NOVEMBER 2015

PREPARED FOR

Nelson City Council

PREPARED BY
Emily Wilton, Environet Ltd
www.environet.co.nz

Environet ltd
Air Quality Specialists

Air quality management in Nelson – modelling of additional scenarios - 2015

EXECUTIVE SUMMARY

This report evaluates the likely impact of a range of management scenarios on PM_{10} concentrations within the four different Airsheds of Nelson. It considers the impact of allowing ultra-low emission burners (ULEB); phasing out pre 2004 wood burners; tradeable burner rights; a point of sale rule whereby older pre 2004 burners are replaced with NES compliant burners or clean heating options at the time a house is sold; performance based standards and allowing NES compliant burners to be installed in new dwellings and existing dwellings using other heating methods subject to additional criteria or for low income or health compromised households.

The methodology and input assumptions used are as per Wilton, (2014c) with a few minor exceptions and a more significant change being the cross boundary impacts of Airsheds C and B2 on concentrations of PM_{10} measured at the monitoring sites in Airsheds A and B1. The 2014 evaluation of cross boundary effects was based on a 2012 Golder report of air dispersion modelling. Because of the potential significance of the cross boundary impacts modelling was updated with 2014 emissions and carried out at a finer spatial resolution to specifically investigate the transfer of pollution between airsheds. Results found a much lower contribution from Airshed C to Airshed A (down to 6%, but with an additional 3% from Airshed B2) and from Airshed B2 to B1 (down to 15%).

Airshed A is currently considered non-compliant with the NES for PM_{10} despite not breaching the standard for PM_{10} during 2015 (one exceedance on 30th May but no breach). A reduction in peak winter concentrations of around 14% is estimated to be necessary for ongoing compliance with the NES when worst case meteorology is considered (Wilton & Zawar Reza, 2014). Airshed A could become compliant with the NES for PM_{10} if older pre 2004 burners are replaced with NES compliant wood burners, particularly if emissions could also be reduced through a behaviour change programme or if households voluntarily moved away from wood burners. Unless management measures are adopted to reduce PM_{10} concentrations to well below the target line there is unlikely to be any capacity in Airshed A for new emissions. It is also worth noting that there is uncertainty around the target line and that greater certainty of compliance would be achieved if options were selected to achieve the target with a buffer.

Airshed B1 may be compliant with the NES for PM_{10} and it is possible that no further reductions in concentrations are required. There is currently no capacity within Airshed B1 for the installation of new burners but the replacement of older pre 2004 burners with time may create capacity. If all pre 2004 burners were phased out there may be capacity for the installation of a maximum of 500 ULEB. This number would be affected by measures adopted for Airshed B2 as the projections for Airshed B1 include a 2% reduction associated with a projected decrease in emissions from Airshed B2. Similarly allowing an increase in PM_{10} concentrations in Airshed B2 to the NES level would result in a further increase in projections for Airshed B1 of 2% (i.e., 4% in total). If the approach of allowing ULEB in Airshed B1 is adopted, it is recommended that measures be integrated to ensure capacity is not exceeded.

Airsheds B2 and C appear compliant with the NES for PM_{10}. A reduction in concentrations in these airsheds is predicted as households replace older burners at the end of their useful life. Allowing some ULEB or NES compliant burners is possible without compromising the NES. It is also possible to allow a smaller number of ULEB or NES compliant wood burners into the airsheds without further degradation in air quality if older burners are phased out or replaced at the end of a 20 year useful life. Emissions from these airsheds have minor contributions to concentrations measured in Airshed A and Airshed B1. In determining the numbers of ULEB that might be able to be installed it should be noted that there is a higher level of uncertainty around the real life emissions for these burners owing to the absence of in home testing.

In Airshed B2 around 2500 ULEB or 550 NES compliant burners could be installed without compromising existing air quality provided older burners were replaced at the end of a 20 year useful life. The 550 NES compliant burners could increase to around 600 with the introduction of a tighter efficiency criterion or to 800 if installations are only allowed in dwellings insulated to post 2007 standards. If the replacement of older burners is not mandated lower limits such as 1250 ULEB or 225 NES burners should be set.

In Airshed C around 3000 ULEB or 700 NES compliant burners could be installed without compromising existing air quality provided older burners were replaced at the end of a 20 year useful life. The 700 NES compliant

burners could increase to around 800 with the introduction of a tighter efficiency criterion or to 1000 if installations are only allowed in dwellings insulated to post 2007 standards. If the replacement of older burners is not mandated lower limits, such as 1500 ULEB or 350 NES burners should be set if existing air quality is to be maintained.

No degradation in air quality and continuation of projected downward trends could be achieved in Airsheds B2 and C by introducing a behaviour change programme targeting a 10% reduction in PM_{10} and allowing up to 1000 ULEB installations in Airshed B2 and 600 ULEB installations in Airshed C.

Allowing tradeable permits shouldn't adversely affect air quality in airsheds where concentrations are below the NES for PM_{10}. In airsheds where reductions in PM_{10} concentrations are required, and haven't been assigned, a tradeable permit system would result in over allocation of airshed capacity.

A point of sale rule whereby older burners are required to be replaced at the time a house is sold was examined for Airsheds B2 and C. It was found to be only minimally effective in reducing PM_{10} concentrations if older burners are replaced at the end of their useful life and moderately effective if not.

Setting a new limit for wood burner emissions was examined for Airsheds B2 and C and assessed relative to maintaining existing air quality assuming the replacement of older burners over time and allowing polluting up to a level indicative of NES compliance. The real life emission rates for these options range from 0.5 g/kg to 1.8 g/kg. A number of issues with this option are raised including a lack of certainty around the real life emissions of appliances tested to a performance based standard (e.g., Canterbury Method).

Options for limiting the installation of new burners into airsheds was examined including health and income restrictions. The impacts of stipulating insulation requirements, limiting house sizes or requiring a higher efficiency criterion were assessed. Insulation requirements were likely to have the greatest impact in terms of reducing fuel consumption.

An evaluation of the impact of secondary technology in reducing PM_{10} concentrations was unable to be carried out owing to the timing around the release of test data that would inform the evaluation. An assessment of the potential impacts will be carried out on receipt of the data.

TABLE OF CONTENTS

1 INTRODUCTION

Air quality in Nelson has improved following the introduction of the Nelson City Council's Air Plan which was notified in 2003 and became operative in 2008. The Plan included management measures targeting domestic home heating as the main source of winter time breaches of the National Environmental Standard (NES) for PM_{10}. The plan aimed to reduce PM_{10} concentrations in Nelson's Airshed A by 70% and in other airsheds by lesser amounts. The measures included in the Air Plan were:

i. A ban on outdoor rubbish burning from 2004
ii. Emission limits for new installations of solid fuel burners of 1.5 g/kg and an energy efficiency of 65% (when tested to AS/NZS 4013).
iii. A ban on the use of open fires from January 2008.
iv. A ban on the installation of solid fuel burners in new dwellings or existing dwellings using other heating methods from 23 August 2003 (Plan notification date).
v. Airsheds A and B1 - staged phase out of older burners from 2010, 2011 and 2013. The latter phase out date of wood burners installed between 2000 and 2003 was withdrawn following 2011 revisions to the NES. This resulted in approximately 120 burners in Airshed A which did not get phased out and for which no legislative replacement date currently exists.
vi. Airshed B2 – staged phase out of older (pre 1991 burners) by 2010 and 1991 - 1996 burners by 2012.

An evaluation of the effectiveness of the Air Plan in reducing PM_{10} concentrations in Nelson to meet the NES was carried out in 2014 (Wilton, 2014c). Results suggested significant reductions in concentrations in Airshed A and B1 where concentrations in breach of the NES historically occurred. Additional reductions in 2014 levels of around 14% are likely to be required for ongoing compliance with the NES (Wilton & Zawar Reza, 2014).

Nelson City Council is in the process of an Air Plan review and is considering additional management measures in airsheds not meeting the NES as well as potentially allowing the installation of new solid fuel burners in areas where PM_{10} concentrations are below the NES. The impact of different management measures has been assessed (Wilton, 2014c) for the four airsheds using a mass emissions based approach. This is an airshed wide approach and focuses on a reduction in sources based on average contributions to concentrations measured at ambient air quality monitoring sites. An evaluation of the effectiveness of additional scenarios is required.

The purpose of this report is to evaluate the likely impact on PM_{10} concentrations in the different airsheds of:

- Allowing the installation of new ultra-low emission burners (ULEB) with limits on the numbers for all airsheds.
- Phasing out burners not complying with the NES design criteria for wood burners in Airsheds B2 and C.
- The potential impact of allowing tradeable burner rights.
- Point of sale phasing out of existing older burners - replacement with NES compliant burner allowed.
- Allowing performance based rules (e.g., Canterbury Method) including an evaluation of the airshed capacity and the emission limit required for all new burners to be compliant and the NES to be achieved.
- Allowing installations of NES compliant wood burners in new and existing dwellings subject to further limitations (e.g., insulation, efficiency, size).
- Allowing installations of NES compliant wood burners in new and existing dwellings for those on low incomes or who have health issues.

An analysis of the likely effectiveness of secondary control technology was also intended for this report. However, results of 2015 testing of the effectiveness of the Oekotube technology in New Zealand were unavailable at the time the report was prepared. An assessment of this report and the potential implications for air quality management in Nelson will be carried out when it becomes available.

2 UPDATE ON 2014 ASSESSMENT

There are a few changes in the baseline information since the 2014 assessment (Wilton, 2014c) as a result of improved information. This section outlines these changes and provides updates of projections graphs for the baseline scenarios for each airshed.

2.1 Airshed A

The 2014 assessment found a further reduction in PM_{10} concentrations in Airshed A is required to meet the NES for PM_{10}. The reduction required has been estimated at around 14% of 2014 levels. This has not changed.

The assessment of baseline projections for domestic heating has not changed since the 2014 evaluation. These were based on the 2014 inventory assessment of households using different heating methods and fuels. Changes in the use of solid fuel heating with time was assumed to be minimal as most households will have replaced older more polluting wood burners with lower emission burners (NES burners) as required under the Air Plan. Some households may not have replaced older burners as required under the air plan and a small number of households with burners installed between 2000 and 2003 (when Council emission limits for wood burners came into effect) can legitimately use non NES compliant burners. Typically an assessment of this type would include an assumption that households would replace wood burners at the end of their useful life (often assumed to be 15 or 20 years).

This assumption around replacement of older burners at the end of their useful life is a key issue for all the analysis in this report. It is unrealistic to not include a replacement assumption. However, in reality not all households will replace burners even when they are no longer operating effectively. In instances where Council needs the reductions associated with the replacement of older burners to achieve compliance with the NES or to enable new emissions into the airshed, consideration should be given to regulating the phase out to ensure the reductions occur.

Assumptions underpinning the emissions and baseline emissions projections for domestic home heating are:

- An average emission factor of 4.5 g/kg for NES compliant wood burners[1].
- The average fuel use for wood burners in Airshed A is 18 kilograms per day (from Wilton, 2014).

A slight change to the motor vehicle emissions assessment was made in that an estimate of re-suspended road dust was made based on the information from (Davy & Xie, 2014) and the methodology reported in Wilton, 2015b).

Motor vehicle emissions were estimated based on the 2014 emission inventory assessment for Airshed A. The emission estimate of seven kg/day from the inventory is based on Ministry of Transport (MOT) data on VKTs by census area unit (CAU) and PM_{10} emission factors from the Vehicle Fleet Emission Model (VFEM version 5.0). The model was adapted for location specific vehicle fleet characteristics, an average vehicle speed of 42 km/hr and local average temperatures.

The 2021 motor vehicle emissions were estimated using the VFEM (version 5.0) with input data as per 2014 with the exception of the output year which was changed to 2021. The model estimates PM_{10} tailpipe emissions from the vehicle fleet will decrease by a third by 2021. Projections in vehicle kilometres travelled are difficult to extrapolate and in fact an evaluation of changes in VKT in Nelson since 2006 suggests no significant changes in VKTs in Nelson since 2006 (Wilton, 2014). A conservative approach would be to assume some increase in VKT in Airshed A by 2021. If the VKTs are estimated to increase by 10% by 2021 the PM_{10} emission estimate from motor vehicles for 2021 would be around five kilograms per day. If the VKT were estimated to increase by 50% by 2021 the PM_{10} motor vehicles emission estimate for 2021 would be around seven kilograms per day.

[1] Although AS/NZS 4013 specifies an emission limit of 1.5 g/kg it is based on prescribed testing regime designed for minimising potential sources of variability in emissions for the purposes of achieving precision in the test data. Real life testing of burners meeting the NES design criteria for wood burners indicate average emissions around 4.5 g/kg (Wilton, Bluett, & Chilton, 2015)

The projections include a value of five kilograms of PM_{10} from motor vehicles for 2021 based on the assumption of a 10% increase in VKT in Airshed A by 2021. The revised projections extend to 2030. No additional increases in VKT are factored in at this stage. However, this may change once Council has access to vehicle projections modelling data. Currently the 2030 motor vehicle projections are based on the 2021 VKT with emission factors derived for 2030. It would seem reasonable to assume a high degree of uncertainty around the 2021 and 2030 emission factors for motor vehicles. However, this is unlikely to impact on projections as motor vehicles are a minor contributor to ambient 24-hour average PM_{10} concentrations on high pollution nights.

No changes to the baseline assessment for industrial and commercial activities were made. Industrial and commercial activities with PM_{10} emissions were assessed for 2014 in the 2014 emission inventory (Wilton, 2014). The Airshed A emission estimate was eight kg/day and was based on a total of seven industrial or commercial discharges (including school boilers) in the Nelson South area.

The 2021 industrial and commercial PM_{10} emissions were estimated based on the assumption of a zero percent increase in PM_{10} emissions from this source in Airshed A. Council canvased industrial users about future expansion or changes that may impact on discharges to air. The result was modest if any growth.

The contribution of natural sources (primarily marine aerosol and soil) to concentrations of PM_{10} in Airshed A was evaluated by Ancelet, Davy, & Trompetter (2013). Spreadsheets of source apportionment outputs were provided by the authors for this study. These indicated average daily contributions of natural sources on days when PM_{10} concentrations were elevated of around 6.7 $\mu g/m^3$ of PM_{10}. There are no changes to this baseline information.

No other contributing sources have been identified. There are no known rural sources of emissions that may be contributing to PM_{10} concentrations.

The 2014 baseline assessment included a contribution of 25% from Airshed C based on a 20-30% contribution indicated in Golder Associates (2012). This work has been updated with a view to better characterising this contribution. It was found that the contribution from Airshed C was much less at around 6% and this value was used for the 2015 update. A small contribution (3%) from Airshed B2 was also included.

2.1.1 Airshed A Implementation of Air Plan

The status quo for Airshed A is full implementation of the existing air plan including compliance checks for households to ensure conversions to NES compliant burners have been carried out where required. Figure 3.1 compares the original air plan reductions adjusted for differences in emission factors (Wilton, 2014a) and the reductions in PM_{10} concentrations in Airshed A (after minimising for the impact of meteorology) and the 2014 emission inventory results (Wilton, 2014b). This shows good consistency in trends in PM_{10} between the different tools used to evaluate changes. It also provides perspective on the further reductions in PM_{10} required to meet the NES relative to 2001 PM_{10} concentrations and emissions.

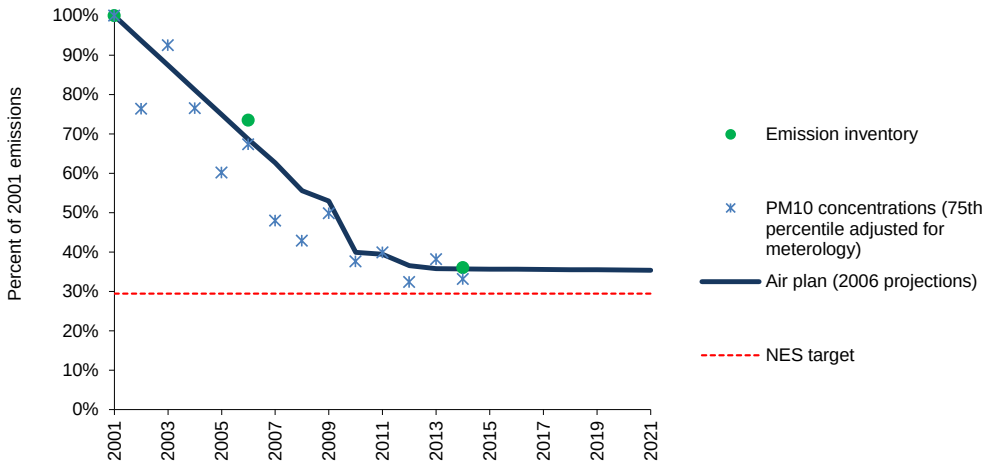

Figure 2.1: Comparison of original air plan projections for PM_{10} (adjusted for changes in emission factors) with trends in concentrations and emission inventory PM_{10} estimates for 2001, 2006 and 2014.

2.1.2 Phase out of non NES compliant wood burners

A number of burners that do not comply with the NES design criteria for wood burners (emission limit of 1.5 g/kg and efficiency of 65% when tested to AS/NZS 4012 and 4013) can legitimately be used in Airshed A as a result of the final phase out date (burner installed between 2000 and 2003) being removed from the Air Plan after the 2011 review of the NES. The youngest of these burners will reach a 15 year life at the end of 2017. It is likely that some of these burners will be replaced through natural attrition around this time. However, including regulatory requirements around the upgrading or removal of these burners will provide greater certainty in achieving reductions in PM_{10}. Figure 2.2 shows the projected impact of this option on PM_{10} concentrations in Airshed A updated for the changes in method described above.

While this option appears close to achieving the NES PM_{10} target at the St Vincent Street monitoring site, additional measures would be required to bridge the remaining gap and to provide a buffer to allow for uncertainties in the projections.

