Management options for reducing PM_{10} concentrations in Blenheim – Update 2009

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Executive Summary

This report updates a 2007 assessment of the effectiveness of management options in reducing PM_{10} concentrations in Blenheim. The change included in this report is a revision to the emission factor for NES compliant wood burners. The current state of knowledge is that these burners may emit around 3 grams of particulate per kilogram of wood burnt (g/kg). Previously an emission factor of 6 g/kg had been used in assessing the effectiveness of management options in achieving the NES.

Concentrations of PM_{10} measured in Blenheim exceed the ambient air quality guideline and National Environmental Standard (NES) concentration of 50 μg m^{-3} (24-hour average) during the winter months. The main source of PM_{10} in Blenheim during the winter months is solid fuel burning for domestic home heating, which contributes around 85% of the anthropogenic PM_{10}. In 2007 the reduction required in PM_{10} concentrations was evaluated and set at 25% based on a maximum PM_{10} concentration of 66 μg m^{-3}. The maximum measured PM_{10} concentration at the Redwoodtown monitoring site in 2008 was 56 μg m^{-3}.

The effectiveness of different management options were evaluted using an emission factor of 3 g/kg. Management measures included all options evaluted previously, which focused largely on domestic home heating as the primary source of PM_{10}, although prohibitions on outdoor rubbish burning were also considered. The methodology used the existing PM_{10} emissions for Blenheim as estimated in the 2005 air emission inventory and made predictions of changes that were time based on a number of scenarios. These emissions projections were then compared to existing concentrations assuming a linear relationship between the two variables.

Baseline projections indicate a reduction of more than 25% is unlikely to occur in the absence of additional controls although some reductions are predicted to occur as older more polluting heating methods are replaced with modern solid fuel burners at the end of their useful life.

A number of management options were evaluated. These included a ban on outdoor rubbish burning and the use of open fires, setting an emission criterion for the installation of new multi fuel burners, a prohibition of the installation of solid fuel burners in new dwellings and existing dwellings using other heating methods and incentives for the replacement of burners with non-solid fuel alternatives. Management options were evaluated based on an assumed burner life of 15 years and for an assumed burner life of 20 years.

Results suggest that the NES may be met with minimal management intervention. In particular a ban on outdoor rubbish burning and not allowing the installation of any burners not meeting the NES design criteria for wood burners may be sufficient to meet the NES by 2013. In addition, a ban on the use of open fires could be considered to increase the certainty of meeting the NES and because of potential energy efficiency gains.

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1 Introduction

Air quality monitoring for PM_{10} has been carried out in Blenheim since 2000. Results indicate concentrations in excess of the ambient air quality guidelines (MfE, 2002) and National Environmental Standards (MfE, 2004). The National Environmental Standards (NES) specify a standard for PM_{10} of 50 μg m^{-3} (24-hour average) with one allowable exceedence per year, effective from September 2005.

In Blenheim, reductions in PM_{10} concentrations are required if the NES is to be met by 2013. There is significant incentive to do this as the NES indicates that a consent authority must decline an application for a resource consent in an area where PM_{10} concentrations exceed the NES if the PM_{10} discharge is likely to significantly increase the PM_{10} in the airshed and if the discharge to be permitted by the resource consent is likely to cause, at any time, the concentration of PM_{10} in the airshed to be above the straight line path. The straight line path is defined as a line that starts on the y axis of a graph at a point representing the extent to which the concentration of PM_{10} in the airshed breaches its ambient air quality standard at 1 September 2005; and ends on the x axis of the graph at the point representing the ambient air quality standard for PM_{10} in the airshed at 1 September 2013.

The NES also specifies that no resource consent for discharges to air may be granted from 1 September 2013 if the concentrations of PM_{10} in the airshed breach the NES or if the granting of the consent is likely to result in a breach.

An air emissions inventory carried out for Blenheim in 2005 indicates that solid fuel burning for domestic home heating is the main source of PM_{10} during the winter months, when concentrations in excess of the NES have been recorded. Just less than one tonne of PM_{10} per day is estimated to be discharged with domestic home heating contributing around 85% (Wilton, 2005).

The first management options report for Blenheim was prepared in 2006. In 2007, the report was updated for the following factors:

- Integration of results of source apportionment work identifying natural and secondary source contributions to PM_{10}.
- Revision to the starting point of the Straight Line Path (SLiP)

This report updates the 2007 work based on a revised emission factor for NES compliant wood burners. The current state of knowledge is that these burners may emit around 3 grams of particulate per kilogram of wood burnt (g/kg). Previously an emission factor of 6 g/kg had been used in assessing the effectiveness of management options in achieving the NES.

2 Revisions to the emission factor for NES compliant wood burners

The emission factor used for NES compliant wood burners is critical in assessing the impact of phasing out of older, more polluting solid fuel burners and replacing them with modern NES compliant burners. Prior to some recent 'real life' emission testing of NES compliant wood burners (Smith et. al., 2008) there was a high degree of uncertainty regarding the emission rates from NES compliant burners.

The results of Smith et. al., (2008) indicate that average emissions from NES compliant wood burners are more likely to be around 3 g/kg than the 6 g/kg that had been used previously. Additional testing using an alternative sampling system is proposed for 2009. However, current knowledge of emissions from these burners supports the use of 3 g/kg.

3 Emissions projections

3.1 Projections in motor vehicle emissions

The inventory estimates the amount of PM_{10} from motor vehicles based on an assessment of vehicle kilometres travelled for Blenheim, the application of the Ministry of Transport's (MOT) "New Zealand Transport Emission Rates" (NZTER) database and overseas data on likely emissions from non-tailpipe sources including brake and tyre wear. The NZTER database includes estimates of changes in tailpipe emissions and estimates significant decreases in tailpipe emissions of PM_{10} between 2005 and 2021. Table 3.1 compares NZTER PM_{10} emission rates under different levels of congestion for 2005 and 2021 based on the 2005 vehicle fleet composition. This suggests a 66% reduction in tailpipe PM_{10} emissions per vehicle kilometre travelled for free flowing traffic conditions.

