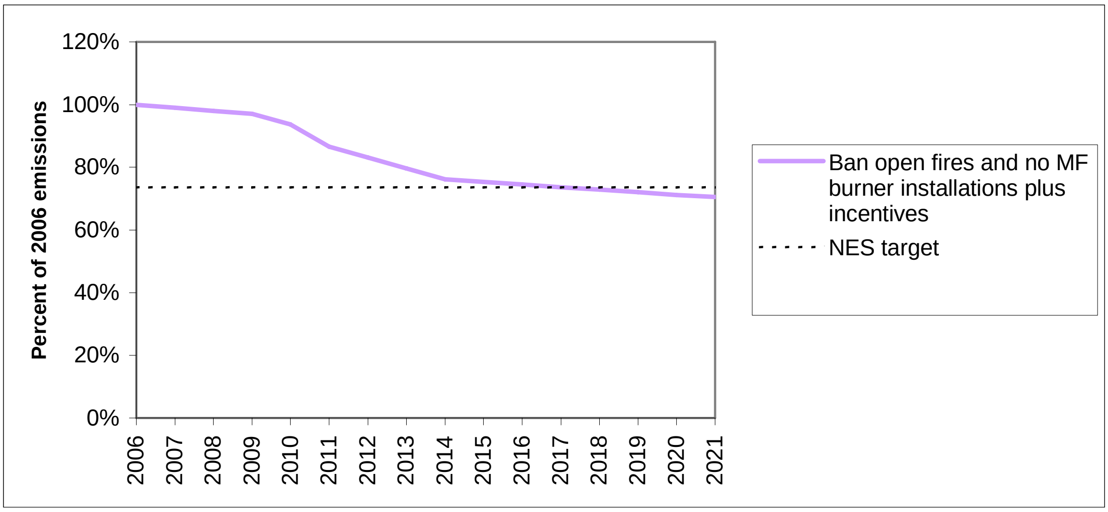

Figure 3-18: PM_{10} emission projections in Hamilton, showing effect of banning open fires and no installations of multi fuel burners, plus incentives for clean heat replacements at the end of the useful life of the burner – with all implementation dates delayed by two years

3.2.3 Summary

The most effective options for achieving the NES in Hamilton (assuming outdoor rubbish burning will continue) appear to be:

1. A ban on open fires, no installations of multi fuel burners and incentives for clean heat replacements for burners at the end of the useful life of the burner.
2. An open fire ban, no installations of multi fuel burners, a prohibition on the installation of any solid fuel burners in new dwellings or existing dwellings using other heating methods and incentives for clean heat replacements for burners at the end of the useful life of the burner.

It is possible that the latter option may achieve the NES without the need for an incentives programme. A delay to the implementation of regulations (from 2009 to 2011) and incentives (from 2008 to 2010) does compromise the likelihood of different options in meeting the NES.

3.3 Taupo

3.3.1 Assumptions

Like Hamilton, the main changes to the management options assessment for Taupo is the increased PM_{10} concentrations, and therefore greater required reduction and the assumption of an emission rate for NES compliant burners of 6 g/kg of PM_{10}. Table 3.5 outlines the average fuel use and emission factors used for different appliance and fuel type categories. Table 3.6 compares the assumptions underlying the original projections (Wilton 2005b) and the revised model projections.

Table 3-5: Revised fuel use and emission factors for 2006 model upgrade

	Fuel Use kg	Emission Factor g/kg
Open fire - wood	20	10
Open fire - coal	9	21
Wood burner -pre 1994	25	11
Wood burner - 1994-1999	25	7
Wood burner -Post 1999	25	6
Pellet	8	2
Woodburner 1.5 g/kg	25	6
Multifuel – wood	17	13
Multifuel – coal	3	28
Oil	4	0.03
Gas	1	0.03

Table 3-6: Changes in assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions (Adapted from Table 4.2 - Wilton, 2005b)

1	A decrease in PM_{10} emissions from motor vehicles of around 66% by 2021. This is based on road transport modelling for a "do minimum" scenario and NZTER projections in tailpipe emissions.
2	The industry contribution to PM_{10} emissions is less than 1% and there is no change in emissions from industry with time.
3	Current outdoor burning emissions occur throughout the week and weekend. Emissions from this source increase with projection population growth.
4	Emission factors for burners as per the 2004 Taupo emission inventory. **Revised Note 2006: Emission factors for NES burners as per Table 3.5**
5	Average fuel use for 1.5 g/kg burners of 29 kg per night as per the post 1999 burners in the 2004 emission inventory survey. **Revised Note 2006: Average fuel use 1.5 g/kg burners of 25 kilograms based on the average for all burners for the 2004 Taupo inventory (Table 3.5).**
6	Average fuel use for other burners as per the 2004 Taupo emission inventory survey. **Revised Note 2006: Same source used but fuel use averaged across all burner age categories.**
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 Taupo of 11% from 2001 to 2021.
11	Unless otherwise stated, 100% of households replacing open fires or older solid fuel burners will install solid fuel burners. **Revised Note 2006: Only 50% of households replacing open fires, if prohibited, will install solid fuel burners*.**
12	An emission factor for 1.5 g/kg burners of 3 g/kg. **Revised Note 2006: An emission factor for 1.5 g/kg burners of 6 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	All wood and multi fuel burners are phased out 15 years following installation. **Revised Note 2006: All wood and multi fuel burners are phased out 20 years following installation.**

*This is based on an evaluation of heating methods in households that use open fires which show a reasonable proportion also have an alternative solid fuel burner.