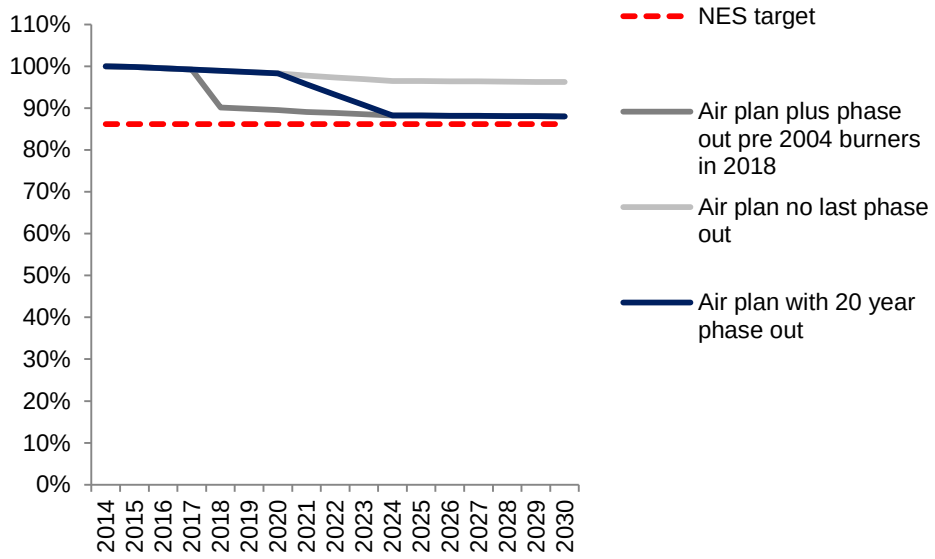

Figure 2.2: Projected improvement in PM_{10} concentrations in Airshed A as a result of phasing out wood burners installed between 2000 and 2003 in 2018, assuming no replacement of these burners and assuming they are replaced 20 years after installation.

2.1.3 Phase out non NES compliant wood burners and behaviour change programme

A behaviour change programme is a non-regulatory approach to reducing PM_{10} emissions from domestic home heating by changing burner operating behaviours. Environment Canterbury are in the process of developing a wood burner behaviour change programme which may be available to other Councils if funding documentation and development of the programme is obtained. The programme promotes the concept of a smoke free chimney with the key message being that no visible smoke is achievable if a burner is operated well. Advice on how to operate a burner to achieve a smoke free chimney has been well researched as have ways of affecting behaviour change. The advantages of this option are that significant reductions in PM_{10} emissions are possible through improvements in burner operation. One limitation, however, is that it requires a change in householder behaviour and therefore its effectiveness is difficult to quantify as it depends on the resources allocated, the effectiveness in changing behaviours and the ongoing commitment of householders toward burner operation. Figure 2.3 shows the impact on projections for PM_{10} if a behaviour change programme were 10% effective in reducing PM_{10}. As a result of new developments in behaviour change programmes a 10% reduction in emissions may be a reasonable expectation for a well implemented programme.

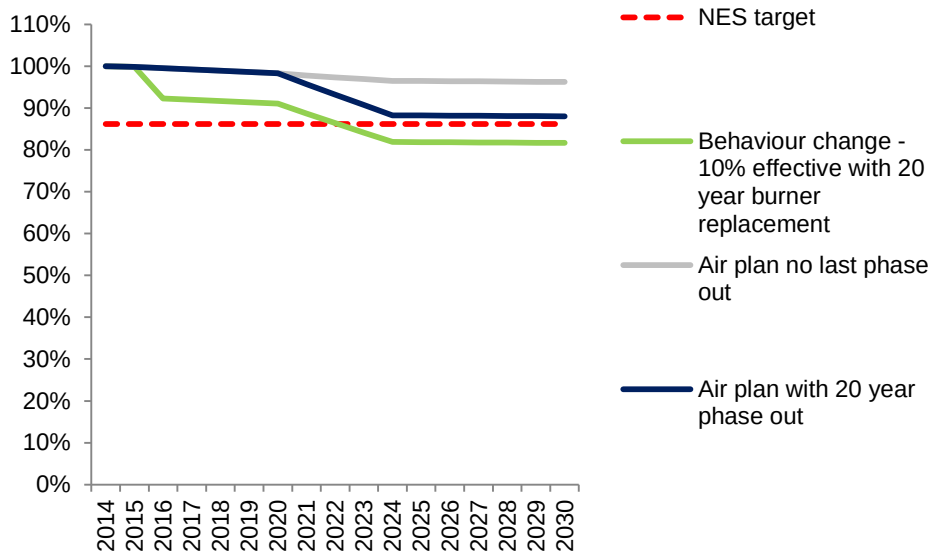

Figure 2.3: Projected improvement in PM_{10} concentrations in Airshed A as a result of a behaviour change programme assuming a 20 year replacement of older burners with NES compliant ones.

2.2 Airshed B1

The 2014 analysis suggested that while there is unlikely to be any spare capacity for emissions in Airshed B1 it is possible that no further reductions are required. There is no change to this evaluation as a result of 2015 monitoring data now being available. However, it is noted that there is greater uncertainty around the assessment for Airshed B1 owing to the different nature of emissions sources in this airshed.

There is no change to the baseline assessment of emissions from domestic heating within Airshed B1.

Assumptions underpinning the emissions and baseline emissions projections for domestic home heating are:

- An average emission factor of 4.5 g/kg for NES compliant wood burners.
- The average fuel use for wood burners in Airshed B1 in Nelson is 20 kilograms per day.

As with the Airshed A assessment an estimate of re-suspended road dust emissions has been made for the 2015 assessment. Baseline tailpipe and brake and tyre wear emissions are as per the 2014 evaluation with allowance for a 10% increase in VKT by 2021. The revised projections extend to 2030. No additional increases in VKT are factored in at this stage. However, this may change once Council has access to vehicle projections modelling data. Currently the 2030 motor vehicle projections are based on the 2021 VKT with emission factors derived for 2030.

Industrial and commercial activities with PM_{10} emissions were assessed for 2014 in the 2014 emission inventory (Wilton, 2014). The Airshed B1 emission estimate was 65 kg/day. The 2030 industrial and commercial PM_{10} emissions were estimated based on the assumption of a zero percent increase in PM_{10} emissions from this source in Airshed B1. Council has canvased industrial users and the result was modest if any increase in emissions.

No change to the baseline natural sources contribution has been made. The contribution of natural sources (primarily marine aerosol and soil) to concentrations of PM_{10} in Airshed B1 was evaluated by Ancelet, Davy, Trompetter, & Markwitz, (2010). Spreadsheets of source apportionment outputs were provided by the authors for this study. These indicated average daily contributions of natural sources on days when PM_{10} concentrations were elevated of around 4 $\mu g/m^3$ of PM_{10} with a maximum contribution of around 6 $\mu g/m^3$. The latter value was used in this study owing to the small number of high pollution events during sample days.

The 2014 baseline assessment also includes a contribution of 50% from Airshed B2 based on modelling by Golder Associates (2012). An updated dispersion modelling report suggests that this is an over estimate and that the contribution from Airshed B2 is around 15%.

Figure 2.4 compares the original Air Plan projections (updated for revised emission factors) with the trend in PM_{10} concentrations, the emission inventory emission estimate for 2014 and the revised projections based on the inventory assessment.

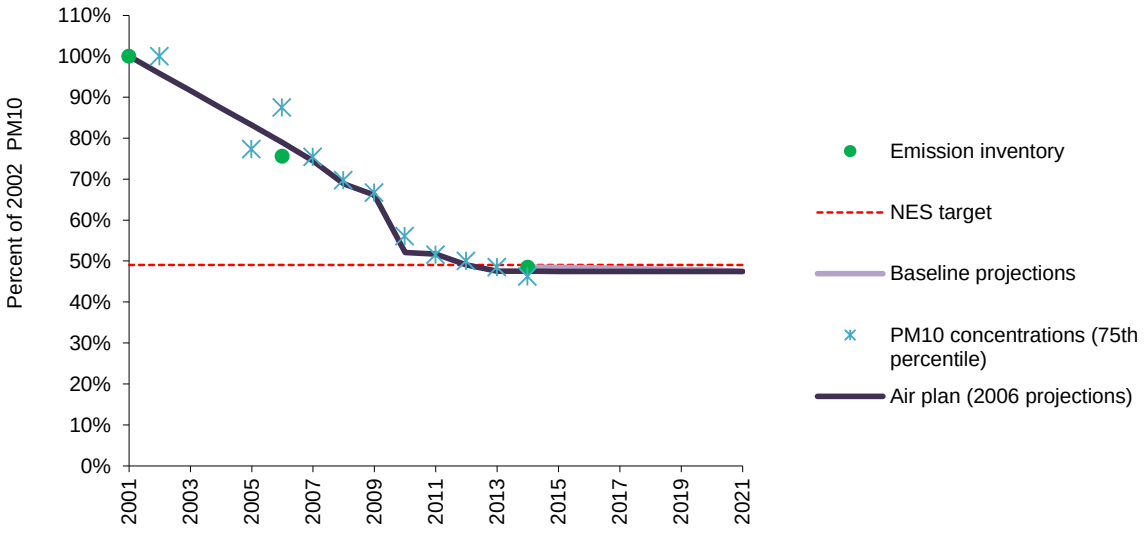

Figure 2.4: Comparison of trends in PM_{10} concentrations with original projections and 2014 emission inventory estimates.

2.2.1 Phase out of non-NES compliant burners

Figure 2.5 shows the estimated impact of phasing out non-NES compliant wood burners in Airshed B1 by 2018, a 20 year natural attrition scenario and a scenario that assumes no replacements of these burners.

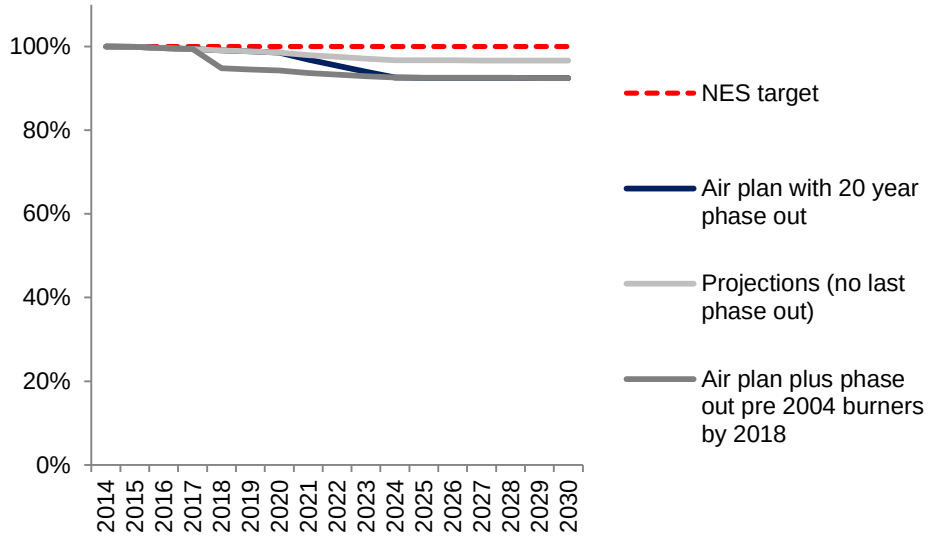

Figure 2.5: Phase out non-NES compliant wood burners in Airshed B1.

2.3 Airsheds B2 and C

The only change to the 2014 assessment in baseline assumptions and projections is the inclusion of re-suspended road dust from motor vehicle movements and the extension of motor vehicles to 2030 as per Airsheds A and B1. Updated projections graphs for baseline scenarios have not been carried out to represent this change owing to the impacts not being discernible.

Monitoring of PM_{10} in Airshed B2 during 2015 indicated a maximum 24-hour average PM_{10} concentration of 31 $\mu g/m^3$ and a second highest concentration around 29 $\mu g/m^3$. This compares with 40 $\mu g/m^3$ and 40 $\mu g/m^3$ in 2010. However, it is unlikely that 2015 represents worst case meteorology and for the purposes of this assessment it is assumed that concentrations of around 40 $\mu g/m^3$ may still occur.

Monitoring of PM_{10} in Airshed C during 2015 indicated a maximum 24-hour average PM_{10} concentration of 38 $\mu g/m^3$ and a second highest concentration around 35 $\mu g/m^3$. This compares with 40 $\mu g/m^3$ and 35 $\mu g/m^3$ in 2008 and 39 $\mu g/m^3$ and 33 $\mu g/m^3$ in 2009. Results suggest the airshed is compliant with the NES for PM_{10}.

Projections modelling and comparison of emissions inventories for Airshed C suggests a reduction in PM_{10} would have occurred between 2006 and 2014 and some of this reduction should have occurred between 2009 and 2015. Unlike other airsheds the reduction estimated in emissions is not supported by monitoring data. This may be because assumed reductions in PM_{10} associated with the replacement of burners at the end of their useful life hasn't occurred and because there have not been regulations requiring the replacements as for other airsheds. From a topographical viewpoint Airshed C is more complex than other airsheds and mixing of air discharges across the airshed is likely to be less uniform. The airshed is therefore less suited to the mass emissions assessment approach underpinning the projections analysis.

Figure 2.6 and 2.7 show the airshed capacity relative to the NES in Airsheds B2 and C and the potential impact of the replacement of older wood burners as a result of natural attrition over a 20 year useful life. This shows further reduction in concentrations of PM_{10} are likely in both airsheds as these burners are replaced.

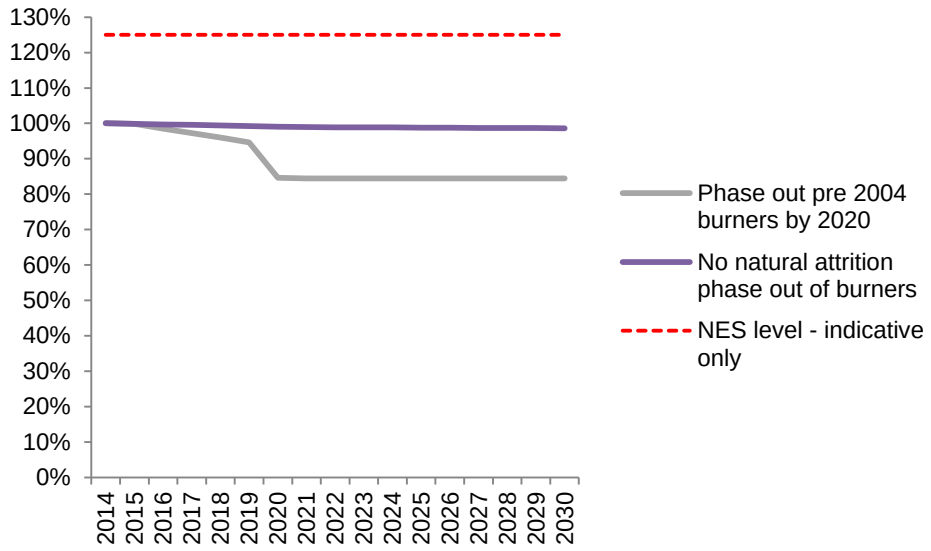

Figure 2.6: Phase out non-NES compliant wood burners in Airshed B2.

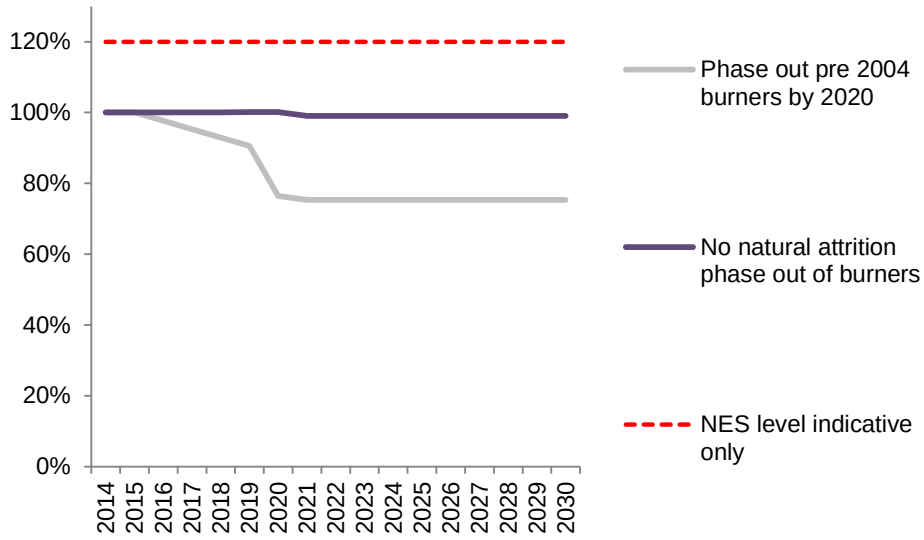

Figure 2.7: Phase out non-NES compliant wood burners in Airshed C.

3 LIMIT INSTALLATIONS OF ULEB

Ultra-low emission burners (ULEB) are burners that have been authorised by Environment Canterbury as meeting the criteria for ultra-low emissions, which includes an emission limit of 0.5 g/kg when tested under real life operating conditions. The Canterbury Method is discussed in more detail in section 4. There are currently three burners authorised as ULEB. Notwithstanding the attempts to simulate "real life" during the test procedure it is unlikely that the real life emissions for these burners will be as low as 0.5 g/kg because of issues of fuel quality and because the test procedures are carried out by combustion experts. In the absence of in home real life testing of any ULEB burners a factor of 1 g/kg has been used. This is the authors best estimate of likely emissions based on their experience with real life testing programmes.

In Nelson a ULEB can be installed as a replacement heating method in a dwelling where a legitimate solid fuel heating option is being replaced but cannot be installed currently in a new dwelling or existing dwelling using another heating method. This section evaluates the likely impact on PM_{10} if the latter were reviewed and ULEB were allowed, but with limits applied to the number of ULEB installed. The required limits are evaluated relative to capacity within the airshed. In the first instance, the NES for PM_{10} is used to define capacity. However, it should be noted that this would result in a significant degradation in air quality. These airsheds also contribute to PM_{10} concentrations in Airsheds A and B1 and increases in emissions in Airsheds B2 and C may potentially result in Airsheds A and B1 becoming non-compliant. Thus the capacity for Airsheds B2 and C is assessed against the current level of air quality with the capacity created by the phase out of pre 2004 burners as well as the capacity based on polluting up to the current NES level.

3.1 Airshed A

In 2014 Airshed A was assessed as unlikely to comply with the NES for PM_{10} with a 14% reduction in emissions required for compliance under worst case meteorological conditions. There is therefore no capacity in Airshed A to allow the installation of ULEB and meet the NES for PM_{10}.