Table 3.1: Comparison of 2005 and 2021 tailpipe PM_{10} emissions (from NZTER)

LOS	2005 PM_{10}	2005 PM_{10}
Congested	0.19	0.07
Interrupted	0.13	0.05
Free flow	0.12	0.04

In contrast, VKTs in Blenheim are most likely to increase from 2005 to 2021 as the population residing in the area is predicted to increase. Congestion may also increase during this time. Predicting the extent of increase in VKTs and congestion is difficult without the use of a road network model. In areas where road network models have been used in conjunction with the NZTER database to predict future PM_{10} estimates, increases in VKTs have been offset by the predicted reductions in VKTs. For example, in Napier and Hastings, VKTs are estimated to increase by 19% and 17% respectively between 2005 and 2021 but PM_{10} emissions from motor vehicles are predicted to decrease by around 50% in both areas.

Estimates of likely worst-case motor vehicle PM_{10} emissions for 2021 could be made based on the assumption of a 70% increase in VKTs in Blenheim and the use of the NZTER database for 2021 PM_{10} emission factors. Figure 3.1 shows estimates of PM_{10} emissions from motor vehicles for this scenario, assuming a 70% increase in VKTs resulted in 5% of VKTs occurring under "congested" conditions and 10% under "interrupted" conditions. A reduction in 2005 PM_{10} emissions of around 24% is predicted for this scenario.

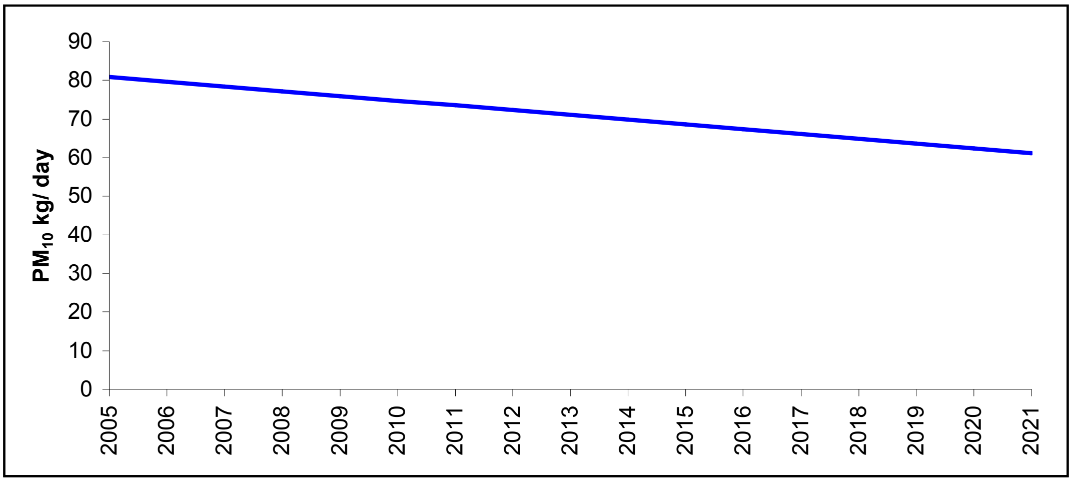

Figure 3.1: Daily motor vehicle emissions in Blenheim from 2005 to 2021 based on a likely worst-case estimate of a 70% increase in VKT with 10% occurring under 'interrupted' and 5% under 'congested' conditions

3.2 Domestic heating

The baseline data used for the domestic home heating projections were the home heating methods and subsequent emission estimates from the 2005 air emissions inventory (Wilton, 2005). Future emissions from this source were estimated based on the following assumptions:

- The number of dwellings increases in Blenheim by 70% from 2001 to 2021.
- Emission factors and fuel factors used in the inventory apply across the whole life of the burner.
- Wood burners are replaced 15 and 20 years after installation (note because of uncertainties surrounding this variable both scenarios are modelled).
- The number of open fires decreases by 10% from 2005 to 2021.
- Existing multi fuel burners (at 2005) decrease by 90% by 2021.
- The number of new installations of solid fuel burners per year is equal to 100% of those removing burners plus 16% of new dwellings and 0.25% of the number of households in 2005 that use electricity and gas[1].
- 13% of the new solid fuel burners installed in Blenheim from 2005 are multi fuel burners[2].
- All households with multi fuel burners burn wood with half of these also burning coal.

These assumptions are based on a combination of emission inventory statistics, emissions testing of solid fuel burners in New Zealand, New Zealand Statistics Department data, evaluations of burner installations data in Blenheim, industry advice and in the case of replacement rates, a best guess approach. Because of the lack of information available

[1] This is based on the assumption that less than 5% of existing houses using gas and electricity will convert to wood burning by 2021.
[2] This is based on the proportion of modern multi fuel burners from the 2005 domestic home heating survey.

on the latter, there is a high level of uncertainty surrounding burner replacement rates. Factors that influence householder' choice of heating method include the cost of heating, lifestyle variables, amenity values associated with different heating methods, and household insulation and size. The impact of management options will therefore be shown for a range of assumed household replacement rates.

3.3 Other sources

In the absence of controls on outdoor burning, emission estimates were assumed to increase in proportion to population increases. Population projections for Blenheim were sourced from New Zealand Statistics Department (2005) using the 2003 revised projections of a 70% increase in population from 2001 to 2021 for the Marlborough District.