Other assumptions included in the analysis are:

- A 10% reduction in the number of open fires from 2005 to 2021.
- The size of an average outdoor rubbish fire is 150 kilograms per burn.
- Around 0.5% of existing houses using other heating methods (1 household per year) convert to solid fuel burners each year.
- 10% of new dwellings install a wood burner.
- 20% of new burner installations are multi fuel burners.
- For options including a ban on open fires, this is effective from 2009.
- For options including a ban on the installation of new multi fuel burners, this is effective from 2009.
- For options including an incentives programme encouraging clean heat alternatives at the end of a burners useful life, the incentives are assumed to be effective from 2009.

3.3.2 Projections

In Taupo, it is very unlikely that PM_{10} concentrations would meet the NES by 2013 in the absence of additional controls. Figure 3.19 shows that a reduction of around 17% is estimated from 2006 to 2021 for a do nothing extra scenario. This compares with a required reduction of around 52%. Management options evaluated in this report for Taupo include:

- A ban on outdoor rubbish burning.
- Ban the use of open fires.
- No new multi fuel burner installations.
- Incentives for clean heating methods
- Prohibition on the installation of solid fuel burners in new dwellings and existing dwellings using other heating methods.
- Combinations of the above.

Figures 3.20-3.22 show the estimated effectiveness of bans on outdoor rubbish burning (Figure 3.20), open fires (Figure 3.21) and open fires plus applying the NES design criteria for wood burners to multi fuel burners. Of these, the ban on open fires is the singly most effective option in reducing PM_{10}, resulting in a reduction of around 8% from 2006 to 2013.

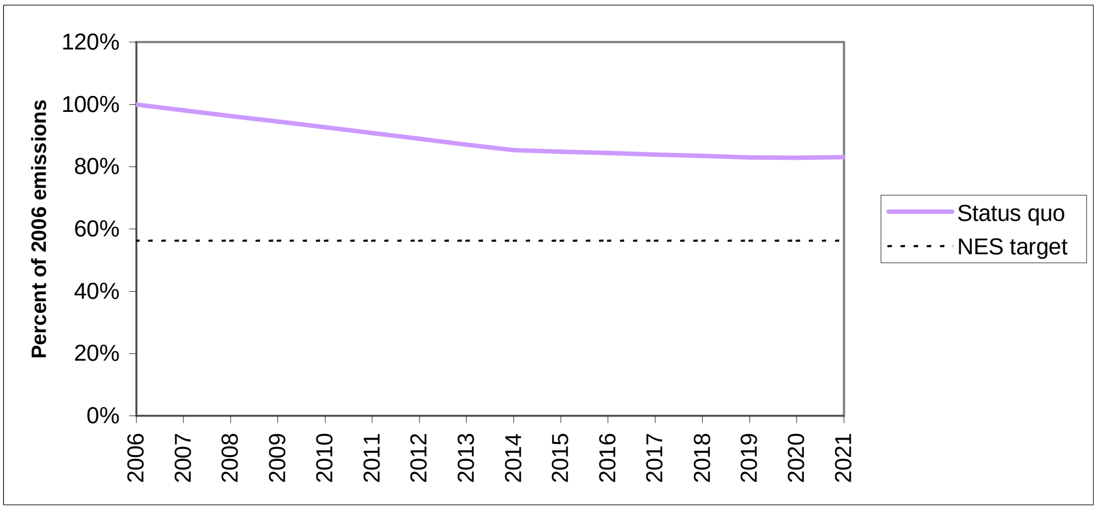

Figure 3-19 : Status quo PM_{10} emission projections for Taupo

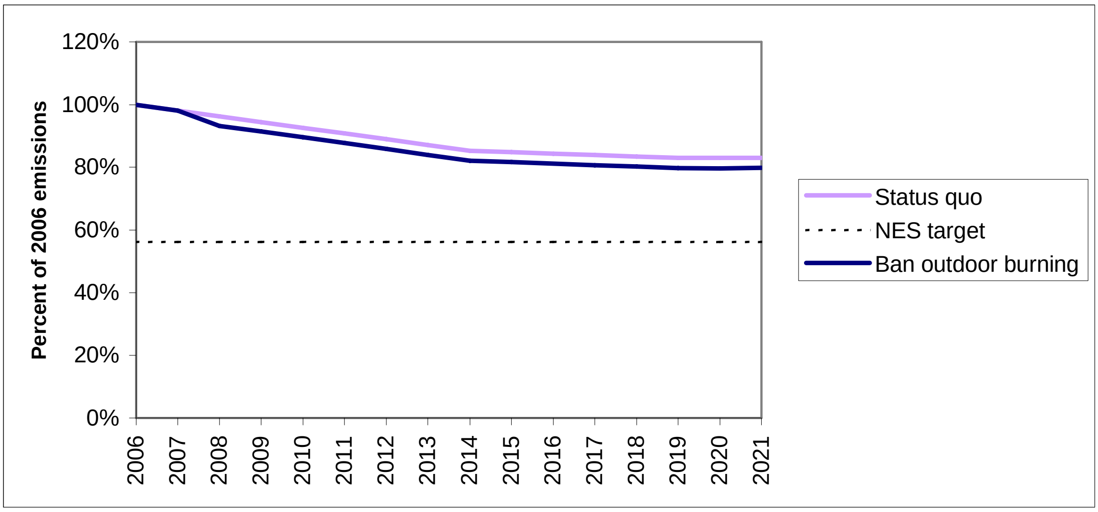

Figure 3-20: PM_{10} emission projections with prohibition of outdoor rubbish burning in Taupo