Allowing the installation of ULEB in Airshed A without compromising attainment of the NES would require other methods to reduce existing levels to create capacity. These measures would need to target reductions of more than 14%. Figure 3.1 shows that PM_{10} concentrations in Airshed A could reach the NES target once all pre 2004 burners are replaced with NES compliant burners and if new ULEB burners are allowed (capped at 200) and if measures were undertaken to improve the operation of the burners. It assumes a reduction in emissions from Airsheds C and B2 as a result of the replacement of older burners over time which contributes to 2% of the reduction observed. Allowing emissions in Airsheds B2 and C to increase to the level of the NES would result in a further 2% increase in emissions in Airshed A.

The option assumes a 20 year natural attrition phase out rate which may or may not occur depending on the planned replacement timeframes for these households. This phase out may result in compliance with the NES but does not create capacity within the airshed. If an additional measure which achieved a 10% reduction in PM_{10} concentrations were adopted (for example behaviour change programme) it may be possible to allow installation of some ULEB burners. The graph illustrates the impact if 200 ULEB were allowed. However if this approach were adopted a lower limit would be recommended initially and increases allowed once better information became available on the likely real life emissions of these burners and the extent to which other measures had achieved the required reductions. In addition it is noted that there is uncertainty around the target line, as well as uncertainty around the real life emissions of ULEB and that greater certainty of compliance would be achieved if options were selected based on ensuring the projections line was below the target with some buffer.

If new ULEB burners were allowed regulations relating to the replacement timeframes for pre 2004 burners would be recommended. Allowing increases in emissions up to the NES for PM_{10} in Airsheds B2 and C is likely to compromise achievement of the NES in Airshed A for this option. Maintaining existing levels of air quality in Airsheds B2 and C (i.e., not allowing for the estimated 2% reduction in Airshed A associated with the natural attrition replacement of burners in Airsheds B2 and C) results in a projection line marginally below the NES target

line for this option. If measures for B2 and C are based on maintaining existing air quality the number of ULEB into airshed A for the above scenario should be further limited to less than 100 burners.

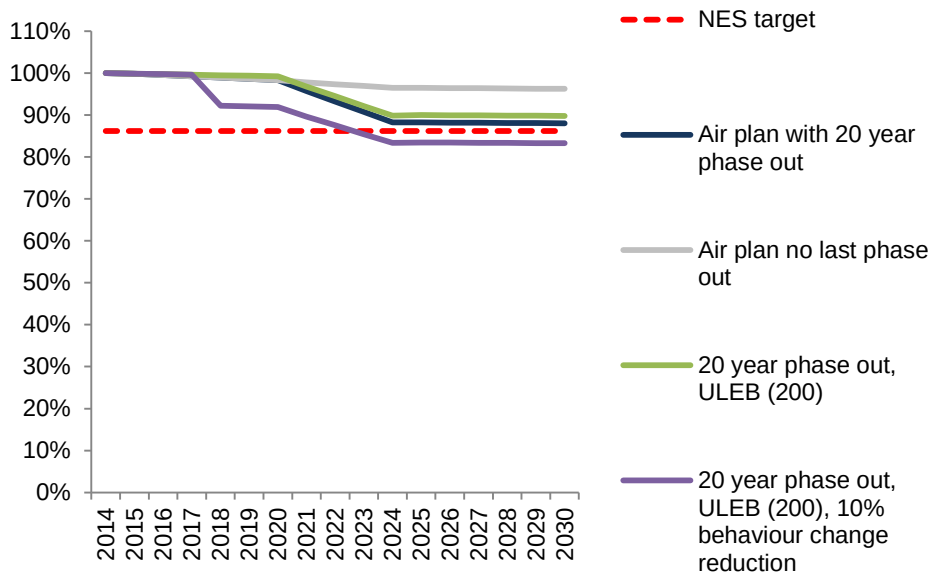

Figure 3-1: Estimated effectiveness of options for Airshed A including allowing ULEB with limits

A further option for reducing PM_{10} concentrations within Airshed A would be to limit the installation of new burners for any burner replacements to ULEB. Figure 3.2 shows the estimated impact on PM_{10} if pre 2004 burners were phased out, with and without a 10% behaviour change reduction.

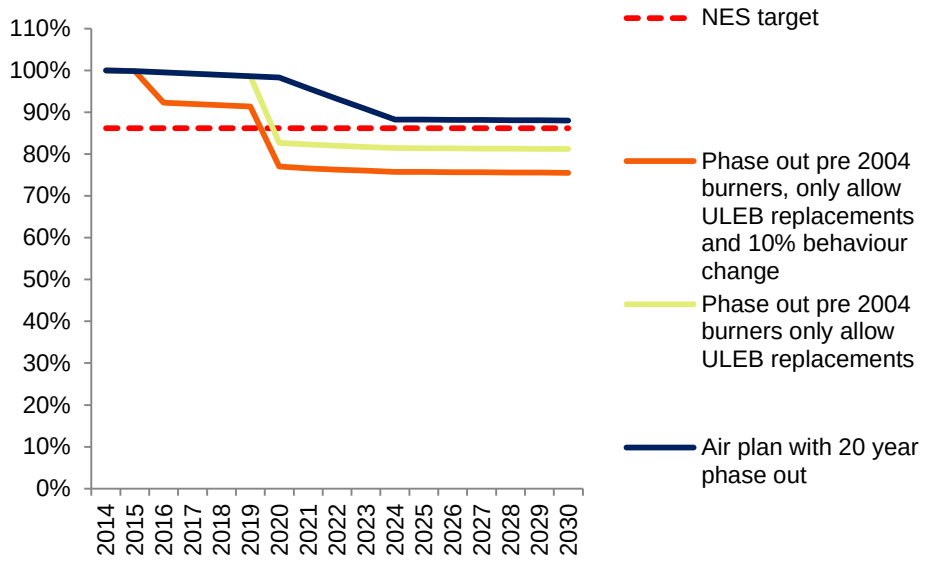

Figure 3-2: Estimated effectiveness of options for Airshed A with new installations limited to ULEB and mandatory phase out of pre 2004 burners.

3.2 Airshed B1

Figure 3.3 shows that there is no capacity[2] in Airshed B1 unless pre 2004 wood burners are replaced at the end of their useful life (based on a 20 year period in Figure 3.3). The with and without further Airshed B2 reductions

[2] Although the green line (no older burner replacements) tracks below the NES target line there are many uncertainties in the analysis. Aiming to be below the NES target line is recommended to increase likelihood of compliance.

is included because subsequent sections of this report consider whether the capacity created by ongoing reductions in emissions in Airshed B2 could be utilised by allowing the installation of NES compliant wood burners or ULEB in new dwellings or existing dwellings using other heating options.

Figure 3.4 suggests that there may be some capacity for allowing installation of ULEB in Airshed B1 of around 500 burners if older burners are phased out and emissions in Airshed B2 do not reduce further (provided they do not increase).

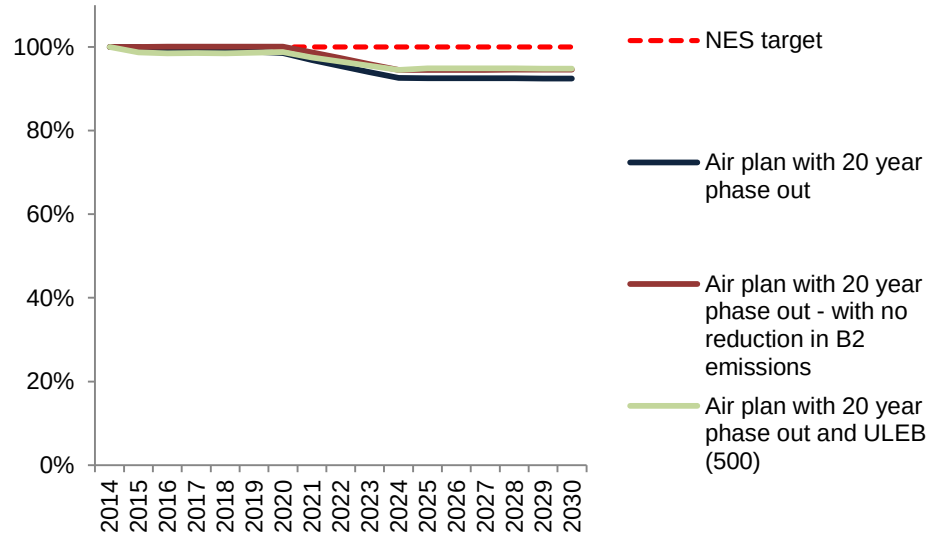

Figure 3-3: Baseline scenario for Airshed B1 with and without further reductions in emissions from Airshed B2

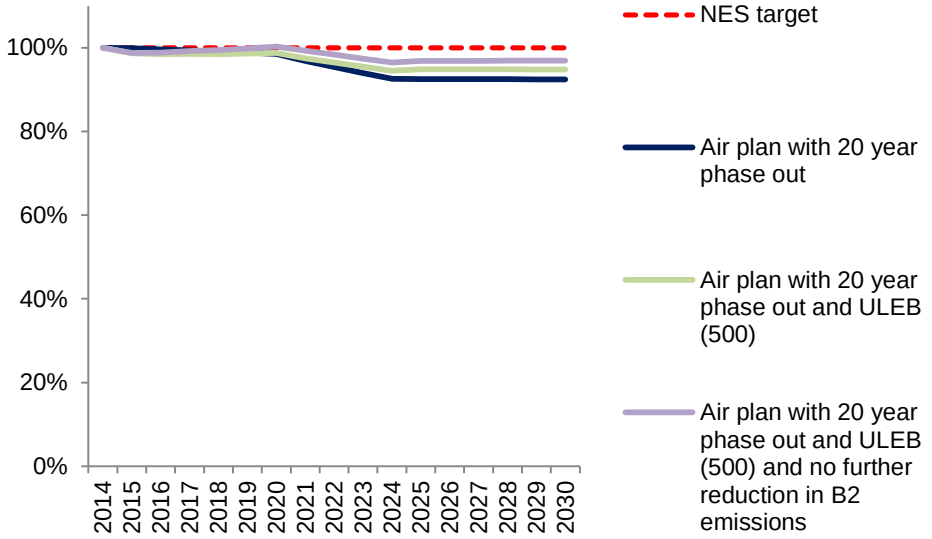

Figure 3-4: Estimated effectiveness of options for Airshed B1 including allowing ULEB with limits

A further option for reducing PM_{10} concentrations within Airshed B1 would be to limit the installation of new burners for any burner replacements to ULEB. Figure 3.5 shows the estimated impact on PM_{10} if pre 2004 burners were phased out, with and without a 10% behaviour change reduction.

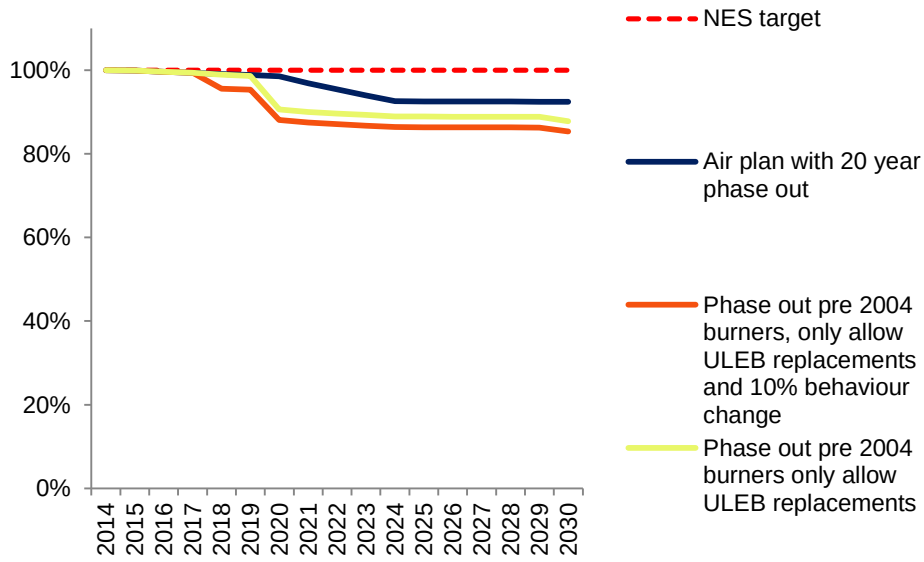

Figure 3-5: Estimated effectiveness of options for Airshed B1 with new installations limited to ULEB and mandatory phase out of pre 2004 burners.

3.3 Airshed B2

Results of air quality monitoring suggest the airshed is compliant with the NES for PM_{10}. While there is capacity within the airshed relative to the current NES for PM_{10}, concentrations from this area contribute to PM_{10} concentrations within Airshed B1. The assessment of capacity for this airshed is made relative to current concentrations (100%) assuming no increase in concentrations within the airshed is acceptable because of the significant contribution of this airshed to Airshed B1 and assuming that concentrations could be allowed to increase up to 50 $\mu g/m^3$ (NES limit). The former value is represented by the 100% line on the graph and a value of around 125% would be indicative of allowing polluting up to the NES.

Figure 3.6 shows that up to 2500 ULEB could be installed in Airshed B2 (limited ULEB scenario) provided households replaced pre 2004 wood burners with NES compliant burners at the end of a 20 year useful life without degrading air quality further. Under an unlimited ULEB scenario up to 4000 ULEB could be installed but air quality would degrade. If households with older burners in this airshed retained their burners allowing 2500 ULEB would result in an increase in PM_{10} emissions in Airshed B2 of around 14%. This is likely to impact on projections for Airshed B1 by an increase of around 4% (loss of reduction plus increase in emissions). It is therefore recommended that consideration be given to a compulsory phase out of pre 2004 burners if more than 1250 ULEB are to be allowed into the airshed. If there is no mandatory phase out of older burner it is recommended that new installations of ULEB be restricted to 1250. This number is based on 50% of households replacing older burners and that air quality is not allowed to degrade. In this instance projections for Airshed B1 would need to be adjusted upwards by around 2%.

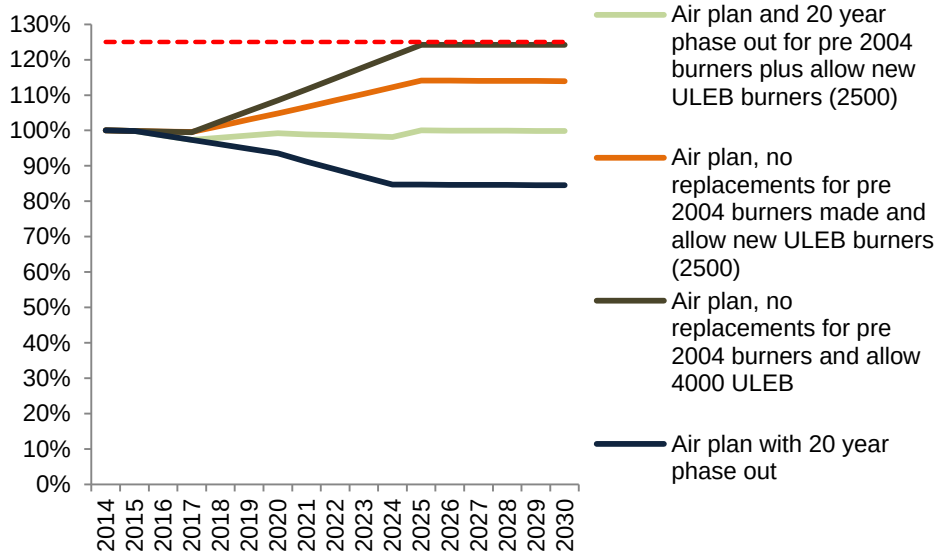

Figure 3-6: Estimated impact of allowing ULEB in Airshed B2 with and without replacement of pre 2004 burners at the end of a 20 year useful life.

Figure 3.7 shows the impact of requiring all new installations of burners meet the ULEB criteria and a 20 year burner replacement.

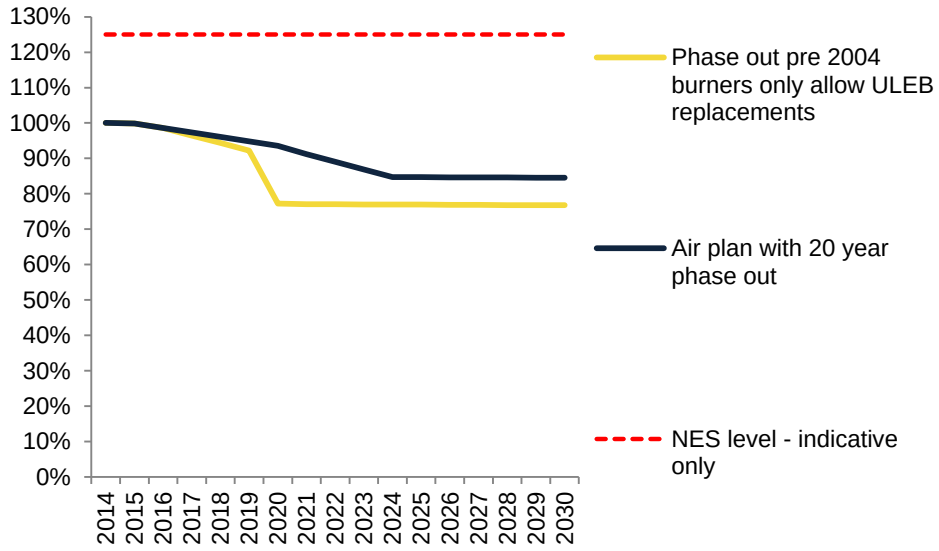

Figure 3-7: Only allow installations of ULEB burners in Airshed B2 and replacement of other heating methods after 20 years useful life.

3.4 Airshed C

Results of air quality monitoring suggest the airshed is likely to be compliant with the NES for PM_{10}. Figure 3.8 shows the estimated impact of both limited and unlimited ULEB[3] which includes up to 3000 new ULEB into Airshed C assuming older burners are replaced at the end of a 20 year useful life. If this does not occur then PM_{10} would increase and likely exceed the NES (as 2500 ULEB installs only just falling below the NES line). As

3 There are currently only around 3100 households that do not use wood in Airshed C and the limited ULEB numbers for no degradation in air quality allows 3000. Thus limited and unlimited ULEB scenarios are virtually identical.

with Airshed B2 existing air quality is represented by the 100% value. If there is no mandatory phase out of older burner it is recommended that new installations of ULEB be restricted to less than 1500. This number is based on 50% of households replacing older burners and that air quality is not allowed to degrade.

