# Auckland Council Air Quality Domestic Options: Cost Benefit Analysis 2013 Update

August 2013 Technical Report 2013/029

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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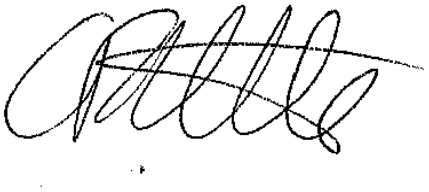
| Approved for Auckland Council publication by:<br><br>  <br><br>Name: Greg Holland<br><br>Position: Manager, Research, Investigations and Monitoring Unit |
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# Auckland Council Air Quality Domestic Options: Cost Benefit Analysis 2013 Update

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# Executive summary

Auckland domestic emissions (from open fires and inefficient wood-burners) contribute about three quarters of Auckland's particulate emissions in winter. Currently, Auckland does not meet regional or central government air particulate standards. The council has identified a number of potential approaches to reduce domestic emissions. Addressing the 'open fire problem' in the region is seen as a key area of opportunity for council.

Market Economics Limited (M.E) have been commissioned to work with council staff in developing a Cost Benefit Model that could be used to assess identified options for managing Auckland's domestic emissions. The cost benefit model runs off council's Domestic Fire Emissions Prediction Model (DEPM). The DEPM provides key inputs for the cost benefit model and we have assumed that the DEPM model is realistic (and that the model calculations are accurate). The health cost and incidences are derived from the DEPM model and the updated Health and Air Pollution in New Zealand (HAPINZ) study. Our CBA focuses mainly on the health effects of domestic emissions associated with $PM_{10.}$

The CBA was completed for the following four policy packages:

- Package 1: Point of sale rule and no new installations except replacements,
- Package 2: Open fire prohibitions and no new installations except replacements,
- Package 3: Point of sale rule and open fire prohibition,
- Package 4: Point of sale rule, open fire prohibition, and no new installations except replacements.

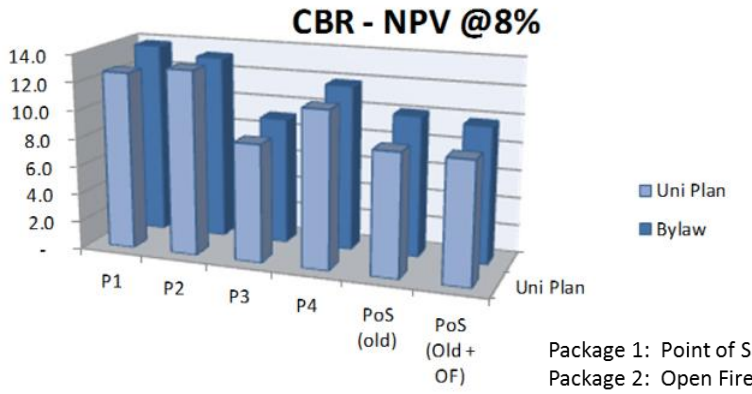
## Assumptions

The benefits were estimated using the emissions (and $PM_{10}$ concentrations) calculated in the DEPM and costs per health case were based on the HAPINZ study (Kuschel et al., 2012). Costs were estimated for both council and households. Council's costs reflect the regulatory and enforcement costs and the homeowner's costs include the appliance cost as well as the installation costs. Council has identified two alternative implementation mechanisms (a bylaw and a plan change) that could be used to steer private sector (i.e. households) to replace burners to achieve the air quality targets. Total cost to council (including overheads) will vary between $334,000 and $1.4m depending on the selected implementation mechanism. This cost does not include any incentives such as interest free loans, low interest financing or any other financial assistance packages that council might. It is stressed that the CBA covers the $PM_{10}$ concentrations associated with domestic fires and not council's wider retrofit your home programme.

The private costs i.e. the cost to the homeowner, includes installation and appliance costs as well as consenting costs. A weighted average cost for installations and appliances was calculated based on variables such as size of the house, cost of appliances, and likely installation costs. The average cost across Auckland for an appliance and its installation is estimated at $5,897 (including GST). The operational costs i.e. the cost of heating the home and the cost of fuel was not included in this analysis.

## Key findings

The evaluation assessed each package in terms of its likely cost, benefit and cost-benefit ratio (CBR), and expressed the results in both discounted (NPV terms) and undiscounted (total) terms. Treasury's default discount rate of 8% was used. The four packages and two basic settings are presented below. The figure (and table) shows the CBR in NPV terms under a bylaw and Unitary Plan approach.