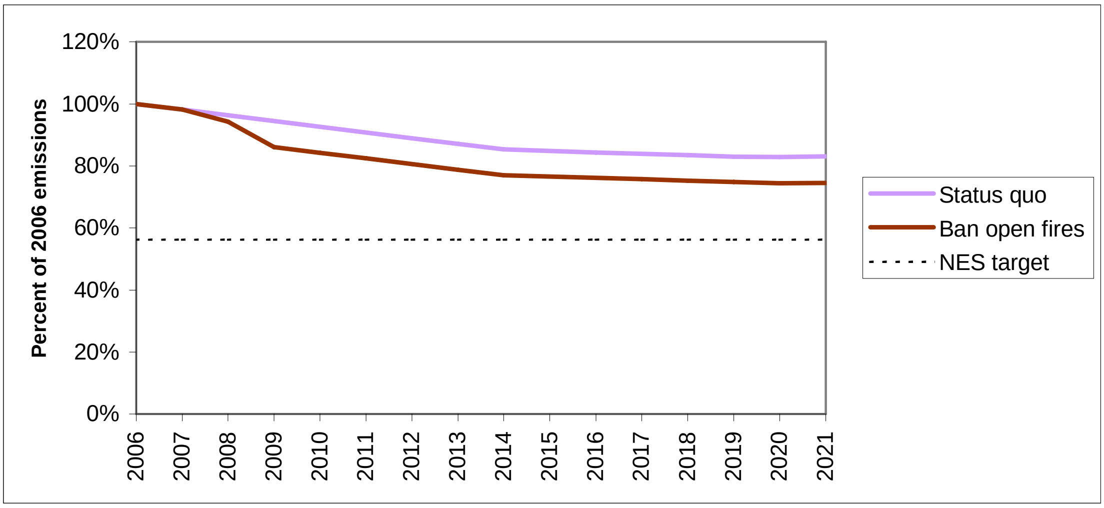

Figure 3-21: PM_{10} emission projections in Taupo, showing effect of prohibiting open fires

Figure 3-22: PM_{10} emission projections in Taupo, showing effect of an open fire ban and no new multi fuel burner installations

Figure 3.23 shows the effectiveness of an incentives programme that encourages 50% of households replacing burners at the end of their useful life to choose non-solid fuel alternatives. An additional option of restricting the useful life of a burner to 15 years is also shown. Unlike Tokoroa, the impact of regulating the life of the burners to 15 years is minimal at 2013 for Taupo.

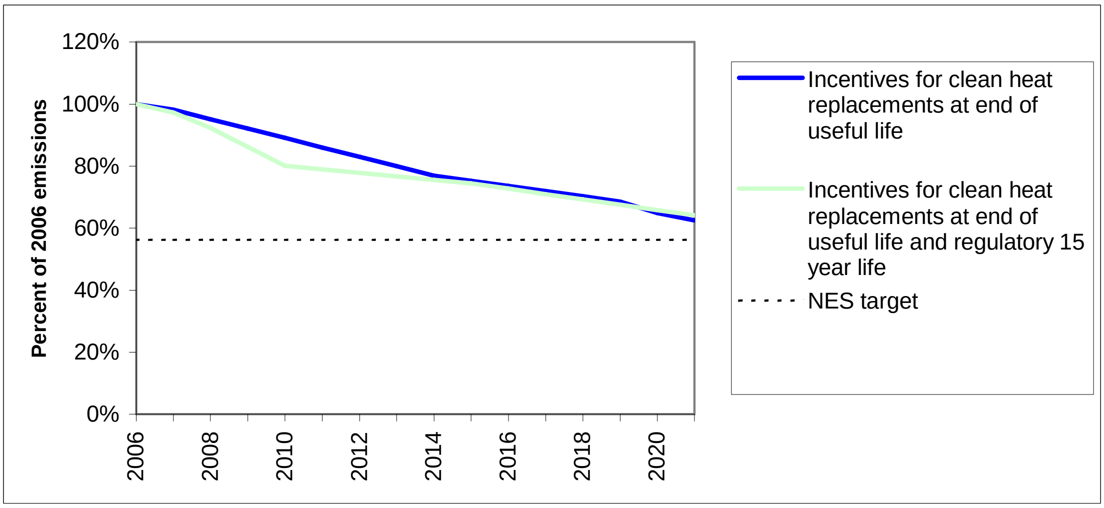

Figure 3-23: PM_{10} emission projections in Taupo, showing effect of incentives for clean heat replacements at the end of the useful life of a burner, and the same incentives plus restricting the use of a burner to 15 years post installation

Figure 3.24 shows a combination of a ban on open fires, a restriction on the installation of multi fuel burners to those meeting the NES design criteria for wood burners and incentives (aimed at a 50% non-solid fuel conversion at the end of the useful life of a burner). This involves the conversion of around 660 burners by 2013, around 110 per year from 2008 to 2013. A reduction of around 36% is estimated for 2013 (increasing to the required 47% by 2017) if all burners are replaced at the end of a 20-year useful life. The number of conversions would be around 1310 by 2013. Additional incentives targeting burners prior to the end of their useful life would be required to meet the NES by 2013.