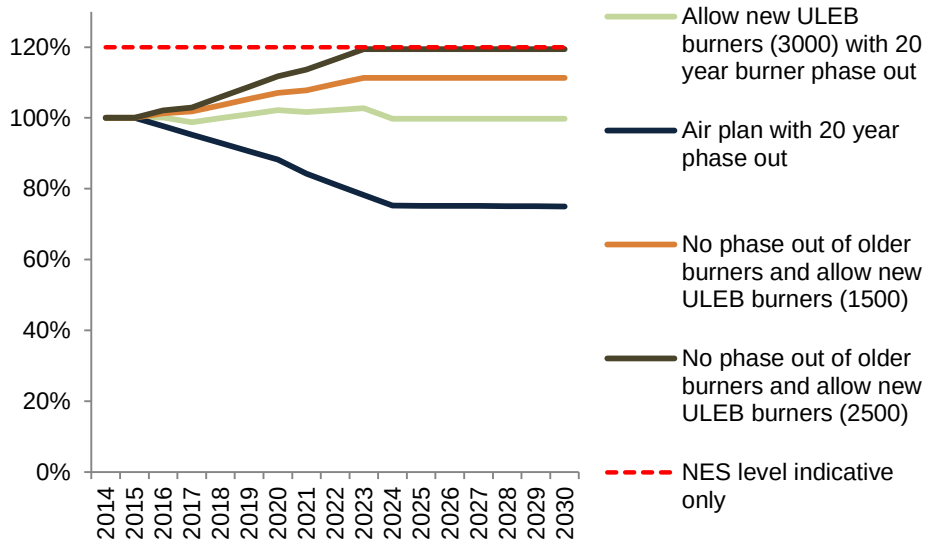

Figure 3-8: Estimated impact of allowing 1500 and 2500 ULEB in Airshed C without replacement of pre 2004 burners at the end of a 20 year useful life and 3000 ULEB with replacement of burners.

Figure 3.9 shows the impact of requiring all new installations of burners meet the ULEB criteria and a 20 year burner replacement.

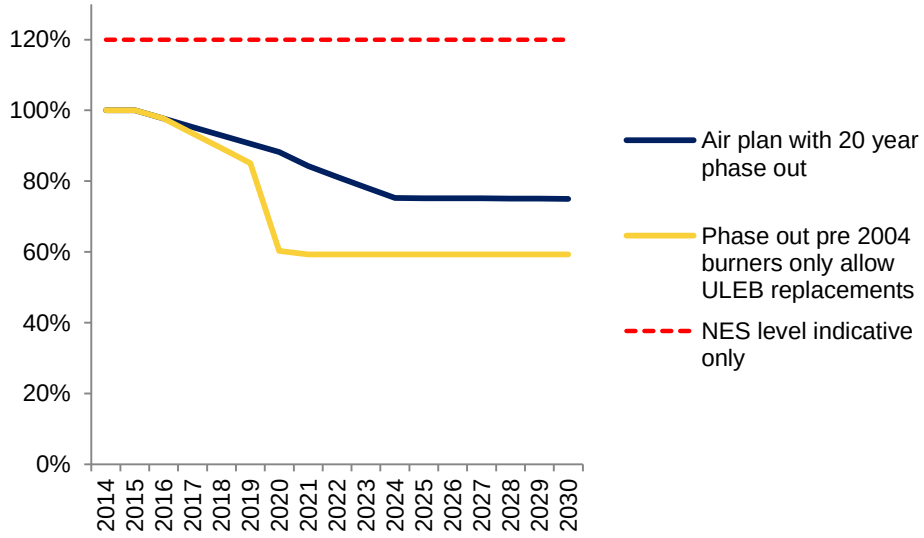

Figure 3-9: Only allow installations of ULEB burners in Airshed C and replacement of other heating methods after 20 years useful life.

4 OLDER BURNER PHASE OUT IN AIRSHEDS B2 AND C

Measures to improve air quality in Airsheds B2 and C to date have been less stringent than in Airsheds A and B1 with open fires and in Airshed B2 all burners pre 1996 requiring replacement with NES compliant wood burners or other cleaner heating options. While burners installed pre 2004 in Airshed C and between 1995 and 2004 in Airshed B2 (burners not meeting the NES design criteria for wood burners) can be still be used wood burners are unable to be installed in new dwellings or existing dwellings using non-solid fuel.

The inability to install wood burners in new dwellings and existing dwellings using other heating methods has been raised as a concern by residents in all airsheds.

A previous evaluation of the impact of relaxing this rule in Airsheds B2 and C which are seemingly compliant with the NES suggests that there is some scope for allowing new low emission burners without compromising attainment of the NES. However, allowing an increase in PM_{10} emissions in these airsheds may further compromise attainment of the NES in Airsheds A and B1 as a result of the movement of contaminated air between airsheds.

This section evaluates the capacity within Airsheds B2 and C that could be created by requiring burners installed prior to 2004 to change to NES compliant wood burners within a specified timeframe. Note however, that the capacity created through the phase out is likely to occur with time anyway as a result of natural attrition and that the introduction of a mandatory phase out for these burners is bringing forward gains that might otherwise have occurred. If it is determined that existing levels of particulate are satisfactory and that further reductions in these airsheds are not the focus of air quality management in other airsheds then allocation of this capacity could be examined. The purpose of this section is to examine this capacity with respect to new installations of NES compliant wood burners and ULEB.

The impact of allowing the installation of NES compliant burners in new dwellings and existing dwellings using other heating methods is then re-evaluated.

4.1 Airshed B2

Figure 4.1 shows the capacity that would be created within Airshed B2 by the phasing out of pre 2004 wood burners and the extent to which this capacity would be taken up by allowing the installation of NES complaint wood burners in new and existing dwellings currently using other heating methods. Limiting the new burner installation numbers to 550 is likely to result in no overall change in PM_{10} concentrations within Airshed B2

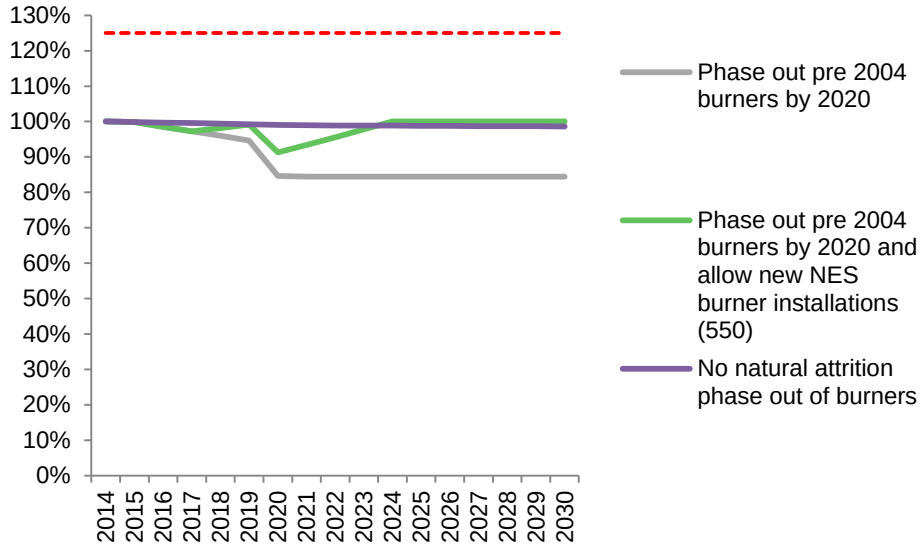

Figure 4-1: Impact of a burner phase out (pre 2004 burners) in Airshed B2 (allow new NES burners installs)

Figure 4.2 shows the impact of a burner phase out in conjunction with allowing ULEB burners rather than NES compliant wood burners in new dwellings and existing dwellings using other heating methods in Airshed B2.

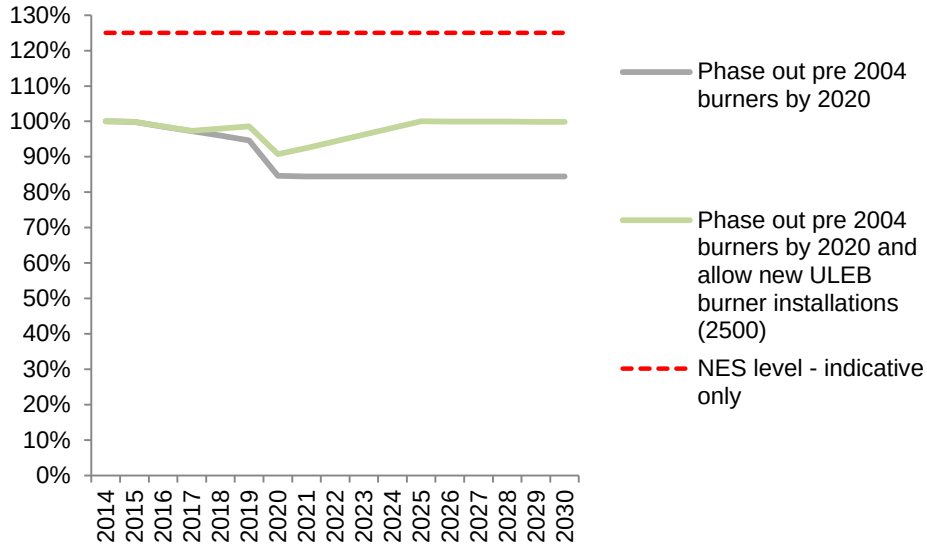

Figure 4-2: Impact of a burner phase out (pre 2004 burners) in Airshed B2 (allow new ULEB installs)

4.2 Airshed C

Further reductions in PM_{10} concentrations in Airshed C are likely as a result of the replacement of pre 2004 wood burners with low emission NES compliant wood burners over time. If a phase out date for these burners were introduced there would be increased certainty around achieving further reductions in Airshed C. Figure 4.3 shows the estimated impact of requiring the replacement of all pre 2004 burners by 2020 and the amount of capacity created that would be absorbed by allowing the installation of up to 700 wood burners in new or existing homes currently using other heating methods.

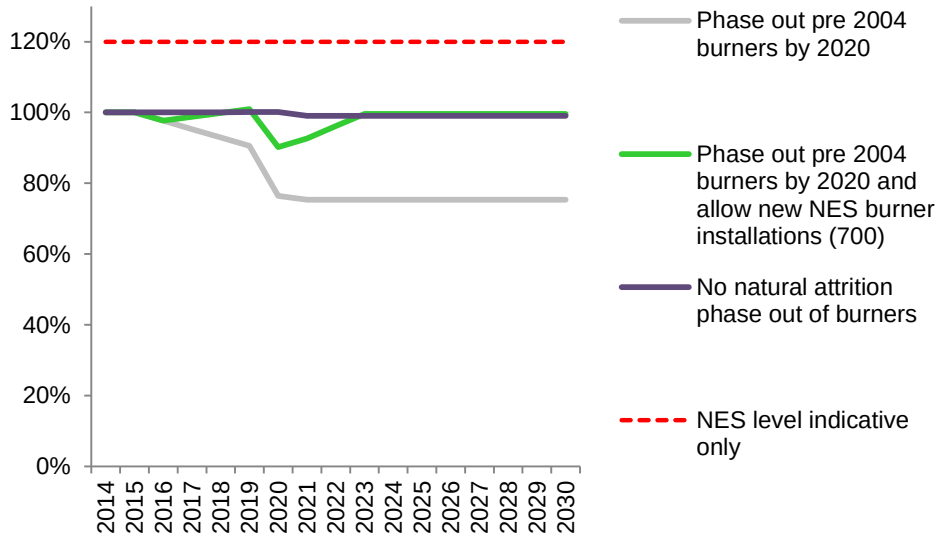

Figure 4-3: Impact of a burner phase out (pre 2004 burners) in Airshed C (allow new NES burners installs)

Figure 4.4 shows the impact of a burner phase out in conjunction with allowing ULEB burners rather than NES compliant wood burners in new dwellings and existing dwellings using other heating methods in Airshed C.

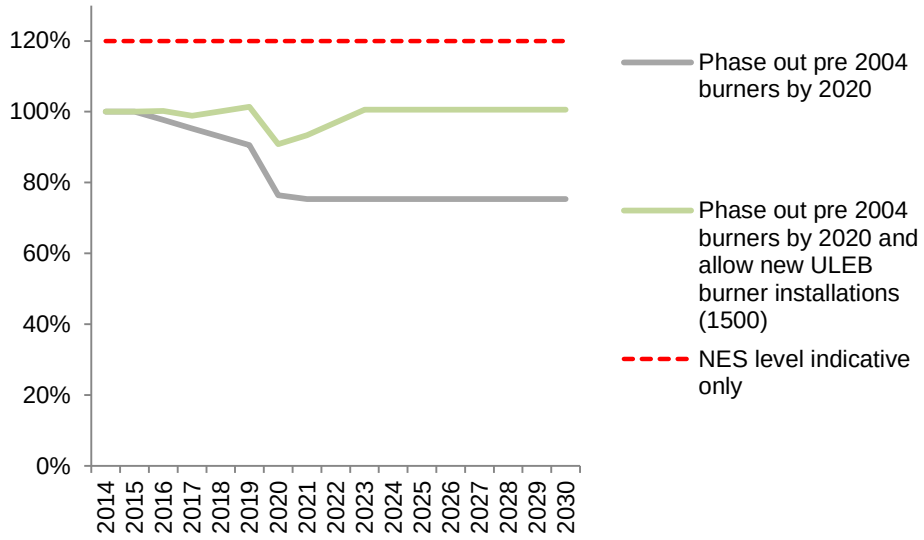

Figure 4-4: Impact of a burner phase out (pre 2004 burners) in Airshed C (allow new ULEB installs)

5 TRADEABLE BURNER RIGHTS

The option of trading the right to have a burner is reasonable in theory as the projections model assumes a 100% replacement rate of wood burners with burners. In reality it is likely that there are some additional gains in air quality made as a result of households choosing non-solid fuel alternatives at the time a replacement heating method is required. The impact of allowing burner rights to be tradeable may limit these gains. In addition, in airsheds where reductions in PM_{10} concentrations are required, and haven't been assigned, a tradeable permit system would result in over allocation of airshed capacity.

Figure 5.1 shows the potential additional benefits that may be achieved in Airshed A through 10% of households replacing pre 2004 wood burners with non-solid fuel alternatives. If tradeable burner permits were allowed any additional reductions such as those illustrated in Figure 5.1 would be reduced. The extent of additional reduction that may occur and the level to which it would be reduced is uncertain and the amounts depicted in Figure 5.1 are indicative only. It should be noted that these gains are not factored into the assessment and therefore could be available to be utilised. However, any decision regarding allowing this should also take into account the certainty around any measures proposed by Council to reduce PM_{10} in Airshed A. If the measures are less certain of achievement of the NES then additional gains associated with households not replacing burners with solid fuel may be required.

Airsheds B2 and C are compliant with the NES for PM_{10} and further reductions in concentrations are predicated in the absence of further air quality management. Allowing tradeable permits for burners in these airsheds should not compromise attainment of the NES.

Airshed B1 appears compliant with the NES and further reductions in this airshed may occur as a result of households replacing pre 2004 burners with NES compliant burners. Allowing tradeable permits for burners in this airshed should not compromise attainment of the NES.

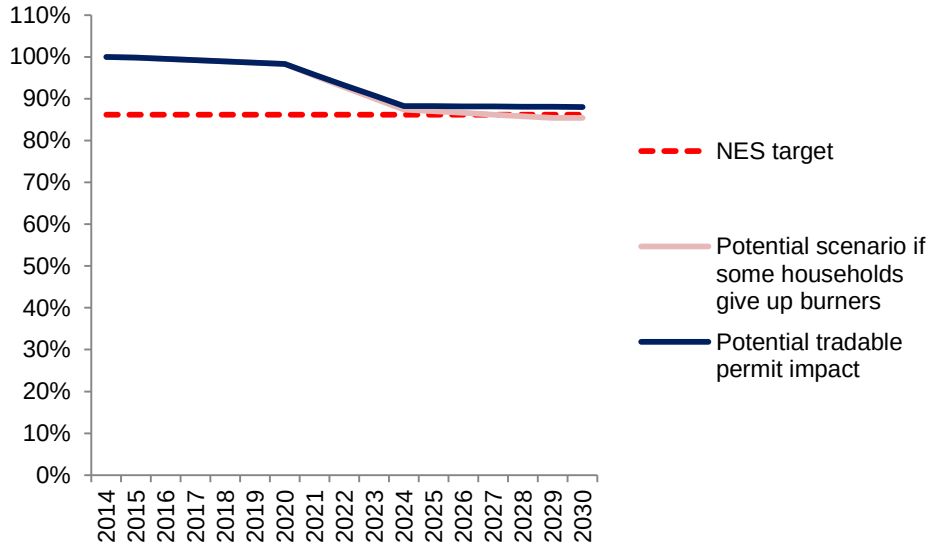

Figure 5-1: Potential impact of allowing tradeable permits in reducing additional gains achieved through households selecting non solid fuel replacement heating methods in Airshed A.

6 POINT OF SALE PHASE OUT OF OLDER BURNERS

A small number of Councils have adopted a point of sale rule whereby an older non-compliant wood or multi fuel burner or open fire must be replaced with a NES compliant wood burner, pellet fire or non-solid fuel heating method at the time a house is sold. In Airsheds B2 and C there are a number of wood burners installed prior to 2004 that are not compliant with the NES emission limits but can still be legally used. This section evaluates the impact of requiring households to remove non complying wood or multi fuel burners at the time a house is sold.

Data on house sales, including the length of time between sales for each dwelling sold was obtained from Corelogic New Zealand for Airsheds B2 and C. This data was integrated with projections modelling data on households using wood burners to estimate the proportion of dwellings being sold that contain non complying burners and the impact of requiring their removal and replacement with an NES compliant burner at the time the house is sold.

6.1 Airshed B2

Figure 6.1 compares the impact of a point of sale rule in Airshed B2 with the options of a 20 year burner replacement and no replacement of older burners at the end of their useful life. This suggests there is minimal impact as a result of a point of sale rule unless burners are not replaced at the end of a useful life in which case the rule is moderately effective.