Changes in emissions from industry are very difficult to predict. Increases can occur as a result of new industry, fuel switching within existing industry or expansion of existing operations. Conversely reductions in industrial emissions are possible as a result of increased efficiencies, process improvements, fuel switching or plant closures. Emissions from industry are assumed to increase by 25% from 2005 to 2021.

4 Managing PM_{10} concentrations in Blenheim

4.1 Methodology

The methodology used to assess the impact of different management options on PM_{10} emissions in Blenheim relies on changing the variables within the projections frameworks for different sources. For example, if a management option aimed to examine the impact of a ban on outdoor rubbish burning from a particular year, the emissions from this source would be removed from the total PM_{10} emissions at the year the ban was assumed to be effective. Estimating the impact of management options for domestic heating is more complex as assumptions regarding replacement heating methods need to be made.

A number of other factors influence the analysis of the effectiveness of management options in reducing PM_{10} concentrations in Blenheim. These include:

1. The relative contribution of different sources to PM_{10} emissions (the emission inventory) and assumptions underpinning this assessment.
2. The potential contribution of sources of PM_{10} not included in the inventory or outside of the study area.
3. Estimated projections in sources of emissions in the absence of additional controls.
4. The relationship between emissions and concentrations in Blenheim.

The 2007 update to the management options report indicates that around 22% of the PM_{10} in Blenheim comes from sources other than those included in the inventory.

The relationship between PM_{10} emissions and concentrations over a 24-hour period for worst-case meteorological conditions depends primarily on two factors:

- Variations in the impact of meteorological conditions on the dispersion of air pollution over a 24-hour period.
- The relationship between emissions and concentrations in an airshed.

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. A greater proportion of domestic heating emissions occur during this time, relative to other sources, and therefore this source may contribute slightly more to PM_{10} concentrations.

In the absence of modelling of the relationship between emissions and concentrations for Blenheim, the assessment of effects has been based on the assumption of a linear relationship between emissions and concentrations and there is no impact on the time of the day that emissions are occurring relative to meteorological conditions. It is possible that this relationship could be confirmed or revised through the use of airshed dispersion modelling.

As indicated here, there are a number of uncertainties associated with the management options assessment. These include both the uncertainties associated with the emission inventory estimates, non-inventory sources, contributions from areas outside of the inventory area and uncertainties associated with the projections of emissions from different sources. The methodology for assessing the effectiveness of management options in reducing PM_{10} in Blenheim includes an evaluation of the uncertainties associated with a number of aspects of the modelling but can not allow for uncertainties such as the contribution from natural sources, or industry or outdoor burning outside of Blenheim.

4.2 Management options assessed

A number of different management options have been evaluated to reduce PM_{10} concentrations in urban areas of New Zealand. Previous studies (e.g., Wilton 2001, Wilton 2002) have evaluated issues surrounding a wide range of options. These include the methods evaluated in this report (as outlined below) as well as other options such as the introduction of smokeless fuels, district heating options, avoiding the use of solid fuel burners on high pollution nights and the effectiveness of education to improve fuel quality and burner operation. The latter option has significant appeal in many areas. However, there are considerable uncertainties relating to the effectiveness of education in improving air quality (as outlined in Wilton & Millichamp, 2002).

Management options included in this analysis were those evaluated in 2007 and include:

1. Status quo including the NES design standard for new installations of solid fuel burners assuming a 15 year replacement rate for solid fuel burners.
2. Status quo including the NES design standard for new installations of solid fuel burners and a 20 year phase out for existing burners.
3. Status quo plus prohibiting outdoor rubbish burning from 2008 (modelling for both the 15 year and 20 year phase out).
4. Options 1 - 3 plus banning the use of open fires from 2010.
5. Options 1 - 4 plus no new installations of multi fuel burners not meeting the NES design criteria for wood burners (effectively a ban on multi fuel burners as currently there are none that meet the NES design criteria for wood burners).
6. Options 1 – 5 plus economic incentives to replace burners with other heating methods at the end of their useful life.

Projections were modelled based on the assumption that solid fuel burners would be replaced 15 years and 20 years following installation. Although 15 years has been quoted by the New Zealand Home Heating Association as the average useful life of a wood burner, some burners may be used for longer periods. In some areas (e.g., Christchurch and proposed for Nelson), the uncertainty associated with burner replacement rates has been reduced by the proposed introduction of regulations requiring the replacement of burners 15 years following installation. It would seem likely that households may be more likely to retain their burners for longer periods in the current economic climate.

The status quo projections also include the introduction of the NES design criteria for the installation of new wood burners. This specifies new burners must meet an emission criteria of 1.5 grams of particulate per kilogram of fuel burnt when tested to NZS 4013. This criteria does not apply to the installation of new multi fuel burners (burners designed for both wood and coal). The installation rate of new multi fuel versus wood burners was taken from the domestic home heating survey carried out during 2005 for Blenheim. This indicated around 13% of new solid fuel burner installations were multi fuel burners (Wilton, 2005). The domestic home heating survey indicates that of the households with multi fuel burners, only around half actually burn coal.

4.3 Baseline projections by source

Figure 4.1 shows the estimated baseline projections in PM_{10} emissions from each source in the absence of additional management measures. These and subsequent projections are based on the assumptions outlined in Table 4.1.

These projections are based on the assumption that older burners are removed 15 years following installation. Because of the uncertainty surrounding this assumption, air management scenarios have been analysed for both a 15-year and 20-year phase out period.