Figure 3.25 shows the impact of the above measures plus additional incentives to replace 20% of the post 1995 solid fuel burners prior to the end of their useful life (between 2008 and 2013). The number of burners removed in the projections shown in Figure 3.25 is 1430. These include both households taking up incentives when replacing burners at the end of their useful life (50% of these households) and households replacing burners prior to the end of their life. This number is only slightly higher than the previous 1310 burners because it assumes that the other 50% of households replacing burners at the end of their useful life will not take up the incentives (and are therefore not included in the 1430 total) but reductions will still be achieved through the conversions of these burners to NES compliant burners. It is likely that an incentives programme targeting burners prior to the end of their useful life would require significantly more resources than one targeting burners at the end of their useful life.

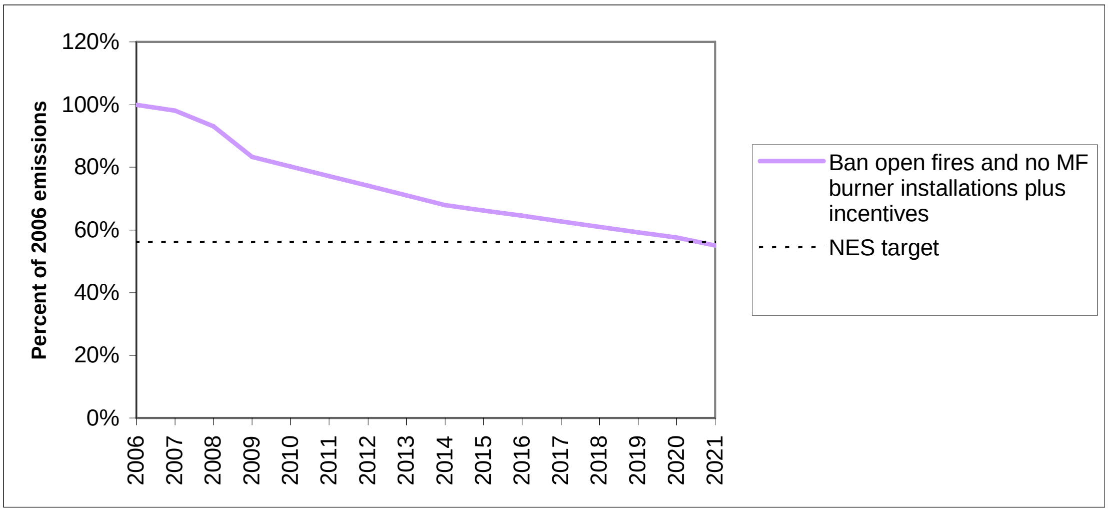

Figure 3-24: **PM_{10} emission projections in Taupo, showing effect of an open fire ban, no installations of multi fuel burners, plus incentives for clean heat replacements at the end of the useful life of the burner**

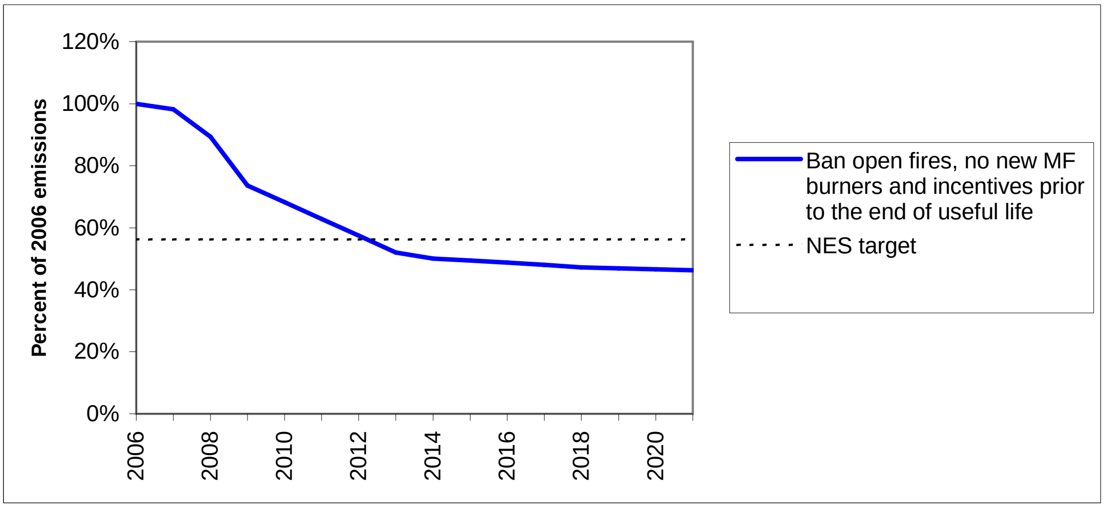

Figure 3-25: **PM_{10} emission projections in Taupo, showing effect of incentives for the replacement of burners with clean heat methods by 2013, including 50% of burners being replaced through natural attrition and the accelerated phase out of 20% of the post 1995 burn**

The impact of delaying the implementation of incentives from 2008 to 2010 and regulations from 2009 to 2011 is shown in Figure 3.26. This indicates a later implementation date may impact on the likelihood of this combination of options achieving the NES by 2013.