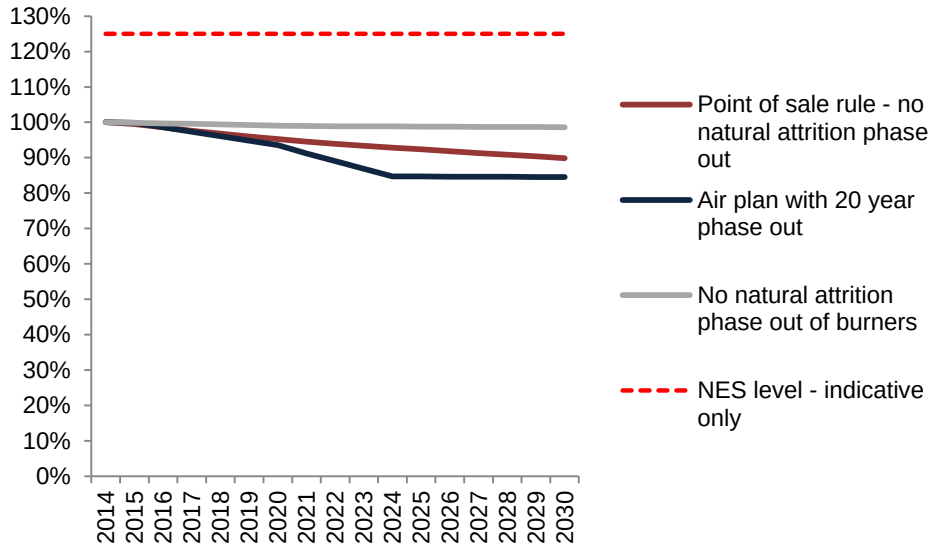

Figure 6-1: Potential impact of a point of sale rule for removing older wood burners in Airshed B2.

6.2 Airshed C

Figure 6.2 compares the impact of a point of sale rule in Airshed C both with and without the assumption that these older burners would be replaced through natural attrition after a 20 year useful life. As with Airshed B2 a point of sale rule has marginal benefits in terms of improvements in air quality.

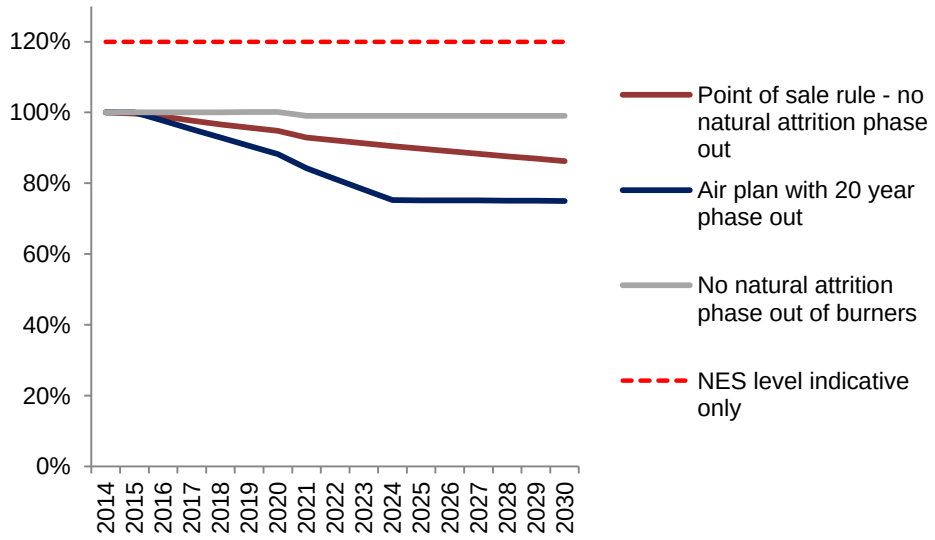

Figure 6-2: Potential impact of a point of sale rule for removing older wood burners in Airshed C.

7 INSTALLATIONS OF NES COMPLIANT WOOD BURNERS SUBJECT TO CRITERIA

7.1 Reduced heating requirement through increased insulation or house size limits

Increasing the level of insulation in a home or limiting the size of the area to be heated by a wood burner can reduce emissions through a reduction in the amount of fuel consumed. The focus of this section is to evaluate the impacts of allowing the installation of NES compliant wood burners in new dwellings and existing dwellings using other heating methods if the dwellings substantially upgrade insulation.

An analysis was carried out using Nelson homes data to estimate the percentage reduction in space heating associated with upgrading of insulation to current requirements for insulation and double glazing for new dwellings. Table 7.1 shows the percentage reduction in space heating requirements through upgrading of different levels of insulation. The reduction in kW data are based on EECA space heating requirements (Christian Hoerning - EECA, pers com, 2013) based on Nelson data for three different heating scenarios[4] for single and two storey dwellings (Wilton, 2015a). The analysis is limited in that no data are available on the R rating of ceiling insulation for existing retrofits. It is assumed that retrofitted insulation in pre 1978 dwellings is to R 3.3 and that all ceiling insulation in 1978-1999 dwellings is 75-120 mm as per the standard appropriate to that time. In addition, the dwelling age data for Nelson is only an approximate fit with the different building code requirements. Results suggest that space heating energy requirements could be reduced by around 40% across Nelson based on current heating patterns if all dwelling were brought up to 2007 building code requirements for insulation. The analysis is based on achieving an average temperature of 18 degrees for the living area and 16 degrees for other areas.

Table 7-1:: Potential space heating energy savings for Nelson based on retrofitting insulation for existing housing age, insulation levels and heating patterns

Existing insulation	Upgrade to	Reduction in kW*	Proportion Nelson households	Population weighted improvement
Pre 78 uninsulated	Post 2007	79%	5%	4%
Pre 78 with retrofit ceiling	Post 2007	72%	15%	11%
Pre 78 with retrofit ceiling, under floor, wall	Post 2007	33%	19%	6%
Pre 78 with retrofit ceiling, underfloor, wall, double glaze	none	0%	9%	0%
1978-1999 to 2007 (ceiling upgrade to 3.3 and double glazed)	Post 2007	69%	19%	13%
1978-1999 already upgraded to 2007 (ceiling upgrade to 3.3 and double glazed)	none	0%	4%	0%
2000-2007	Post 2007	36%	12%	4%
2000-2007 upgraded to 2007	none	0%	3%	0%
Post 2007 households	none	0%	12%	0%
Total			100%	40%

*the reduction in space heating requirements was calculated using EECA data adjusted for the proportion of dwellings in Nelson with one or more storeys and by heating extent (e.g., whole house all day)

[4] Living area evening only, 24/7 living area with kitchen and bedrooms evening only, and evening heating only for the living area, kitchen and bedrooms.

The benefits of improved insulation in a dwelling may be realised through an increase in household warmth, a reduction in household energy consumption or most likely a combination of the two. If the benefits are realised through increased household warmth there is unlikely to be a reduction in fuel consumption or energy requirements. Figures 7.1 to 7.4 show estimates of the likely impact of allowing NES compliant burners in new dwellings and existing dwellings using other heating methods in Airsheds A, B1, B2 and C based on setting a minimum requirement for insulation equivalent to post 2007 requirements and the assumption that 80% of energy savings would be realised by a reduction in fuel consumption. An estimated reduction in average fuel consumption of 32% was used based on the 40% from Table 7.1 assuming 80% realised in reduced fuel consumption.

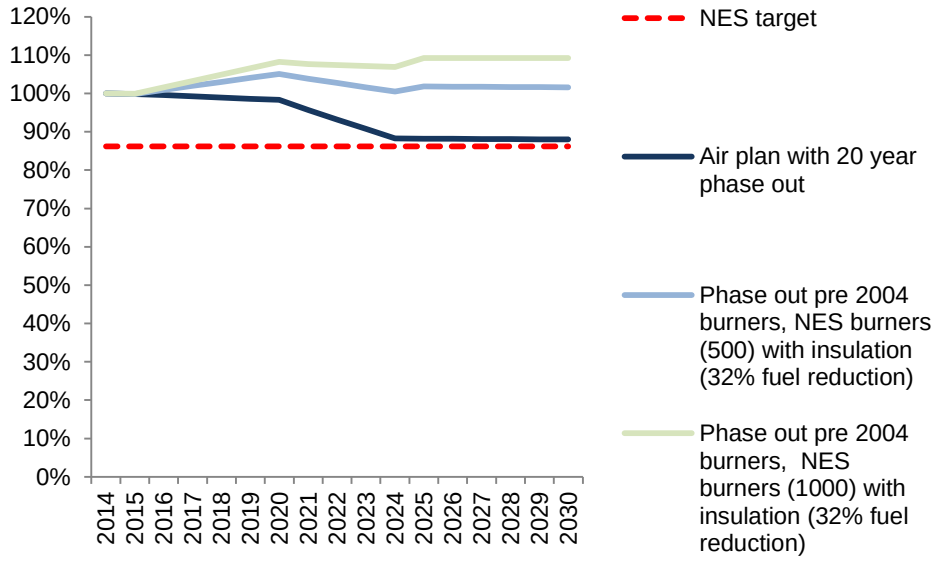

Figure 7-1: Potential impact of allowing 500 and 1000 new NES compliant burners in Airshed A in dwellings insulated to 2007 building standards

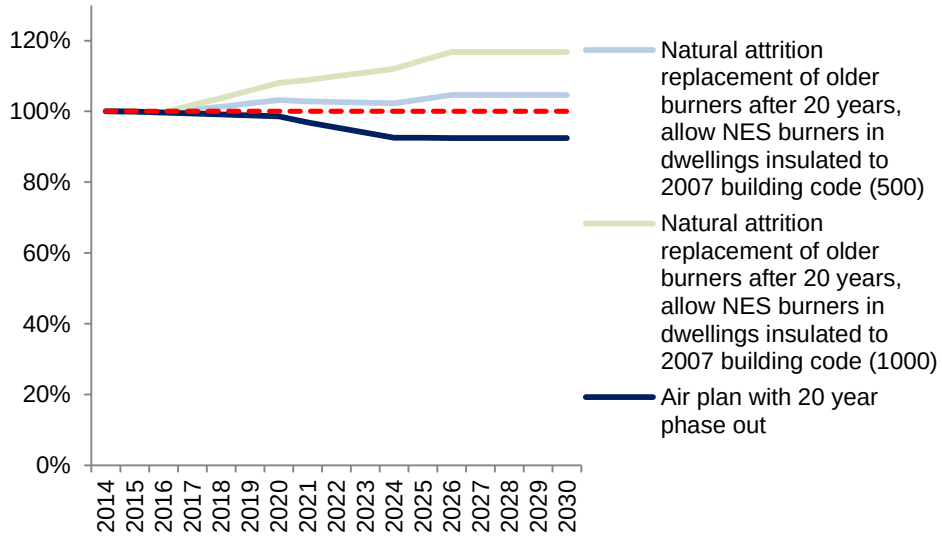

Figure 7-2: Potential impact of allowing 500 and 1000 new NES compliant burners in Airshed B1 in dwellings insulated to 2007 building standards

Figure 7.1 indicates that allowing NES burner installations into Airshed A would compromise achievement of the NES for PM_{10}. Figure 7.2 suggests that there may be capacity to allow some new burner installations into Airshed B1. However, a reduction of around 2% by 2030 is estimated to occur in this airshed as a result of a reduction in PM_{10} emissions from domestic heating in Airshed B2. Allowing NES compliant burners in Airshed B2

would further limit any minor capacity that may be available for increased emissions in Airshed B1 if older burners are phased out. It is also worth noting that the capacity illustrated in Figure 7.2 arises as a result of the replacement of pre 2004 wood burners with NES compliant burners and that the reduction may not occur in reality unless regulated and enforced.

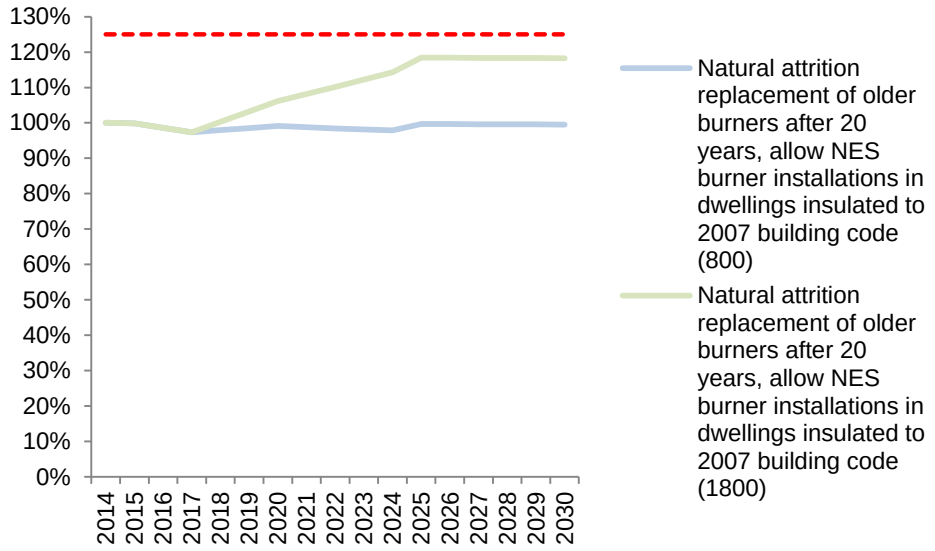

Figure 7-3: Potential impact of allowing 800 and 1800 new NES compliant burners in Airshed B2 in dwellings insulated to 2007 building standards

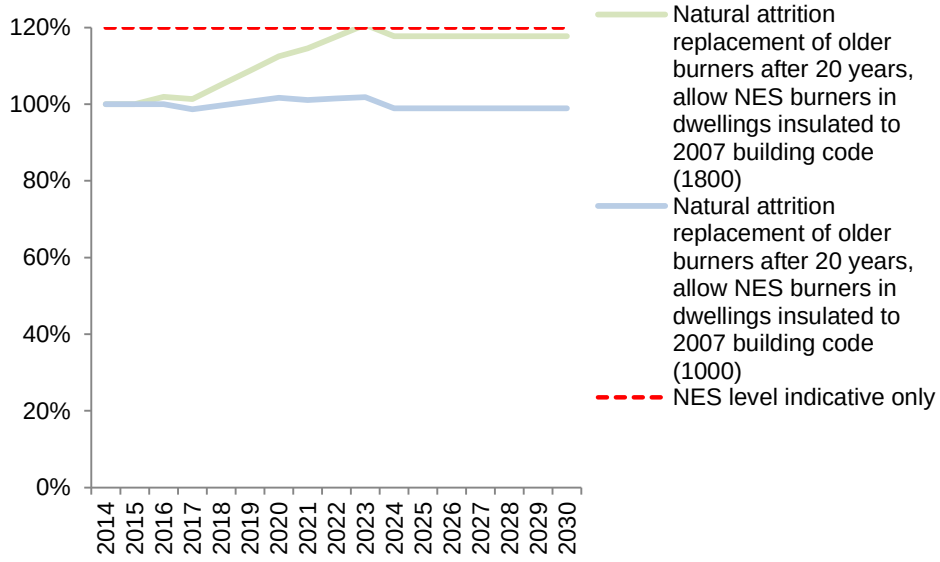

Figure 7-4: Potential impact of allowing 1800 and 1000 new NES compliant burners in Airshed C in dwellings insulated to 2007 building standards

For Airsheds B2 and C capacity for new NES compliant burners is assessed against current air quality (indicated by 100%) and by allowing polluting up to the NES. It should be noted that while an evaluation has been done around the latter it is based on limited monitoring data and therefore contains a higher degree of uncertainty and risk.

Figures 7.3 and 7.4 indicate there is likely capacity within Airsheds B2 and C to allow the installation of NES compliant wood burners in new dwellings and existing dwellings using other heating methods that are insulated to post 2007 building code requirements. In Airshed B2 around 800 new NES compliant burners are offset by the phase out of older burners. Thus if 1800 burners were installed in Airshed B2 and all households with pre 2004

burners did not replace them at the end of their useful life it is likely that the airshed would become non-compliant. The same issue exists for Airshed C although the offset number is higher at 1000.

Given the uncertainties of the analysis if new installations of NES burners are to be allowed (in new dwellings and existing dwellings using other heating methods with increased insulation) requiring the replacement of older burners at the end of a 20 year life and limiting the number of installations to a maximum of 800 in Airshed B2 and 1000 in Airshed C would be recommended.

7.2 Reduced wood burner fuel consumption through house size limits

Allowing new installations of wood burners in new dwellings and existing dwellings currently using other heating methods for smaller households would result in fewer households installing burners (because of the limits placed on house size) and because a smaller dwelling should require less energy for space heating than a larger one on average. However, it should be noted that a larger 180m^2 well insulated household is likely to require less energy for space heating than a 90m^2 uninsulated or partially insulated dwelling (Table 7.2).

Table 7-2: Estimated annual kW space heating energy requirements for a 90 m^2 and 180 m^2 dwelling for evening only heating of 18 degrees in the living area and 16 degrees in other areas.

	Annual kW space heating energy requirements	
	90 m^2	180 m^2
Post 2007 households	1247	2494
2001-2007 households	1665	3331
1978-1999 households	6588	13175
Pre 1978	8589	17178

An indication of the size of Nelson dwellings is given in Table 7.3 which shows that 74% of Nelson households are three bedrooms or larger. Restricting the installation of NES compliant burners into dwellings with two or fewer bedrooms is likely to significantly limit the numbers that could be installed. The energy requirements are also likely to be lower on average, depending on insulation levels but the proportional reduction in the energy consumption for the main living area will be less than for the house overall. A 40% reduction in energy consumption was estimated based on dwelling sizes of 90 m2 (smaller dwelling) and 140 m2 (medium sized dwelling). However, the reduction in wood burning fuel consumption is likely to be less owing to the main living area size differential being less than the whole house size differential. For the purposes of this assessment a 30% reduction in fuel consumption was assumed.