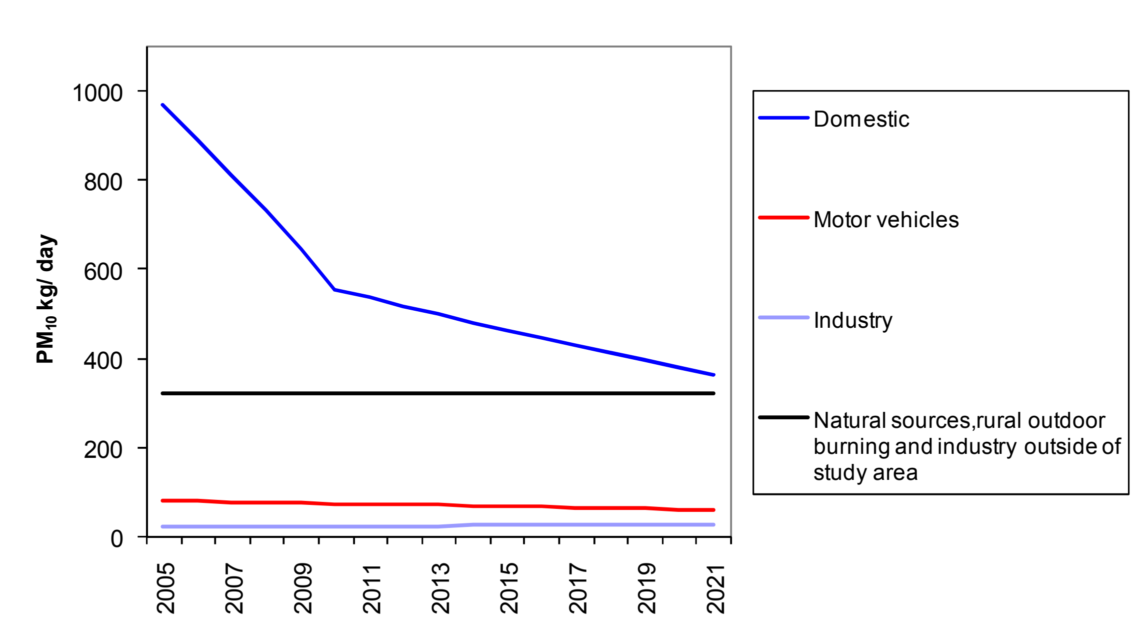

Figure 4.1: Baseline projections in PM_{10} emissions from all sources

Table 4.1: Assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions

1	A decrease in PM_{10} emissions from motor vehicles of around 20% by 2021. This is based on the assumption of a 70% increase in VKTs with 85% occurring under free flowing conditions, 10% under interrupted flow conditions and 5% occurring under congested conditions. Emission rates are based on the NZTER database emission factors for 2021 for the Blenheim 2005 vehicle fleet profile.
2	The industry contribution to PM_{10} emissions increases by 25% from 2005 to 2021.
3	Current outdoor burning emissions occur throughout the week and weekend.
4	Emission factors for burners as per the 2005 Blenheim emission inventory.
5	Average fuel use for 1.5 g/kg burners of 17 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 Blenheim air 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 70% increase in the number of households in Blenheim from 2001 to 2021.
11	Unless otherwise stated, 85% of households replacing older solid fuel burners or multi 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 fuel burners from 2005 will meet an emission criterion of 1.5 g/kg when tested to NZS 4013.
14	As per the 2005 air emission inventory, 100% of households with multi fuel burners use wood and 50% use coal.
15	Around 16% of new dwellings install solid fuel burners[3]. Of these around 13% are new multi fuel burners and the remainder are wood burners.
16	Around 90% of the 2005 multi fuel burners are phased out by 2021. Wood burners are phased out 15 years after installation for some scenarios and 20 years after installation for other scenarios.
17	Natural sources contribute around 160 kg/day, industry outside of the study area contributes 57 kg/day and other sources not included in the inventory (e.g., sulphate) contribute 100 kilograms of PM_{10} per day.
18	No significant change in natural source emissions from outdoor rubbish burning in rural areas and industrial emissions from outside of Blenheim from 2005 to 2021.

4.4 Status quo

Figure 4.2 shows the projected PM_{10} emissions assuming wood burners are phased out 15 years and 20 years following installation. This suggests that the NES for PM_{10} is unlikely to be met in Blenheim in the absence of additional controls for the assumptions outlined in Table 4.1.