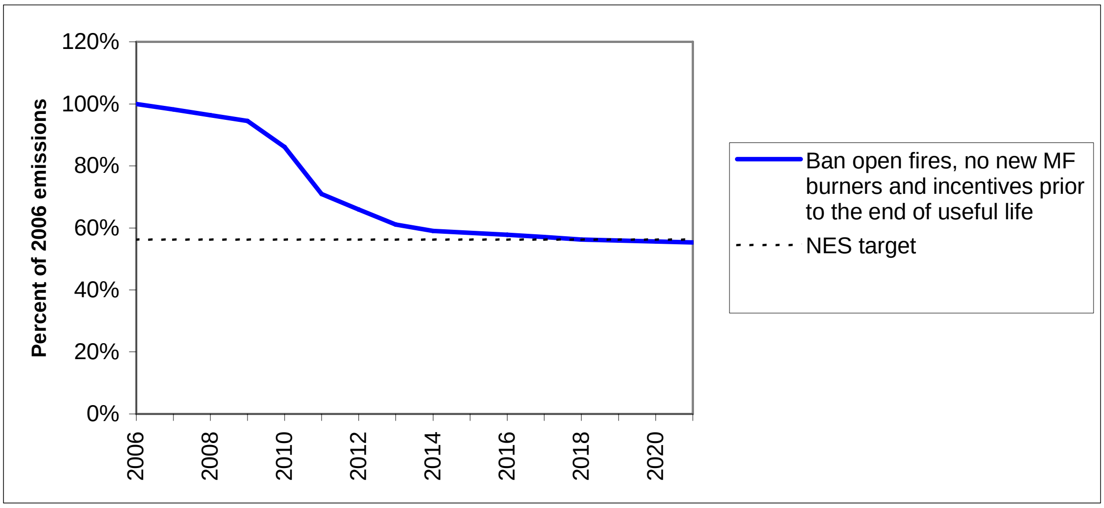

Figure 3-26: PM_{10} emission projections in Taupo, with implementation of management options delayed by two years. The plot shows the impact of incentives for the replacement of burners with clean heat methods by 2013, including 50% of burners being replaced through natural attrition and the accelerated phase out of 20% of the post 1995 burners prior to the end of their 20-year assumed useful life

3.3.3 Summary

It is likely that a combination of regulatory measures and incentives would be required to achieve the NES for PM_{10} in Taupo by 2013. This includes a ban on the use of open fires, the NES for wood burners applies to multi fuel burners and incentives to replace 20% of post 1995 burners with clean heat by 2013, including uptake of the incentives by 50% of the pre 1995 burners being replaced from 2008 to 2013 through natural attrition.

3.4 Te Kuiti

3.4.1 Assumptions

The reduction required in PM_{10} concentrations in Te Kuiti has been estimated at around 28%. This is higher than the 12% shown in the previous management options assessment. The other key difference to the management options assessment for 2005 for Te Kuiti is the increased PM_{10} concentrations, and therefore a greater required reduction and the assumption of an emission rate for NES compliant burners of 6 g/kg of PM_{10}. Table 3.7 outlines the average fuel use and emission factors used for different appliance and fuel type categories. Table 3.8 compares the assumptions underlying the original projections (Wilton 2005a) and the revised model projections.

Table 3-7: Revised fuel use and emission factors for 2006 model upgrade

	Fuel Use kg	Emission Factor g/kg
Open fire - wood	9	10
Open fire - coal	6	21
Wood burner -pre 1994	31	11
Wood burner - 1994-1999	31	7
Wood burner -Post 1999	31	6
Pellet	8	2
Woodburner 1.5 g/kg	31	6
Multifuel – wood	26	13
Multifuel – coal	10	28
Oil	5	0.03
Gas	0.6	0.03

Table 3-8: Changes in assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions (Adapted from Table 4.2 - Wilton, 2005b)

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 outdoor burning emissions occur throughout the week and weekend. Emissions from this source increase with projection population growth.
4	Emission factors for burners as per the 2004 Te Kuiti domestic heating emissions assessment. **Revised Note 2006: Emission factors for burners as per Table 3.7**
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. **Revised Note 2006: Average fuel use 1.5 g/kg burners of 31 kilograms based on the average for all burners for the 2004 Te Kuiti domestic heating survey (Table 3.7).**
6	Average fuel use for other burners as per the 2004 Te Kuiti emission inventory survey. **Revised Note 2006: Same source used but fuel use averaged across all burner age categories.**
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. **Revised Note 2006: Only 50% of households replacing open fires, if prohibited, will install solid fuel burners*.**
12	An emission factor for 1.5 g/kg burners of 3 g/kg. **Revised Note 2006: An emission factor for 1.5 g/kg burners of 6 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.
15	All wood and multi fuel burners are phased out 15 years following installation. **Revised Note 2006: All wood and multi fuel burners are phased out 20 years following installation.**

*This is based on an evaluation of heating methods in households that use open fires which show a reasonable proportion also have an alternative solid fuel burner.

Other assumptions included in the analysis are:

- A 10% reduction in the number of open fires from 2005 to 2021.
- The size of an average outdoor rubbish fire is 150 kilograms per burn.
- Around 0.5% of existing houses using other heating methods (1 household every three years) convert to solid fuel burners each year.
- 10% of new dwellings install a wood burner.
- 10% of new burner installations are multi fuel burners.
- For options including a ban on open fires, this is effective from 2009.
- For options involving a ban on the installation of new multi fuel burners this is effective from 2009.

- For options including an incentives programme encouraging clean heat alternatives at the end of a burners useful life, the incentives are assumed to be effective from 2009.

3.4.2 Projections

Significant reductions in PM_{10} concentrations in Te Kuiti are predicted from 2006 to 2021 in the absence of additional controls on domestic home heating. Figure 3.27 shows a 27% reduction in emissions is predicted relative to a required reduction of around 28%.

Figure 3.28 shows the impact of a ban on outdoor rubbish burning in Te Kuiti.