Table 7-3: Number of bedrooms by heating method (from Wilton, 2015)

	Wood burner	Electric	Gas	Average distribution
1 bedroom	0%	3%	0%	3%
2 bedroom	13%	26%	23%	23%
3 bedroom	53%	46%	52%	48%
4 bedroom	27%	21%	19%	21%
5 bedroom	6%	3%	4%	4%
6 bedroom	1%	0%	1%	1%

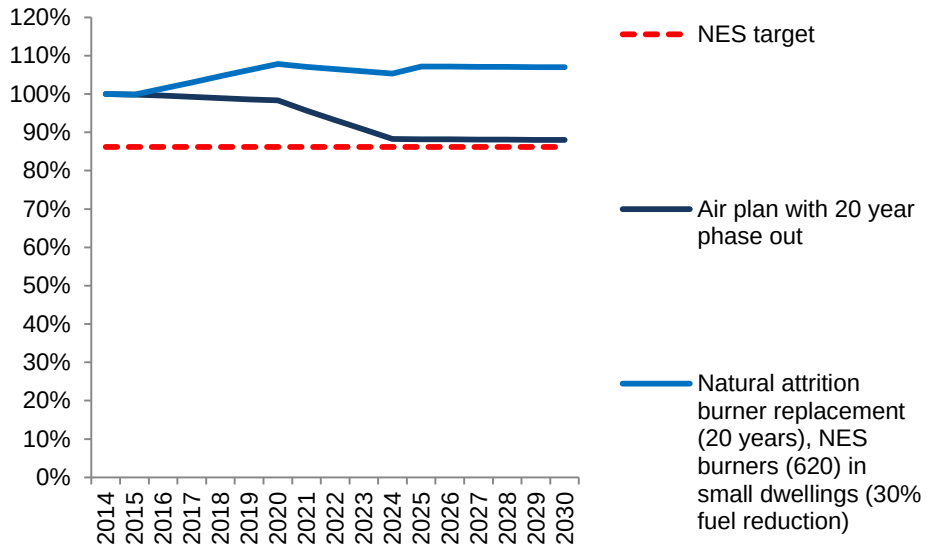

Figure 7-5: Potential impact of allowing NES compliant burner installations in Airshed A in small dwellings.

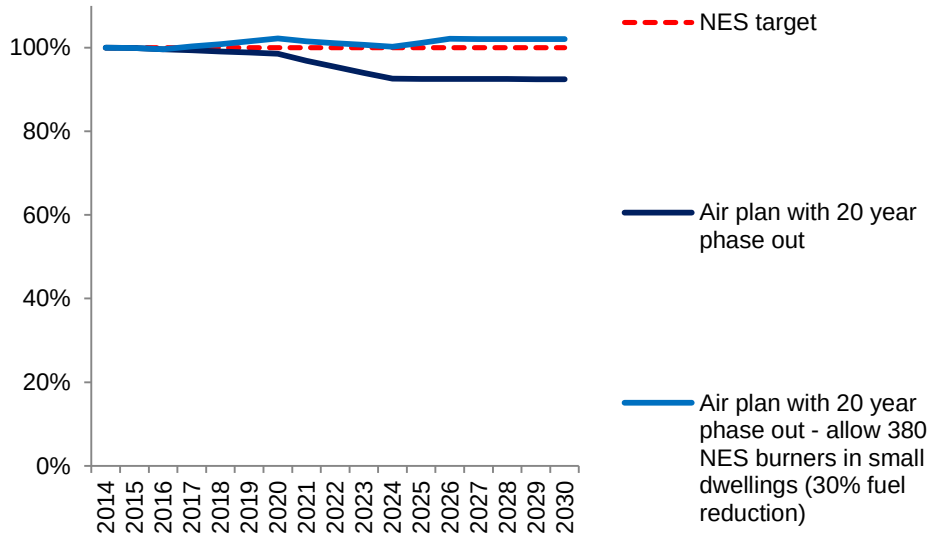

Figure 7-6: Potential impact of allowing NES compliant burner installations in Airshed B1 in small dwellings.

Figures 7.5 and 7.6 show the estimated impact of allowing NES compliant burners in small dwellings in Airsheds A and B1 respectively. In Airshed A an additional 620 new burners are assumed to be allowed to be installed based on 26% of dwellings not having wood burners being less than three bedroom. In Airshed B1 the number is smaller owing to fewer households in the airshed.

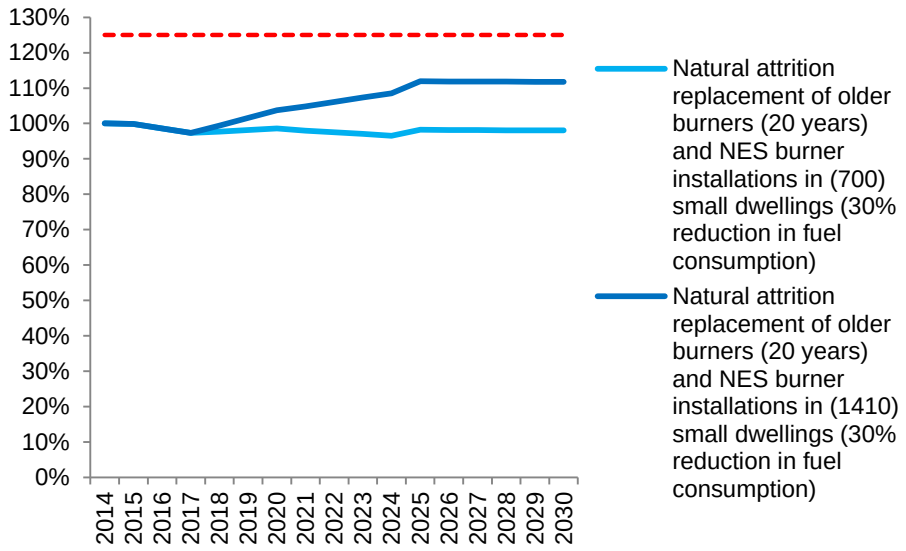

Figure 7-7: Potential impact of allowing NES compliant burner installations in Airshed B2 in small dwellings.

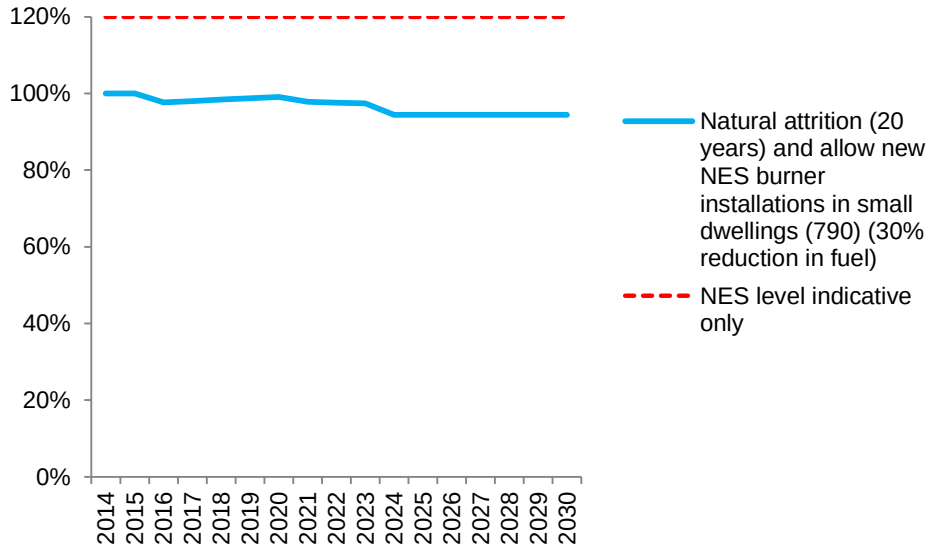

Figure 7-8: Potential impact of allowing NES compliant burner installations in Airshed C in small dwellings.

Figure 7.7 shows that allowing new burner installations into small dwellings in Airshed B2 could affect around 1400 households and that if all these households were to install burners, even with a 30% reduction in average fuel consumption, existing air quality is likely to be compromised. The 1400 households was estimated by subtracting households with burners in 2030 from projected dwelling numbers and multiplying by 24% based on the assumption that around 24% of households would meet a smaller home criteria (to be defined should the option be favoured). In reality many smaller households are unlikely to install a burner as other methods are typically more popular in smaller dwellings (see Table 7.3). Figure 7.7 also shows that around 700 burners could be installed in small dwellings without compromising existing air quality, assuming pre 2004 burners are all phased out by 2030.

Figure 7.8 suggests allowing the installation of NES compliant burners in small dwellings in Airshed C is unlikely to compromise existing air quality. However, as with previous options impacts on Airshed A should be considered.

7.3 Burner efficiency criteria

An efficiency criterion of 65% is specified as a requirement of the NES design criteria for wood burners. However, a small number of burners currently authorised under the standard have efficiencies of 75% or above. A more efficient burner means more of the energy contained within the fuel becomes available for space heating thus reducing the amount of fuel burnt. The real life efficiencies of burners are likely to vary from the tested efficiencies as the performance will alter depending on operation. However, it is likely that a burner that tests with a higher efficiency will be more efficient on average than one that tests to a lower level. In theory a criterion of 75% could potentially use 15% less fuel than a burner that is 65% efficient. The average efficiency of burners installed in Nelson is unknown but is likely to be between 65% (minimum for NES compliant burners) and 70% as the majority of the burners approved as NES compliant lie within this range. If it is assumed that the average efficiency is around 68% a reduction in fuel consumption of around 10% may be possible if a new efficiency limit of 75% were introduced.

Figures 7.9 to 7.12 show the estimated impact of allowing the installation of NES compliant burners with an increased efficiency criterion of 75% in Airsheds A, B1, B2 and C. In Airsheds B2 and C the numbers of NES compliant burners has been set based on maintaining existing air quality and allowing air quality to degrade to the point of NES compliance. It should be noted that while an evaluation has been done around the latter it is based on limited monitoring data and therefore contains a higher degree of risk.

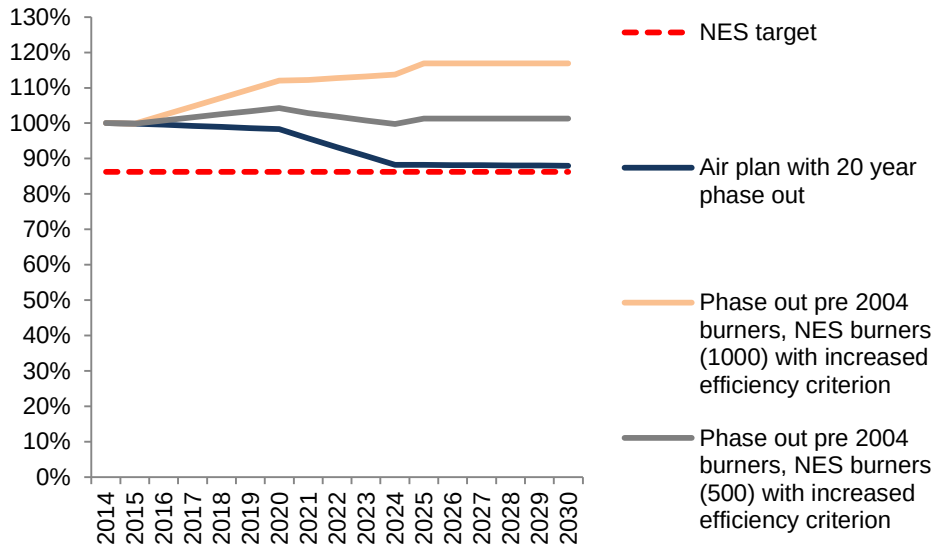

Figure 7-9: Potential impact of allowing NES compliant burner installations in Airshed A with increased energy efficiency criterion (75%).

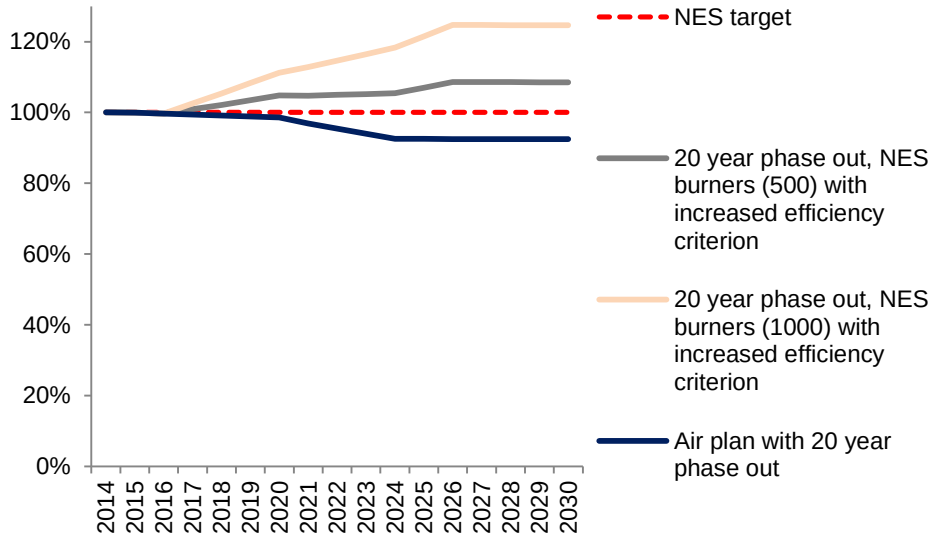

Figure 7-10: Potential impact of allowing NES compliant burner installations in Airshed B1 with increased energy efficiency criterion (75%).

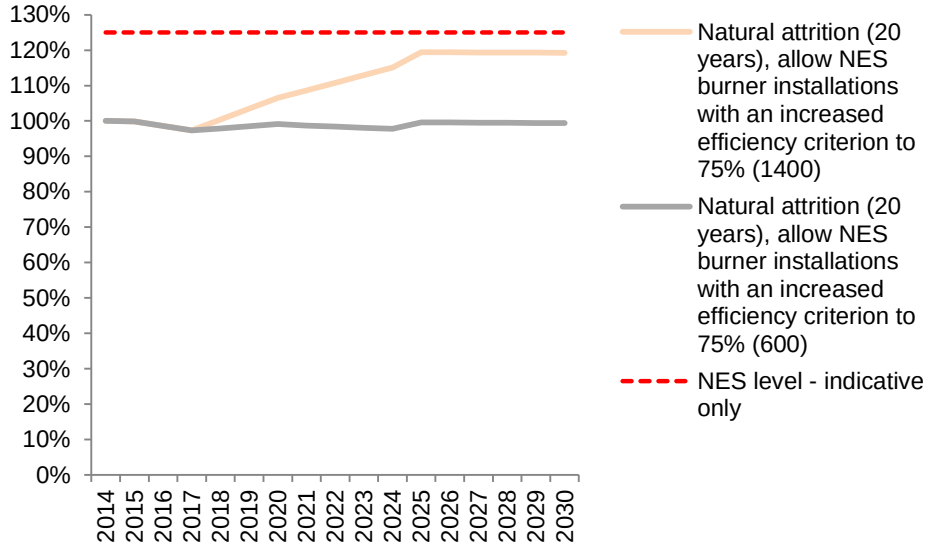

Figure 7-11: Potential impact of allowing NES compliant burner installations in Airshed B2 with increased energy efficiency criterion (75%).

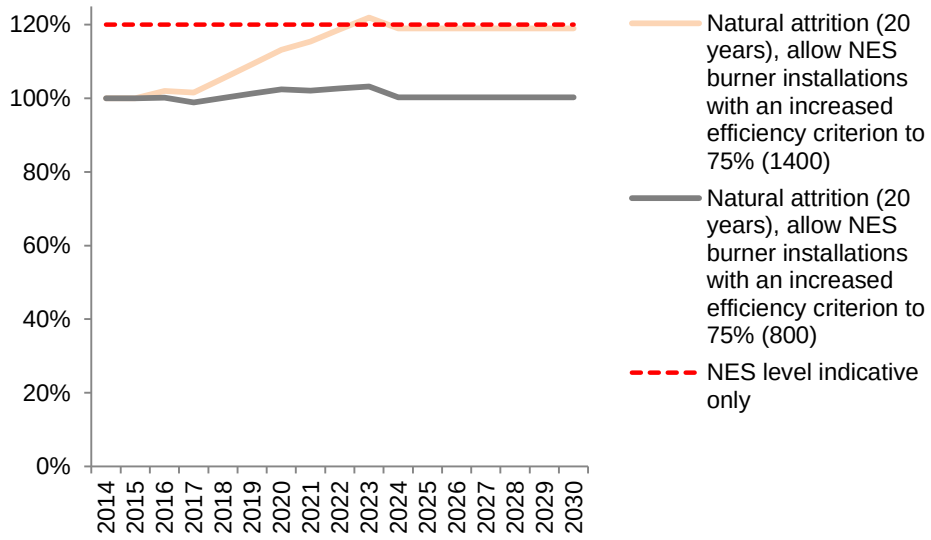

Figure 7-12: Potential impact of allowing NES compliant burner installations in Airshed C with increased energy efficiency criterion (75%).

7.4 Low income households

This section considers the impact of allowing the installation of NES compliant wood burners in low income households in Nelson. The use of wood burners is likely to be appealing to low income households as the operating cost of wood burners is lower than most other heating methods (7-10 cents/ kWh) and similar to a heat pump (7-15 c/kWh) if wood is purchased[5]. The option of obtaining wood free of charge provides a significant opportunity for savings for households that are able to source free wood. Table 7.4 shows the proportion of wood obtained free of charge by income for Nelson households. Overall in Nelson around 34% of wood used on wood burners is self-collected.

A key limitation with this option is that the households for which wood burners would provide the most advantages (in terms of potential savings as a proportion of income) are unlikely to be able to afford the capital costs of purchasing a burner. There may also need to be controls on the numbers of burners that could be installed by the same household as it would be possible for a low income household to purchase a wood burner sell the home and then purchase another new wood burner in a new dwelling. Similarly, and perhaps more likely, a renting household on low income could be used to justify the installation of burners in more than one dwelling (if no restriction are placed on ownership).

Table 7-4: Summary of income by heating method data (note households using wood and another method included as wood households only) (from Wilton, 2015a)

Annual household income	Self-collected	Bought
<$33,000	29%	71%
$33,000-$50,000	42%	58%
$52,000-$77,000	32%	68%
>$77,000	35%	65%

Table 7.5 summarises information on heating methods by income by airshed for Nelson households. Note that the income question included around a 13% non-response rate classified as “don’t know/ refused” in Table 7.5. The income distribution of these households is uncertain. In addition the analysis contains a three way cross

[5] Heat cost data for Nelson provided by Richard Popenhagen, Nelson City Council.

tabulation (heating method, income and airshed) and will therefore be subject to greater uncertainty owing to smaller sample sizes for each output. The results presented in Table 7.5 are therefore indicative only.