[3] Based on burner installation data for 2004 and 2005

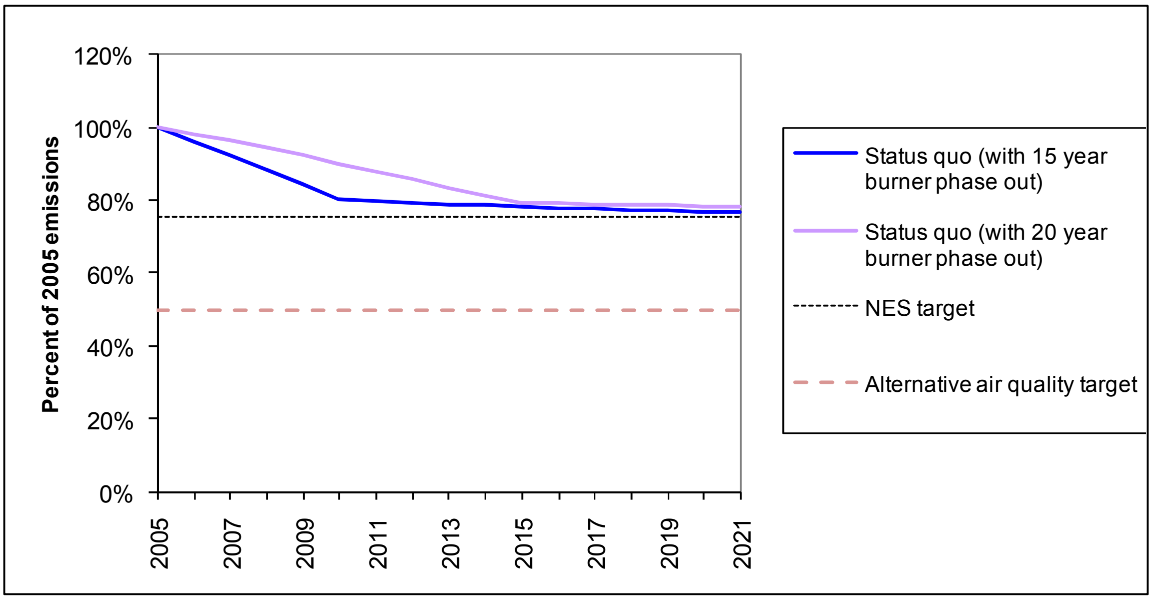

Figure 4.2: Status quo projections for PM_{10}

4.5 Ban on outdoor rubbish burning

Outdoor rubbish burning in the urban area of Blenheim is estimated to contribute around 6% of the daily anthropogenic PM_{10} emissions during the winter. Emissions from this source are predicted to increase with increases in population and in the absence of controls. Figure 4.3 shows the impact of a ban on outdoor rubbish burning during the winter months from 2009 on daily PM_{10} estimates from 2005 to 2021. Results suggest that the NES may be bet by 2013 for both the burner phase out options.

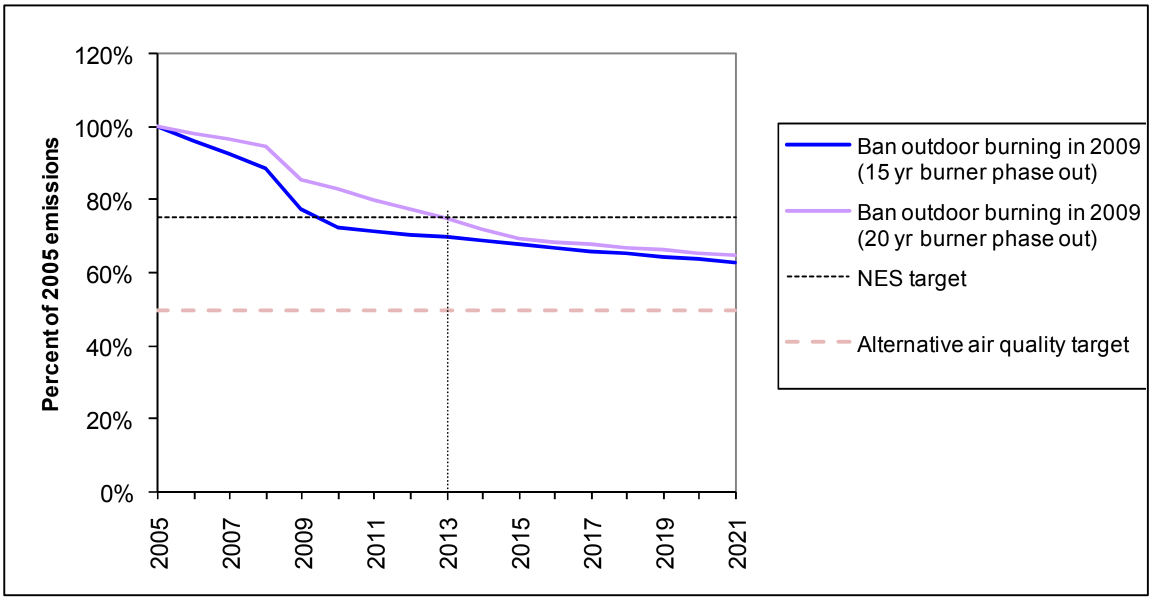

Figure 4.3: Status quo plus a ban on outdoor rubbish burning

4.6 Ban on outdoor rubbish burning and open fires

The addition of a ban on the use of open fires in Blenheim is shown in Figure 4.4. The latter analysis assumes open fires are not used beyond 2010 and that 50% of open fires are replaced with solid fuel burners. The latter assumption may be conservative as the domestic home heating survey carried out for the 2005 air emission inventory indicates that over 80% of the households that used open fires had an alternative heating method, with 50% having wood burners that they used in the main living area.

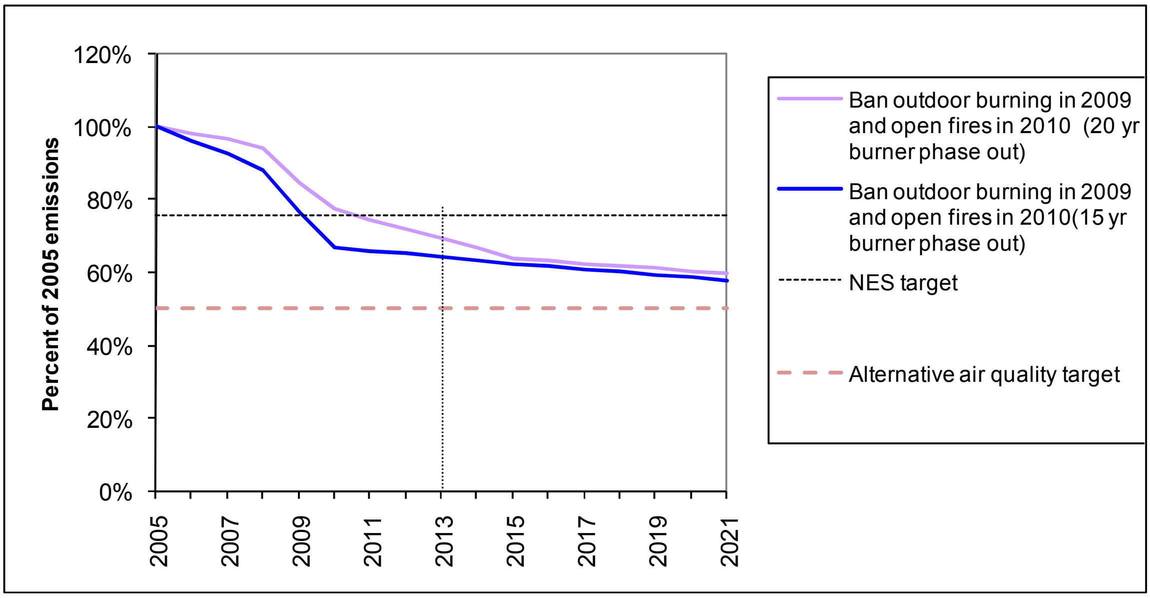

Figure 4.4: Status quo plus a ban on outdoor rubbish burning and the use of open fires.