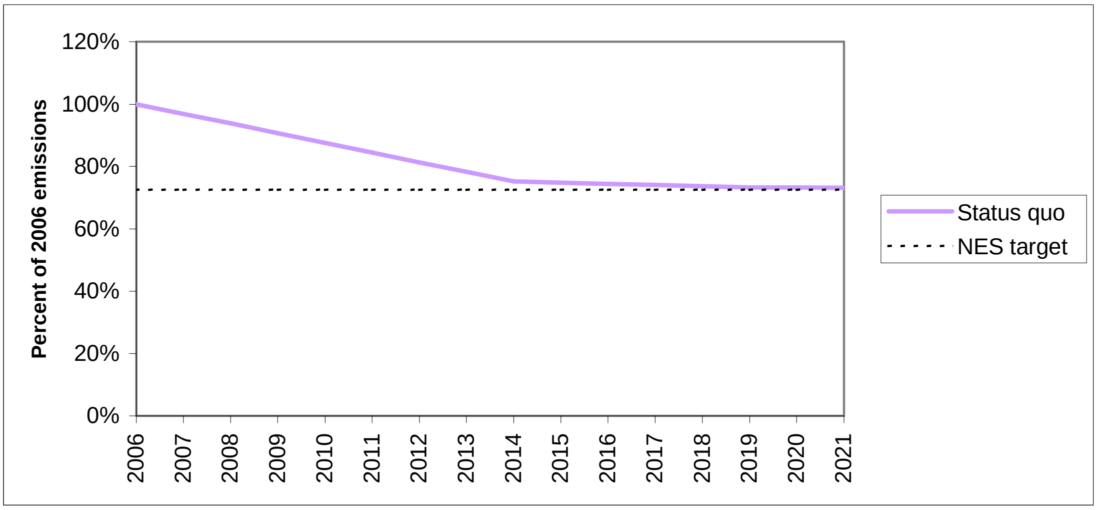

Figure 3-27: Status quo PM_{10} emission projections for Te Kuiti

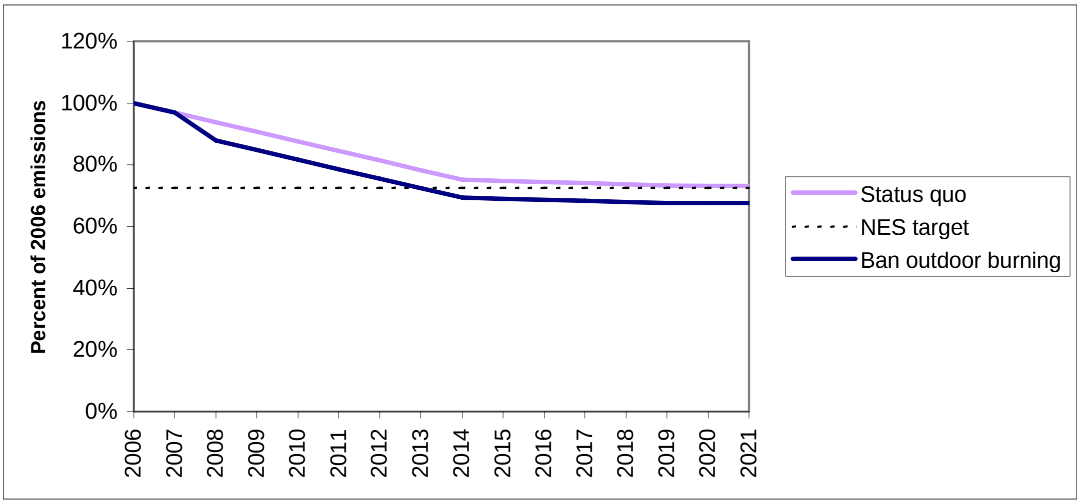

Figure 3-28: PM_{10} emission projections in Te Kuiti, showing effect of banning outdoor rubbish burning

A ban on the use of open fires was not found to be an effective regulatory measure for Te Kuiti because of the significant difference between average daily fuel use on an open fire compared with a wood burner. The estimated effectiveness of a ban on open fires and requiring all new multi fuel burners meet the NES design criteria for wood burners is shown in Figure 3.29.

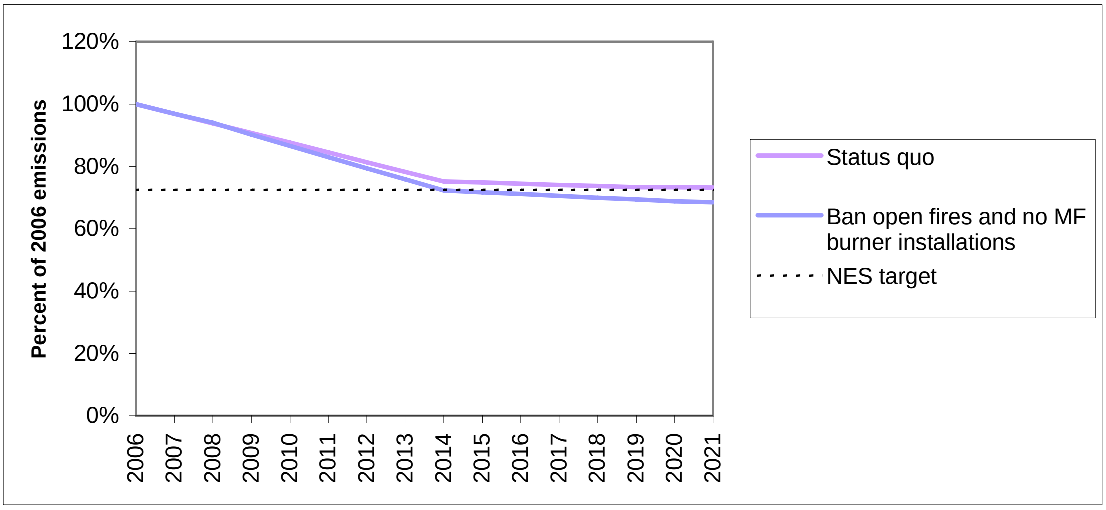

Figure 3-29: PM_{10} emission projections in Te Kuiti, showing effect of an open fire ban and no new multi fuel burner installations

A further combination of regulatory options without incentives is shown in Figure 3.30. This suggests that the NES for PM_{10} may not be met by 2013 without additional measures.