Results suggest that at least 700 households in Airshed A do not have a wood burner and have an annual household income of less than $33,000. If all non-respondent households were in this income bracket the total would be around 1000 households. This number would reduce if any allowances were limited to owner occupied dwellings. Figure 7.9 (previous section) shows that even with an increased efficiency criterion for NES compliant wood burners, Airshed A could not sustain an additional 1000 or 500 wood burners and meet the NES for PM_{10}.

In Airshed B1 there is no capacity to allow new installations of NES burners in the absence of additional air quality measures. Table 7.5 shows at least 800 households with annual household incomes of less than $33,000 in Airshed B1. There may be the capacity for an additional 500 ULEB if pre 2004 burners installed from 2000-2003 are phased out. The ULEB on the market at present are unlikely to be an attractive option for low income households owing to the high capital costs (currently around $10,000 installed but with the potential to decrease e.g., as more are approved or if manufacturing is relocated).

Table 7.5 suggests at least 900 households without wood burners earn less than $33,000 per year in Airshed B2. An additional 570 households do not report income levels, many of which may be low income households. In Section three of this report, Airshed B2 was found to be able to sustain an additional 500 NES compliant wood burners whilst maintaining existing PM_{10} levels if pre 2004 wood burners installed from 1996-2003 were phased out. Table 7.5 shows around 400 households not currently using wood with an average income of $21,000 or less. It is likely that at least a further 100 households from the non-respondents would be in this category. Limiting installations of new burners in Airshed B2 to households with annual incomes of less than $21,000 is unlikely to result in this level of uptake as many of these households are unlikely to be able to afford to install a burner.

In Airshed C the installation of up to 700 NES compliant wood burners may be possible without compromising the NES for PM_{10} in that airshed. Table 7.5 shows at least 1000 households without wood burners with annual incomes of less than $33,000 in Airshed C.

Table 7-5: Summary of income by heating method data (note households using wood and another method included as wood households only)

	Wood burner	Electricity (excl wood users)	Gas (excl wood users)	Other (excl wood users)	Total (excl wood)
Airshed A					
Under $21,000	81	162	14	27	203
$21,000 - $33,000	216	419	41	27	486
$33,001 - $52,000	216	594	54	81	729
$52,001 - $77,000	365	500	41	27	567
$77,000 and over	500	527	122	14	662
Don't Know/Refused	122	257	54	27	338
Airshed B1					
Under $21,000	81	230	14	41	284
$21,000 - $33,000	216	459	27	41	527
$33,001 - $52,000	243	513	81	14	608
$52,001 - $77,000	392	446	68	14	527
$77,000 and over	392	419	108	14	540
Don't Know/Refused	189	405	27	27	459
Airshed B2					
Under $21,000	149	365	14	14	392
$21,000 - $33,000	149	459	41	41	540
$33,001 - $52,000	297	459	41	14	513
$52,001 - $77,000	243	662	54	27	743
$77,000 and over	473	594	81	14	689
Don't Know/Refused	122	527	27	14	567

	Wood burner	Electricity (excl wood users)	Gas (excl wood users)	Other (excl wood users)	Total (excl wood)
Airshed C					
Under $21,000	54	311	14	0	324
$21,000 - $33,000	162	675	27	14	716
$33,001 - $52,000	257	473	54	14	540
$52,001 - $77,000	284	459	68	14	540
$77,000 and over	540	729	135	27	891
Don't Know/Refused	135	351	27	41	419

An approach of restricting the installation of NES compliant burners based on household income has merit as the benefits of wood use will be greatest within this group. Table 7.5 suggests that limiting the annual income categories to less $21,000 would be most appropriate relative to the number of households that may be able to install burners in airsheds that have capacity. However, uptake from this group is likely to be limited. If restrictions on the installation of NES compliant wood burners in new dwellings and existing dwellings using other heating methods were to be relaxed based on an income criteria it may be more reasonable to use an upper income limit of $50,000 (low income category from Wilton, Baynes, & Bluett, 2010) and set a limit on the total number of installations.

7.5 Health compromised households

The prevalence of respiratory and other chronic health impacts within households in Nelson was assessed by survey questionnaire in 2014 as part of the emission inventory survey for Nelson. Survey questions for health endpoints are outlined as follows and were derived as part of a collaboration between Environment Canterbury, the Canterbury District Health Board and the author working as a consultant to Environment Canterbury.

- Does anyone living at this house have a respiratory illness or other problems with breathing that require treatment?
- Does anyone living at this house have any other long term health issues (excluding respiratory and mental health/ stress related issues) which require treatment? (long term means more than 6 months).

Results found around 18% of households in Nelson contained at least one occupant with respiratory illness. This proportion increased to 33% of households in Nelson when other chronic illnesses were also included and reduces to 26% when only owner occupied dwellings are considered. It is likely that this proportion would reduce slightly following a more robust definition of health impacts. Figure 7.13-7.16 show the estimated impact in Airsheds A, B1, B2 and C if 26% of households without burners installed an NES compliant wood burner.

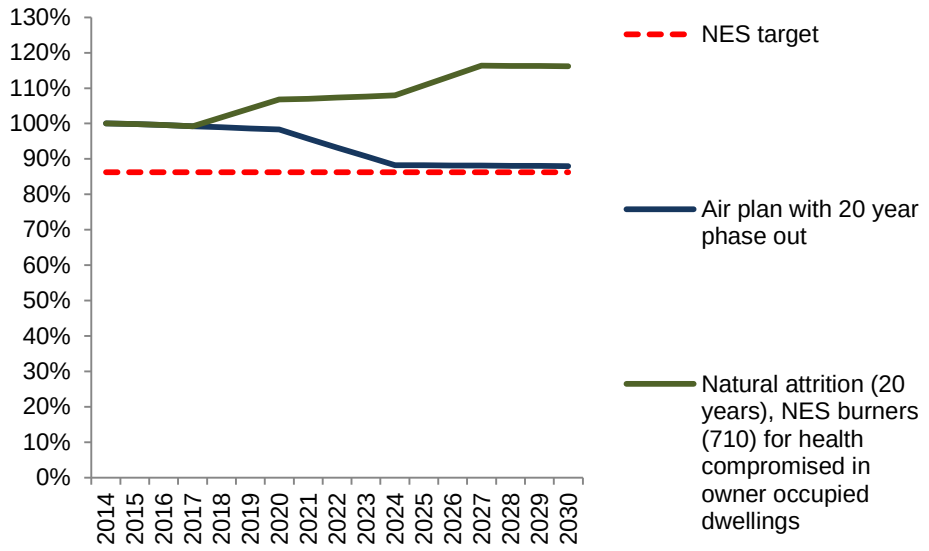

Figure 7-13: Potential impact of allowing NES compliant burner installations in Airshed A in owner occupied dwellings whose residents have respiratory or other chronic health impacts.

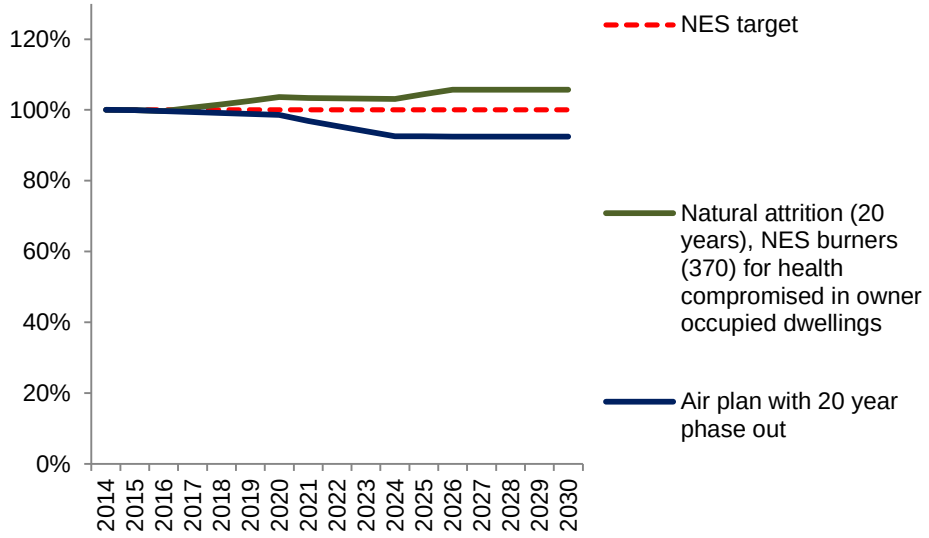

Figure 7-14: Potential impact of allowing NES compliant burner installations in Airshed B1 in owner occupied dwellings whose residents have respiratory or other chronic health impacts.

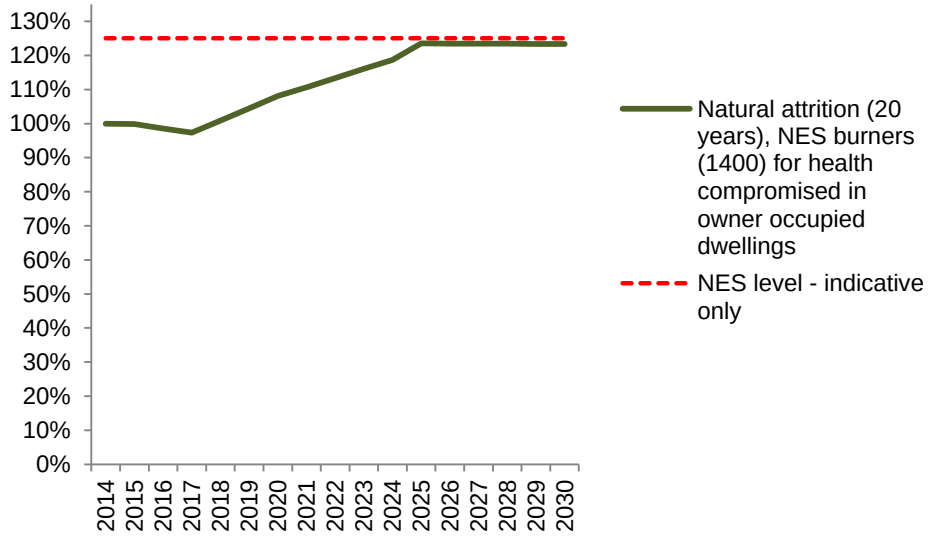

Figure 7-15: Potential impact of allowing NES compliant burner installations in Airshed B2 in owner occupied dwellings whose residents have respiratory or other chronic health impacts.

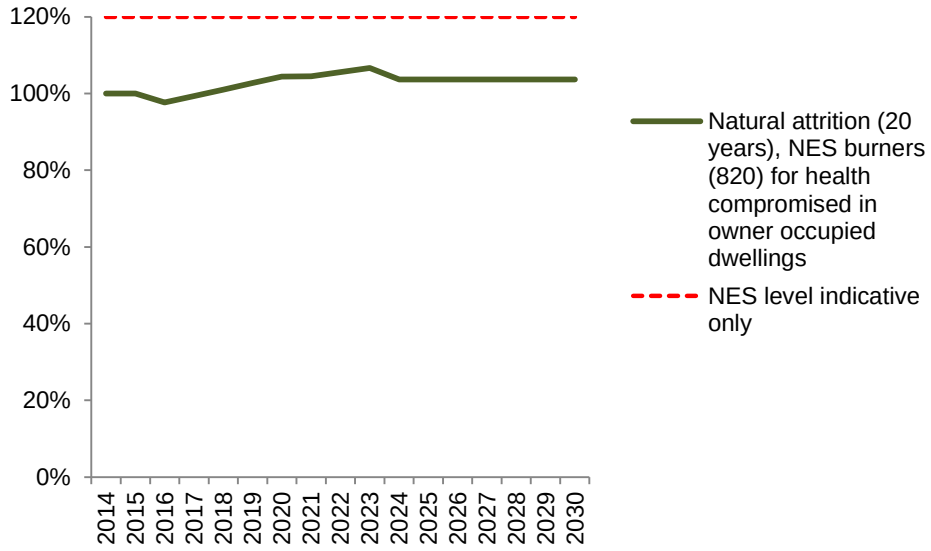

Figure 7-16: Potential impact of allowing NES compliant burner installations in Airshed C in owner occupied dwellings whose residents have respiratory or other chronic health impacts.

8 PERFORMANCE STANDARDS FOR BURNERS

The objective of this section is to assess the “real life” emission limit required if all household were allowed burners and for the airshed to be compliant with the NES. This is referred to as a performance based rule rather than the current emission limits (AS/NZS 4012/ 4013) which are based on a laboratory simulation of burner operation using very strict procedures and fuels.

Environment Canterbury has introduced a performance based rule for their “ultra low emission burner” (ULEB) category. Their emission limit is set at 0.5 g/kg of particulate under real life conditions. They have developed the “Canterbury Method 1” and “Alternative Method” as ways of defining test procedures to simulate “real life” operation.

8.1 The current test method – AS/NZS 4012/4013

The current method for testing wood burners for compliance with particulate emissions criteria and energy efficiency in New Zealand are the AS/NZS 4012:2014 and AS/NZS 4013:2014 standards. Wood burners meeting the NES design criteria must have an average emission from this test regime of 1.5 grams of particulate per kilogram of fuel burnt (g/kg) and a space heating efficiency of 65% or higher. In all areas of New Zealand new wood burner installations on properties less than two hectares must comply with the emission limit and efficiency criterion. In some areas of New Zealand the limit applies to any sized properties and in other areas lower emission criteria are specified by local councils. The NES allows testing to be done using alternative methods if functional equivalency can be demonstrated and if the burner in question is specifically excluded from the standard.

The AS/NZS 4012 and 4013 standards are very prescriptive in method, procedure and fuel quality because a high degree of control over the burning is required to minimise variations in emissions occurring as a result of parameters unrelated to the design of the burner. The standard was designed to enable particulate emissions from wood burners to be tested and compared in terms of their relative impact on the environment (with respect to particulate emissions) rather than as a measure of their absolute impact (“real life” particulate emissions).

In home testing carried out in New Zealand indicates that the real life emissions from wood burners meeting the 1.5 g/kg criterion may be around 4-5 g/kg on average. Large variability in emissions is observed and burner operation and fuel quality is a significant contributor to PM_{10} emissions. The impact of these variables is purposely not included in the test method because it has focused on obtaining precision, so it can robustly compare one burner to the next, rather than on accuracy, that is, measuring the most relevant thing in terms of environmental outcome.

The test method also does not include sampling during start up when emissions are typically high.

8.2 A performance based test method

A performance based test method would be a shift in philosophy to an accuracy based approach and would require priority be given to simulating a real life emission rather than designing a test that could reproduce results. It is probable that accuracy would come at the expense of precision and as a result the level of confidence in the test output would be reduced.

Another key issue with having a performance based emission limit is defining test procedures to simulate “real life” operation. The reason that real life emissions vary from laboratory procedures are because burner operation and fuel quality varies between households and because laboratory technicians operating the fires are skilled combustion experts strictly following instructions for burner operation. An understanding of what test regime might represent “average” is required to give a truly representative result. This is not information that could be accurately or practically obtained by survey or observation. Moreover, a test procedure needs to use the same level of skill of operator. The Environment Canterbury Canterbury Method defines a representative operating behaviour but there is no certainty that the test method accurately defines average burner behaviour and it is

likely that the operation of the test by laboratory technicians will mean that the emission is lower than what would happen when the burner is operated by typical households. Exceptions may occur in instances where the burner technology being adopted minimises the impact of the operator. For example, one of the ULEB approved under the Canterbury Method has automated air supply.

Another key requirement of a performance based approach is ensuring that the potential variability in emissions, through operator behaviour, is reduced so that the operation of burners is as close as possible to the test regime. This is a limitation of the current burner technology which has a high degree of scope for operator mismanagement and it is recommended that if a performance based approach is taken additional rules are included to ensure that any technologies approved include design features to minimise operator mismanagement. These might include for example, automated or semi-automated fuel supplies or automated oxygen flows.

Environment Canterbury also specifies that the emissions must be sustainable in that:

- A burner cannot be operated in such a way as to bypass the technology that results in ultra-low emissions.
- The burner cannot be reasonably tampered with in such a way as to affect its performance. This generally means that it is unable to be tampered with using hand tools available in a home such as screwdrivers, spanners and files.
- If maintenance (such as cleaning and filter changing) is required for the technology to be effective in reducing emissions there must be a process in place that ensures this happens (such as a condition of a resource consent).
- The technology for reducing PM_{10} emissions must be designed to be effective for the duration of the burner's life.

The performance limit evaluation has been assessed based on two approaches.

1) **Using existing capacity within the airshed**

   In airsheds with some capacity for new burners an evaluation has been made of the emission limit required if all households without burners installed them without the airshed capacity being exceeded. In this instance two levels of airshed capacity are used:

   - Capacity set based on existing air quality - relies on the assumption that older pre 2004 burners will be replaced after 20 years and that the capacity created by their replacement can be used to allow new installations of burners.
   - Capacity set based on allowing an increase in PM_{10} concentrations to a level of around 50 $\mu g/m^3$ (24-hour average).

2) **Creating new capacity by requiring existing households to convert.**

   In airsheds with no capacity (Airshed A and B1) an evaluation has been made on what the required performance limit would be assuming all households with burners had to meet the limit. In a practical sense this would require a phase out of existing NES compliant wood burners and the replacement with burners meeting the new performance specification.

8.3 Airshed A

The performance limit specification has been assessed based on the approach creating new capacity by requiring existing households using wood burners to convert to "new limit" wood burners.

The performance limit required for Airshed A based on all capacity within the airshed being used and the assumption that all households were able to install burners with (projected household numbers at 2030 of 4680). The assumption is that they burn the same amount of fuel on average (around 18 kilograms per night) and that the reduction required in PM_{10} in Airshed A relative to 2014 is 14% - thus capacity is set at 14% less than 2014 concentrations. An average real life emission factor of 1.5 g/kg would be required to meet this standard. Given the uncertainties with the specification of the limit representing actual average real life emissions it is recommended that a lower test limit value be used (e.g., less than 1.0 g/kg) if this approach is adopted.

Because the performance limit evaluated is a higher standard that the Canterbury Method (0.5 g/kg) it is likely that existing technology could pass the standard but that the average household emissions would still be higher because of operational aspects. Ways around this include additional specifications that the technology includes measures that will adequately minimise potential for behavioural components and in addition the Council adopts and enforces a no visible smoke rule to ensure onus is on the householders to operate burners properly.