4.7 Ban on outdoor rubbish burning and open fires and no new burner installations except as solid fuel burner replacements

Figure 4.5 shows the impact of prohibiting the installation of solid fuel burners in new houses and existing dwellings currently using other heating methods from 2010 in addition to an outdoor burning ban and a ban on the use of open fires.

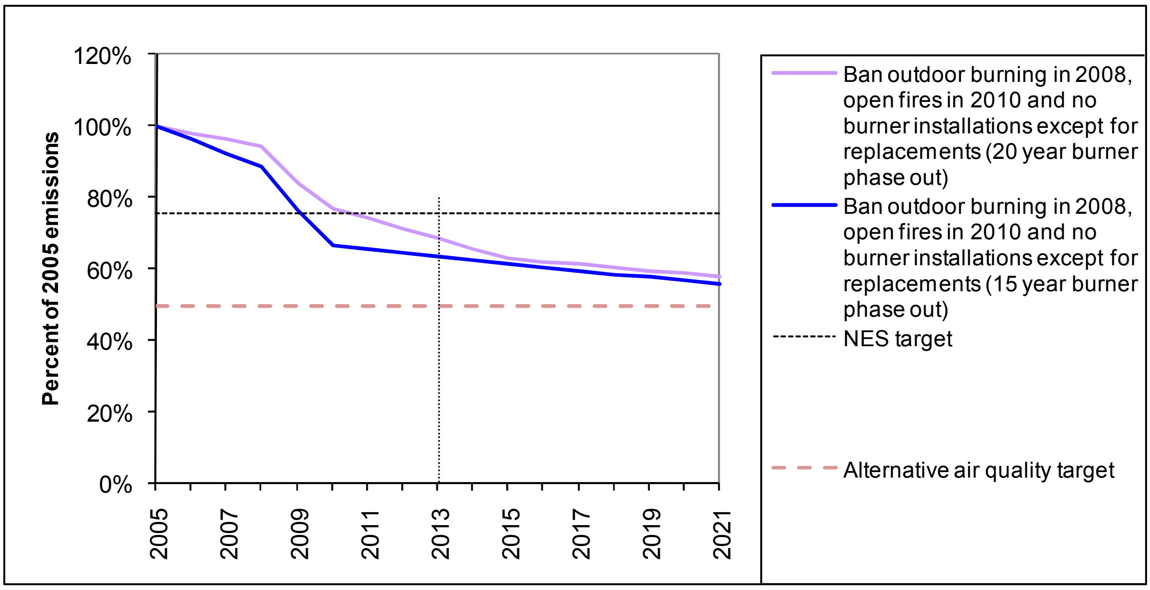

Figure 4.5: Status quo plus a ban on outdoor rubbish burning, a ban on the use of open fires and no new burner installations except to replace existing burners from 2010.

4.8 Ban on outdoor rubbish burning, open fires and new multi fuel burners must comply with the emission rate criterion specified in the NES design standard for wood burners

In 2005, the Ministry for the Environment introduced the requirement that all new wood burner installations meet an emission criterion of 1.5 grams of particulate per kilogram of fuel burnt (referred to as the NES design criteria for wood burners). However, there are currently no restrictions on emission rates for new installations of burners designed to burn coal or a combination of wood and coal. The air emission inventory domestic home heating survey suggests that around 13% of households installing new solid fuel burners from 2000 to 2005 in Blenheim installed multi fuel burners.

Additional reductions in PM_{10} are predicted if the emission criterion specified in the NES design standard for wood burners were to apply also to multi fuel burners (Figure 4.6). At present there are no multi fuel burners that meet this criterion so the assumption is made that households that might otherwise have installed a multi fuel burner will instead install a low emission wood burner.