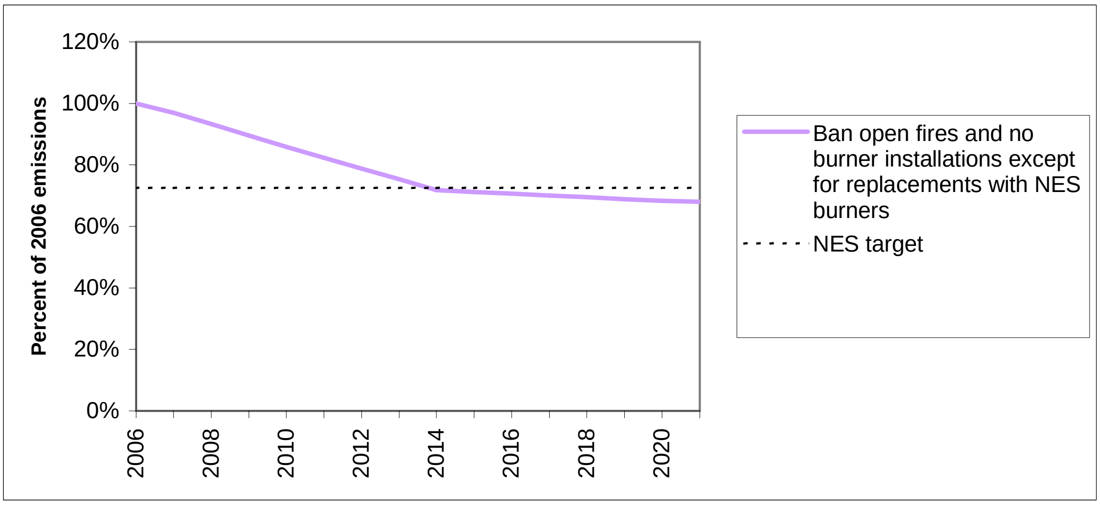

Figure 3-30: PM_{10} emission projections in Te Kuiti, showing effect of an open fire ban, no installations of multi fuel burners, plus no installations of solid fuel burners in new dwellings or existing dwellings using other heating methods

Figure 3.31 shows the effectiveness of an incentives programme that encourages 50% of households replacing burners at the end of their useful life to choose non-solid fuel alternatives. This involves the replacement of around 200 solid fuel burners with clean heat alternatives at the end of their useful lives.

A combination of the same incentives programme (targeting 15% rather than 50% of households replacing burners) with an open fire ban and a ban on the installation of multi fuel burners is shown in Figure 3.32. This involves the replacement of around 80 burners or 13 burners per year from 2008 to 2013. Figure 3.33 shows the impact of delaying the implementation of incentives and regulations by two years.

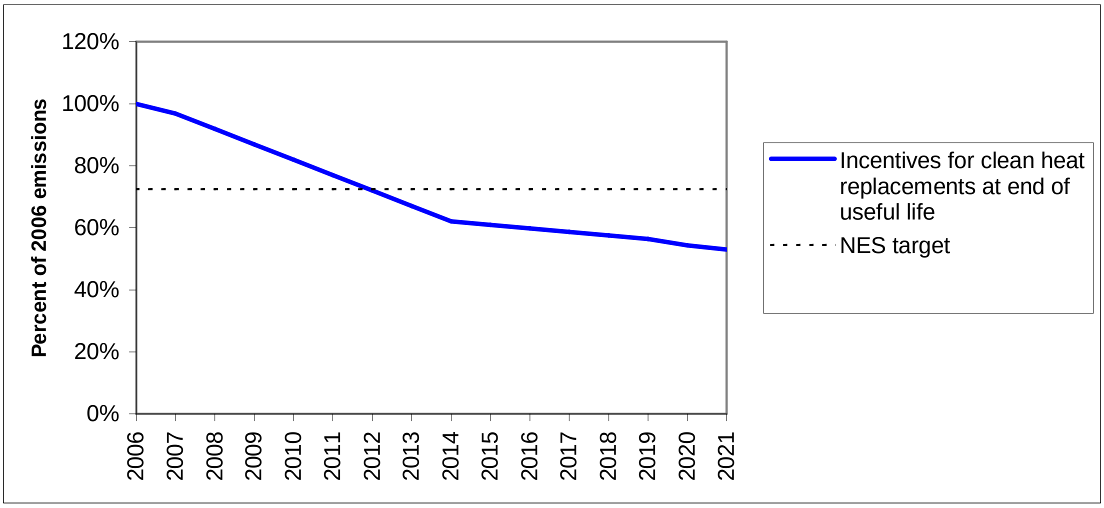

Figure 3-31: PM_{10} emission projections in Te Kuiti, showing effect of incentives for clean heat replacements at the end of the useful life of a burner