8.4 Airshed B1

The performance limit specification has been assessed based on the approach creating new capacity by requiring existing households using wood burners to convert to “new limit” wood burners.

The performance limit required for Airshed B1 based on all capacity within the airshed being used, that a further 5% reduction on 2014 values was necessary to ensure ongoing compliance and the assumption that all households were able to install burners with (projected household numbers at 2030 of around 2300). The assumption is that they burn the same amount of fuel on average (around 21 kilograms per night). An average real life emission factor of 2 g/kg would be required to meet this standard. Given the uncertainties with the specification of the limit representing actual average real life emissions it is recommended that a lower test limit value be used if this approach is adopted.

8.5 Airshed B2

8.5.1 Allocating existing capacity

If existing air quality is to be maintained there is no spare capacity unless older burners are replaced with NES compliant burners. If they are and all households not currently using burners were to install one (around 5400 households) the real life emission would need to be around 0.5 g/kg.

If air quality is allowed to be degraded up to the NES level and around 5400 households were to install burners the real life emission would need to be 1.1 g/kg.

Given the uncertainties with the specification of the limit representing actual average real life emissions it is recommended that lower test limit values be used if either approach is adopted.

8.5.2 Creating new capacity by requiring existing households to convert

The performance limit required for Airshed B2 was assessed based on no increases in existing emissions (current concentrations are below the NES but increases compromise attainment of the NES in Airshed B1) and projected household numbers at 2030 of 7600. The assumption is that they burn the same amount of fuel on average (around 19 kilograms per night). An average real life emission factor of 1.5 g/kg would be required to meet this level of emissions. Given the uncertainties with the specification of the limit representing actual average real life emissions it is recommended that a lower test limit value be used if this approach is adopted.

8.6 Airshed C

8.6.1 Allocating existing capacity

If existing air quality is to be maintained then there is no spare capacity in the airshed unless older burners are replaced with NES compliant burners. If they are and all households not currently using burners were to install one (around 3100 households) the real life emission would need to be around 1 g/kg. This is a reasonable fit with the current limit specified by ECan for ULEB of 0.5 g/kg in terms of likely real life emissions.

If the air quality were allowed to degrade up to the NES level and around 3100 households were to install burners the real life emission would need to be 1.8 g/kg. Given the uncertainties with the specification of the limit

representing actual average real life emissions it is recommended that a lower test limit value be used if this approach is adopted.

8.6.2 Creating new capacity by requiring existing households to convert

A 25% reduction in PM_{10} emissions from Airshed C is predicted by 2030 if older burners are phased out at the end of a 20 year useful life. This reduction helps attainment of the NES for PM_{10} in Airshed A. Capacity for Airshed C is therefore set at 75% of 2014 emissions for the purposes of evaluating an appropriate performance standard for burners for the airshed. Based on a total households of around 4700 using burners and an average daily fuel use of around 17.5 kg/day an average real life emission of 1.3 g/kg would be required. Given the uncertainties with the specification of the limit representing actual average real life emissions it is recommended that a lower test limit value be used if this approach is adopted.

9 CREATE CAPACITY THROUGH BEHAVIOUR CHANGE

Options for managing air quality in this report have been assessed based on a range of approaches towards future air quality. In airsheds where the NES is not achieved or is marginally achieved (A and B1) measures have been presented that include a reduction in concentrations to achieve the NES (or ensure ongoing compliance with the NES). The impact of allowing increases in concentrations in these airsheds has also been demonstrated.

In airsheds where the NES is achieved (B2 and C) options assessed in the status quo (a continual improvement in air quality), maintaining existing air quality whilst allowing new installations of burners and allowing emissions up to the NES.

This section considers a further option for Airsheds B2 and C which includes maintaining a downward trajectory for PM_{10} concentrations whilst allowing for some new burner installations. The scenario modelled to achieve this is creating capacity for new burner installations through introducing a behaviour change programme and allowing natural attrition replacements of older burners as per the status quo. The number of burners that could be installed for this and other scenarios for each airshed is outlined in Appendix A.

Figure 9.1 and 9.2 show the estimated impacts of this scenario on Airsheds B2 and C respectively. Note that whilst the benefits of the behaviour change programme are introduced in this scenario in 2016 achievement of the full reduction may be delayed depending on implementation.

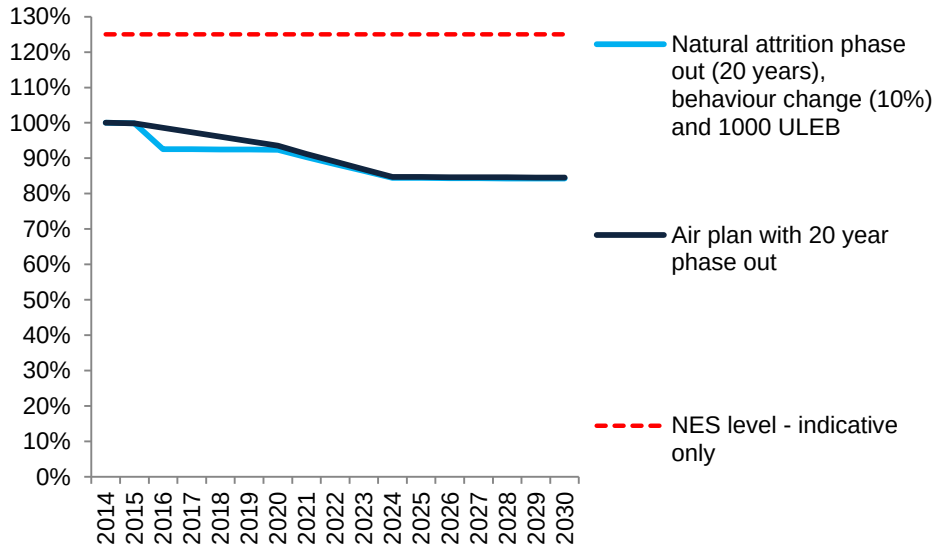

Figure 9-1: Behaviour change targeting a 10% reduction in PM_{10} and allow 600 ULEB installations in Airshed B2 with natural attrition replacement of older burners after a 20 year useful life.

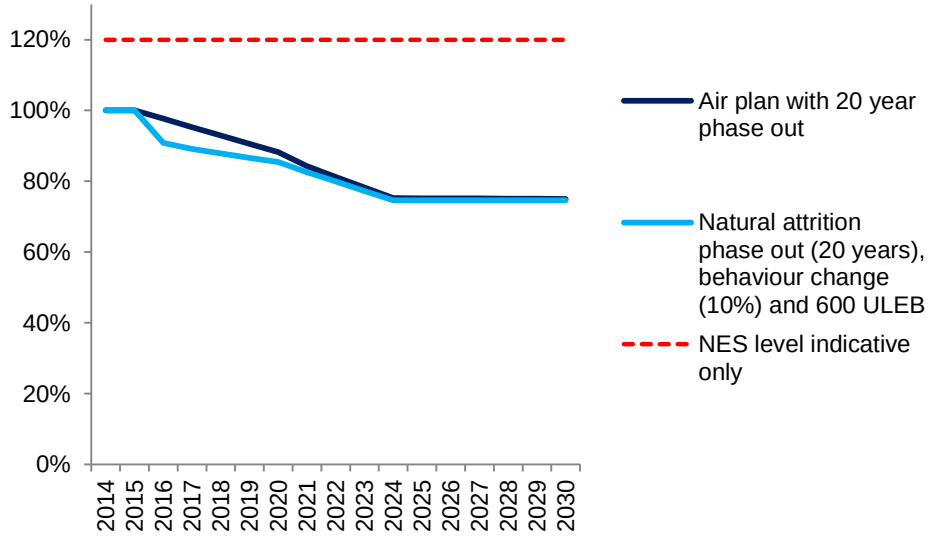

Figure 9-2: Behaviour change targeting a 10% reduction in PM_{10} and allow 600 ULEB installations in Airshed C with natural attrition replacement of older burners after a 20 year useful life.

10 DISCUSSION AND SUMMARY

This report evaluates the likely impact of a range of scenarios on PM_{10} concentrations within the different airsheds of Nelson. It considers the impact of allowing ultra-low emission burners (ULEB), phasing out pre 2004 wood burners, tradeable burner rights, a point of sale rule whereby older pre 2004 burners are replaced with NES compliant burners or clean heating options at the time a house is sold, performance based standards and allowing NES compliant burners to be installed in new dwellings and existing dwellings using other heating methods subject to additional criteria or for low income or health compromised households.

Options evaluated for Airshed A include management measures to achieve the NES and management measures to create capacity to allow the installation of ULEB. The potential impact of tradeable permits was also evaluated. A range of options could be adopted to meet the NES and create capacity (e.g., phase out older burners and implement a behaviour change programme). Unless stringent measures are adopted (e.g., set a new performance standard for wood burners and require replacement of existing burners with new limit burners) the number of new burners, even those meeting the ULEB emission criteria, would be limited (e.g. 200 or fewer). Allowing tradeable permits in this airshed may compromise achievement of the NES unless a strong regulatory approach is taken to reducing concentrations. Compliance with the NES for PM_{10} in Airshed A is unlikely with the phase out of older burners, a 10% effective behaviour change programme and allowance for 200 ULEB if increases in PM_{10} concentrations up to the NES limit in Airsheds B2 and C are allowed. The number of ULEB should be reduced to less than 100 if existing air quality is maintained in Airsheds B2 and C or zero if emissions in Airsheds B2 and C are allowed to increase. For any assessment involving the introduction of ULEB burners consideration should be given to uncertainties around the real life emission factors.

Currently there is no capacity within Airshed B1 for the installation of new burners but the replacement of older pre 2004 burners with time may create capacity. If all pre 2004 burners were phased out there may be capacity for the installation of a maximum of 500 ULEB. This number will be affected by measures adopted for Airshed B2 as the projections for Airshed B1 include a 2% reduction associated with a projected decrease in emissions from Airshed B2.

Similarly allowing an increase in PM_{10} concentrations in Airshed B2 to the NES level would result in a further increase in projections for Airshed B1 of 2% (i.e., 4% in total).

Airsheds B2 and C appear compliant with the NES for PM_{10}. A reduction in concentrations in these airsheds is predicted as households replace older burners at the end of their useful life. Requiring these households to replace older burners at the time a house is sold achieves minimal improvement in air quality over a 15 year period owing to the large proportion of dwellings that are not resold within a 20 year timeframe. Allowing some ULEB or NES compliant burners within both airsheds without compromising existing air quality is possible if older burners are phased out.

Allowing ULEB is a good fit with the current Air Plan provisions which allow for revising rules to consider improved technology. More burners could be installed if a ULEB performance test and emission limits were introduced than for a NES emission limit criteria. However, one of the main benefits of allowing wood burning is that it is a cost effective heating method that can result in significant savings if wood is obtained free of charge. The people most in need of a wood burning option are those in older dwellings with limited cost effective insulation options and who are unable to afford other forms of heating. The current cost of a ULEB is more than twice that of an NES compliant wood burner and it is likely that they would be cost prohibitive for those that would benefit the most from being able to have one. Environment Canterbury have regulated for ULEB requiring the replacement of existing NES compliant burners with ULEB burners based on an expectation that the cost of the ULEB burners will reduce to become more affordable (pers comm, Nadeine Dominesse (2015)). Prices would have to reduce significantly for this to occur.

Allowing ULEB or NES compliant burners in Airsheds B2 and C is possible without compromising the NES provided numbers are limited. However, because PM_{10} is a non-threshold contaminant any increases in concentration can result in an increase in health impacts. Moreover, allowing degradation of air quality, particularly polluting up to a guideline or standard, is inconsistent with the nationwide philosophy for air quality planning which typically promotes the maintenance or enhancement of existing air quality. The assessments for

these areas are also based on limited monitoring data and therefore contain a higher degree of uncertainty and risk.

If the approach of allowing wood burners into new dwellings or existing dwellings using other heating methods were to be adopted and no regulatory measures were placed on the phase out of older burners then an upper limit of around 1250 ULEB or 225 NES burners in Airsheds B2 and 1500 ULEB or 350 NES burners in Airshed C would be recommended. If regulations were included to require the phase out of older burners the recommended limits could be revised to 2500 (ULEB) and 550 (NES) in Airshed B2 and 3000 (ULEB) and 700 (NES) in Airshed C.

No degradation in air quality and continuation of projected downward trends could be achieved in Airsheds B2 and C by introducing a behaviour change programme targeting a 10% reduction in PM_{10} and allowing up to 1000 ULEB installations in Airshed B2 and 600 ULEB installations in Airshed C.

An assessment of the number of NES compliant burners that could be allowed in Airsheds B2 and C was made for three scenarios that would likely require less fuel to be burnt. These were allowing new burners in dwellings with improved insulation, in small dwellings and if the efficiency criteria of the burners were increased to 75%. For the latter option around 600 NES compliant burners could be installed in Airshed B2 and 800 in Airshed C if older burners were replaced at the end of a 20 year life without compromising existing air quality. If there were no mechanisms for ensuring the replacement of older burners it would be prudent to limit the number of new installations to around 300 and 400 respectively. .

Options for prioritising burner installations based on income were examined because the benefits of wood burning would be greatest for households on low incomes. It is worth noting that the capital cost associated with wood burner installation is likely to be prohibitive for many very low income households.

Setting a new limit for wood burner emissions was examined for Airsheds B2 and C and assessed relative to maintaining existing air quality assuming the replacement of older burners over time and allowing polluting up to a level indicative of NES compliance. The real life emission rates for these options range from 0.5 g/kg to 1.8 g/kg. A number of issues with this option are raised including a lack of certainty around the real life emissions of appliances tested to a performance based standard (e.g., Canterbury Method).

REFERENCES

Ancelet, T., Davy, P., & Trompetter, B. (2013). Source apportionment of PM10 and PM2.5 in Nelson Airshed A. GNS Science Consultancey Report 2013/146. 95p.

Ancelet, T., Davy, P., Trompetter, B., & Markwitz, A. (2010). Source apportionment of PM10 at Tahunanui, Nelson. GNS Science Consultancey Report 2010/198.

Davy, P., & Xie, S. (2014). Improving estimates of non-exhaust particulate matter emissions from motor vehicles. *Air Quality and Climate Change*, *48*(1).

Golder Associates. (2012). Development of an Air Quality Model and Meteorological Data Sets for the Nelson-Richmond Urban Area. Golder Associates Report Number 0978104449.

Wilton, E. (2014a). Evaluation of Nelson Airshed A – progress towards the NES and airshed capacity - preliminary report. Nelson City Council Technical Report, unpublished.

Wilton, E. (2014b). Nelson Air Emission Inventory - 2014. Nelson City Council Technical Report.

Wilton, E. (2014c). Nelson Air Quality Assessment – Meeting the NES for PM10 2014 update.

Wilton, E. (2015a). Heating, household and dwelling data for Nelson - 2014.

Wilton, E. (2015b). Napier, Hastings and Havelock North Air Emission Inventory – 2015.

Wilton, E., Baynes, M., & Bluett, J. (2010). Good Practice Guide for Designing and Implementing an Incentives Programme for Domestic Heating', Envirolink Tools project number ,. NIWX0802, prepared for Foundation for Science, Research and Technology. Retrieved from http://tools.envirolink.govt.nz/dsss/emissions-and-socio-economics-spatial-model/

Wilton, E., Bluett, J., & Chilton, R. (2015). Home heating emission inventory and other sources evaluation.

Wilton, E., & Zawar Reza, P. (2014). Assessment of trends in PM10 concentrations in Airshed A and evaluation of airshed capacity. Nelson City Council Technical Report.

APPENDIX A: SUMMARY ULEB AND NES INSTALLATION NUMBERS

Airshed B2 – possibly acceptable Current households no wood ~4670 Total households ~ 6750 Older pre 2004 burners ~ 360 can be replaced with NES	ULEB "Acceptable"	NES "Acceptable"	ULEB Maintain AQ	NES Maintain AQ	ULEB Pollute to NES	NES Pollute to NES
Capacity created by phase out of older burners			2500	550	5000-6500	1100-1400
No mandatory phase out – assume 50% replace within 20 years			1250	225	3750-5250	775-1105
No extra capacity created			0	0	2500-4000	550-880
Capacity created through behaviour change (10%)	1000	220				
Airshed C (alert) worse than acceptable Current households no wood ~3100 Total households ~4600 Older pre 2004 burners ~ 620 can be replaced with NES	ULEB "Acceptable"	NES "Acceptable"	ULEB Maintain AQ	NES Maintain AQ	ULEB Pollute to NES	NES Pollute to NES
Capacity created by phase out of older burners			3000	700	4500-5500	1000-1200
No mandatory phase out – assume 50% replace within 20 years			1500	350	3000-2850	680-900
No extra capacity created			0	0	1500-2500	330-550
Capacity created through behaviour change (10%)	600	130				

Airshed A – (action) worse than alert Current households no wood ~2900 Total households ~4425 Older pre 2004 burners ~200 can be replaced with NES	ULEB "Alert"	ULEB "Alert"	ULEB Maintain AQ	NES Maintain AQ	ULEB Pollute to NES	NES Pollute to NES
Capacity created by phase out of pre 2004 burners plus behaviour change achieving 10%, plus a 2% reduction in other airshed contributions	200	40	n/a	n/a	200	40
Capacity created by phase out of pre 2004 burners plus behaviour change achieving 10%, other airsheds maintain existing air quality	100	25	n/a	n/a	100	25
Capacity created by phase out of pre 2004 burners plus behaviour change achieving 10%, other airsheds pollute to NES*	0	0	n/a	n/a	0	0
Capacity created through behaviour change (10%)	0	0				
Airshed B1 (alert) worse than acceptable Current households no wood ~1600 Total households ~2260 Older pre 2004 burners ~ 120 can be replaced with NES	ULEB "Acceptable" Improve air quality through natural attrition	ULEB "Acceptable" Improve air quality through natural attrition	ULEB Maintain AQ	NES Maintain AQ	ULEB Pollute to NES	NES Pollute to NES
Capacity created by phase out of older burners and decrease in emissions in B2					500	125
Capacity created by phase out of older burners and maintain emissions in B2					160	35
Capacity created by phase out of older burners and B2 pollutes to NES**					0	0
Capacity created through behaviour change (10%)	0	0				

* note projections line not below target

** note projections line below target but only enough for a marginal buffer for uncertainties (a few percent)