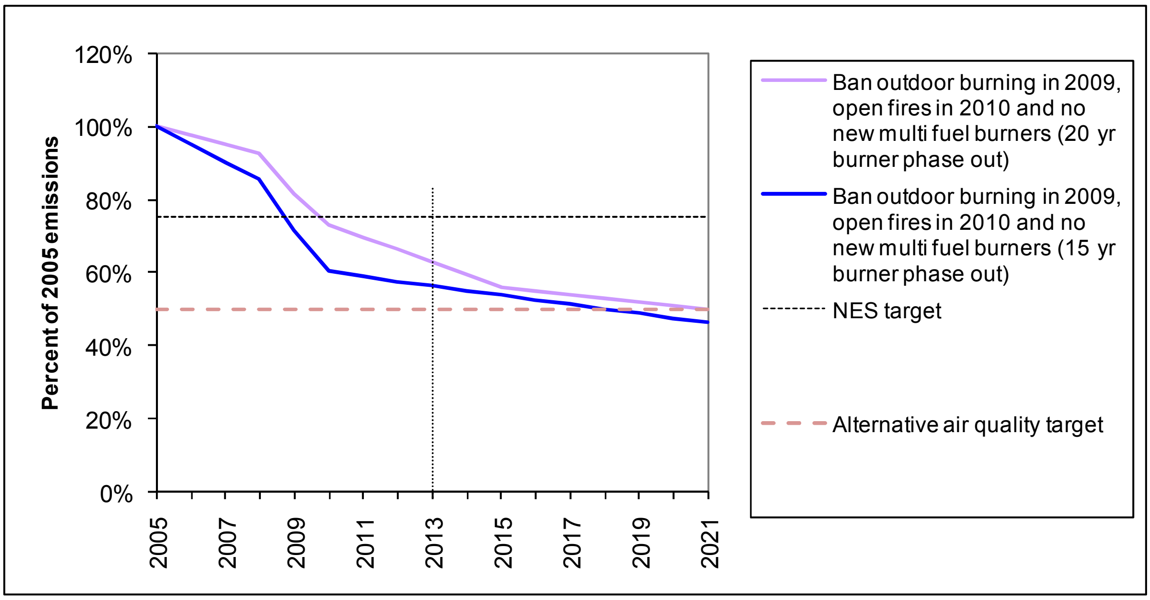

Figure 4.6: Status quo plus a ban on outdoor rubbish burning, the use of open fires and all new solid fuel burners installations in Blenheim must meet the emission criterion specified in the NES design standard for wood burners.

Figure 4.6 suggests that the combination of a ban on outdoor rubbish burning, the use of open fires and not allowing new installations of multi fuel burners (unless they meet the NES design criteria for wood burners) would result in PM_{10} concentrations meeting the NES by 2013.

4.9 Ban on outdoor rubbish burning in 2009 and no new multi fuel burner installations from 2010

Because of the improved predicted effectiveness of management options it is possible that the NES is achieved without having to ban the use of open fires, although the latter is likely to have energy efficiency benefits in addition to improving air quality. Figure 4.7 shows the predicted impact of an outdoor burning ban combined just with regulations prohibiting the installation of new multi fuel burners. Results suggest the NES may be met with this combination of options, although the uncertainties associated with the predictions should be also considered. In addition the assumption is made that 15% of households with solid fuel burners convert to non solid fuel at the time a fire is replaced. Figure 4.8 shows the same options as Figure 4.7 but with the assumption that 100% of households replace burners with new burners.

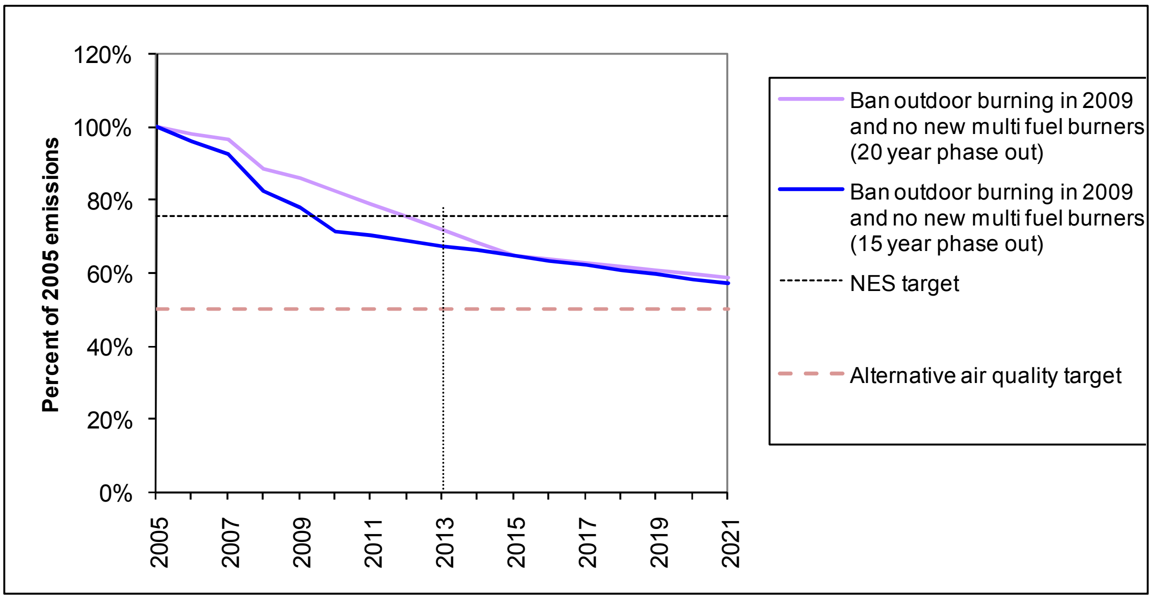

Figure 4.7: Ban outdoor rubbish burning and no new multi fuel burner installations from 2010 (85% of households removing solid fuel burners replace them with NES compliant burners).