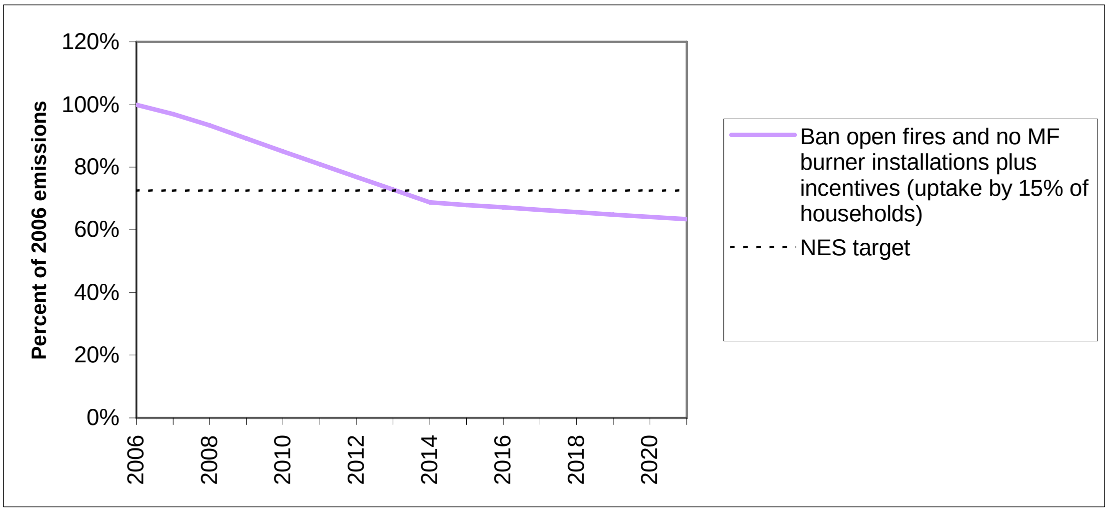

Figure 3-32: PM_{10} emission projections in Te Kuiti, showing effect of an open fire ban, no multi fuel burner installations, plus incentives for end of life replacements (with a 15% uptake of the incentives)

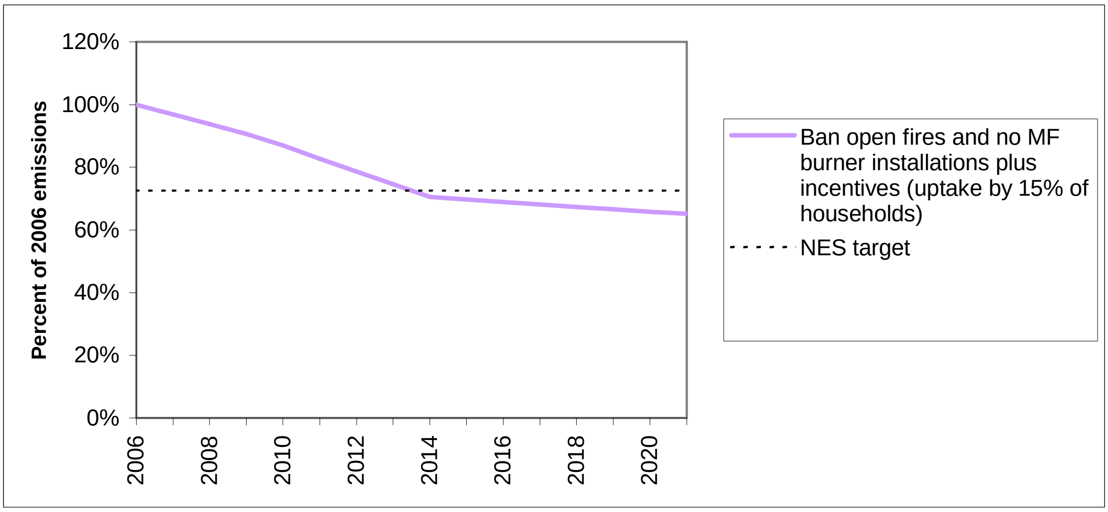

Figure 3-33: PM_{10} emission projections in Te Kuiti, with implementation of regulation and incentives delayed by two years. The plot shows the impact of an open fire ban, no multi fuel burner installations, plus incentives for end of life replacements (with 15% uptake of incentives)

3.4.3 Summary

The most effective options for reducing PM_{10} from domestic heating in Te Kuiti are:

1. An incentive programme to convert 50% of households using solid fuel burning to clean heat methods at the end of their assumed 20 year useful life. This would involve funding sufficient to encourage around 200 households replacing solid fuel burners at the end of their useful life to choose clean heating alternatives.
2. A ban on open fires, no new multi fuel burner installations and an incentives programme to convert 15% of households replacing burners at the end of their assumed 20 year useful life. This would involve funding sufficient to encourage around 80 households replacing solid fuel burners at the end of their useful life to choose clean heating alternatives.

4 Conclusions

An incentives programme encouraging households to replace existing solid fuel burners with non-solid fuel alternatives at the end of their useful life could be an effective method of reducing PM_{10} emissions in all areas. In most areas, regulations such as a ban on the use of open fires and restrictions on the installations of all burners to those that can meet the NES design criteria for wood burners would be necessary in addition to an incentives programme.

In Taupo, additional measures are likely to be required to achieve the NES. These could involve additional regulation or incentives encouraging households to replace solid fuel burners with clean heat options prior to the end of their useful life. The timeframe within which incentives and regulations are implemented impacts on the ability of these options to achieve the NES by 2013.

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