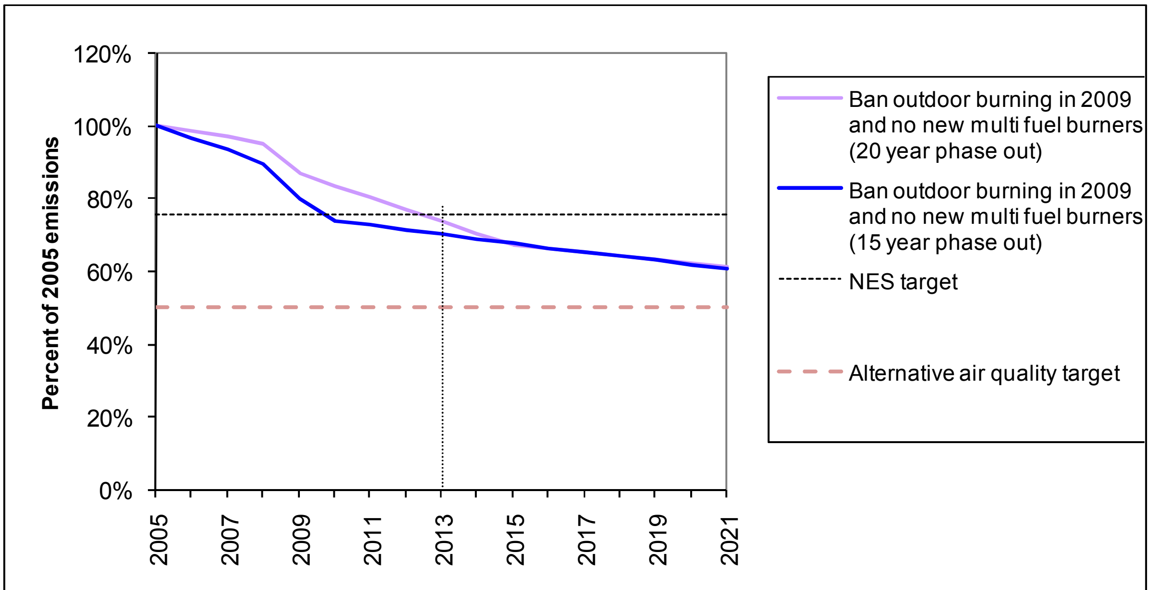

Figure 4.8: Ban outdoor rubbish burning and no new multi fuel burner installations from 2010 (100% of households removing solid fuel burners replace them with NES compliant burners).

4.10 Uncertainty estimates

Estimates of projections in PM_{10} are based on assumptions including variables such as emission rates, fuel use rates, population projections and household heating choices. Figure 4.9 shows the estimated upper and lower uncertainty bands if the uncertainty (estimated at 95% CI) surrounding each of these variables is combined statistically[4] for the management options shown previously in Figure 4.6. Factors not included in the uncertainty analysis include the reliability of the air quality monitoring results and the likelihood that they have captured "worst-case" meteorological conditions and variations in the contribution of sources originating outside of the study area.

The uncertainty analysis indicates some chance that the combined management options considered here may not be sufficient to achieve the NES for PM_{10} in Blenheim.

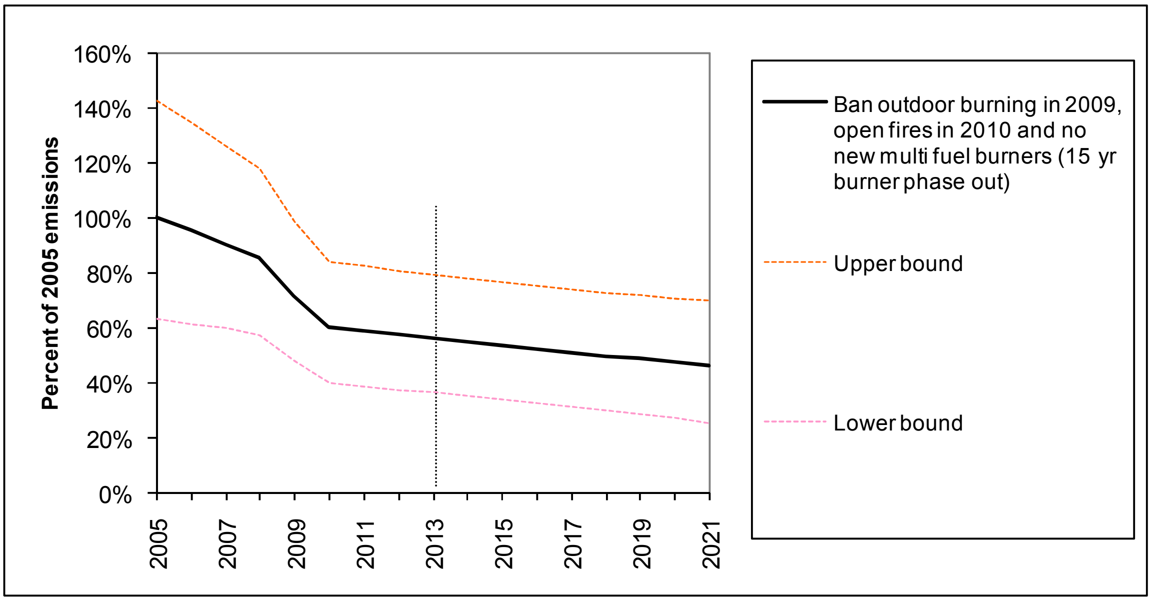

Figure 4.9: Estimated uncertainty bands for a ban on outdoor burning, open fires and no new multi fuel burner installations from 2010.

[4] Statistical formulae are based on Topping (1971)

5 Summary

Air quality monitoring in Blenheim shows PM_{10} concentrations in excess of the NES occur during the winter months at the Redwoodtown monitoring site. Based on monitoring results to date, excluding the 2004 Brooklyn Street results, a reduction of around 25% would be required to meet the NES. The main source of PM_{10} is solid fuel burning for domestic home heating, which contributes around 85% of the daily anthropogenic PM_{10} during the wintertime.

An analysis of the effectiveness of different management options in achieving this reduction suggests that some management intervention is required. The most effective measures examined in this analysis included a combination of a ban on outdoor rubbish burning, the use of open fires and the application of the NES design criteria for wood burners to multi fuel burners. It is also possible that a ban on outdoor rubbish burning and not allowing new installations of multi fuel burners would be sufficient to achieve the NES by 2013. Consideration could also be given to making the burner replacements mandatory after a specified time (e.g., 15 or 20 years) to ensure burners are replaced as predicted in the model.

This projection analysis has been done based on the best available information and provides a good indication of the likely management options required to improve PM_{10} concentrations to meet the NES in Blenheim.

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