Package 1: Point of Sale & Replacements
Package 2: Open Fire Ban & Replacements
Package 3: Point of Sale & Open Fire Ban
Package 4: Point of Sale, Open Fire Ban & Replacements

| CBR | Package 1: Point of Sale and Replacements | Package 2: Open Fire Ban and Replacements | Package 3: Point of Sale Rule and Open Fires Ban | Package 4: Point of Sale Rule, Open Fires Ban and Replacements |
|---|---|---|---|---|
| **Bylaw** | 13.8 | 13.2 | 9.1 | 11.8 |
| **Unitary Plan** | 12.7 | 13.2 | 8.4 | 11.2 |

With reference to the CBR ratio, the higher the ratio, the more benefit is generated for each level of costs incurred – this reflects the relative efficiency of the policy option in generating a return (benefit) for each dollar invested (cost).

Package 1 and Package 2 implemented using a Bylaw approach returns the highest CBR (close to 14). This is followed by Package 4 and finally Package 3. The bylaw option returns slightly higher CBRs for all packages suggesting that it is more efficient than the Unitary Plan approach.

Importantly the (undiscounted) CBR compares the benefits and cost of each package but does not consider the overall scale and timing of benefits associated with each package. Overall, Package 4 has the highest benefits returning health benefits in excess of $4.6bn (the sum of annual benefits between 2012 and 2031). Package 1 is projected to generate the second highest benefit with total effects of around $3.9bn between 2012 and 2031). This is followed by Package 3 with some $3.3bn of health effects (again between 2012 and 2031).

All packages return positive CBRs and it would be possible to build a case for any one of the four packages. Therefore, selecting a package (or a combination of packages) would need to consider council's wider policy mandate.

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# Abbreviations

| | |
|---|---|
| ARC | Auckland Regional Council |
| AQNES | Air Quality National Environmental Standards |
| CAU | Census Area Unit |
| CBA | Cost Benefit Analysis |
| CBR | Cost Benefit Ratio |
| DEPM | Domestic Emissions Projections Model |
| GRIT | Generating Input-Output Tables |
| HAPINZ | Health and Air Pollution in New Zealand |
| MfE | Ministry for the Environment |
| NES | National Environmental Standards |
| NZIER | New Zealand Institute for Economic Research |
| NPV | Net Present Value |
| $PM_{10}$ | Particulate Matter (less than 10 mircometres) |
| VOSL | Value of a Statistical Life |

# 1.0 Introduction

Auckland Council is seeking ways to manage Auckland's air quality and has identified emissions coming from domestic fires as an area to influence. This report summarises the findings of a cost benefits analysis of different policy options aimed at improving Auckland's air quality. The focus of this assessment is on policy options associated with domestic fires.

Auckland domestic emissions from open fires and inefficient wood-burners contribute about three quarters of Auckland's particulate emissions in winter. Currently, Auckland does not meet regional or central government air particulate standards. Council staff have identified a number of potential approaches to reduce domestic emissions and are working through ways to implement the measures. The Auckland Regional Council 2010 document '*Domestic Fire Emissions: Scenario Analysis'* proposes that to gain maximum air quality benefits, policies restricting open fire use must be implemented in tandem with appropriate wood-burner retrofit projects. Additionally the report emphasises the advantages of public education (which can be delivered through retrofit interventions/informing strategies) to influence fuel quality, wood burner operation, and wood burner/flue maintenance. Such initiatives are seen as critical components of improving Auckland's air quality when coupled with reducing vehicle emissions (which is central government's responsibility). Addressing the 'open fire problem' in the region is seen as a key area of opportunity for council to:

- Reduce air pollution,
- Reduce health effect risks faced by vulnerable communities (including children, the elderly and those with respiratory disease),
- Improve domestic energy efficiency, and
- Improve housing stock (by making homes drier and warmer).

This Cost Benefit Analysis (CBA) expands council's understanding of the results associated with the policy options identified during the 'Domestic Fire Emission: Scenario Analysis work (October 2010; IR2010/007) by translating the options into (potential) costs and benefits. This report is an update of the 2011 Cost Benefit Analysis and reflects some changes in the variables used in the initial study.

## 1.1 Study objectives and approach

The Auckland Regional Council (ARC) assessed the health effects of domestic emission at over $181m per year and preliminary work suggested that the community and health benefits of approximately $5 accrue for every $1 spent in reducing $PM_{10}$ emissions (ARC, 2009a). It has also been estimated, by Parfitt et al. (2009), that the approximate cost of replacing the 52,000 non-compliant wood burners to achieve the 58% fine particle emissions reduction target in Auckland (to meet Air Quality National Environmental Standards (AQNES) by 2016), is $308m.

Auckland Council have not carried out a comprehensive CBA of the domestic fire emission management options, and believe such an analysis is required to give decision makers confidence that;

- The AQNES $PM_{10}$ standard will be met by 2016 as a minimum for statutory purposes,
- That air quality management policy options seek to maximise net social benefits;
- The mix of options that will be most effective and efficient is chosen; and
- The regulatory tools chosen will be able to deliver the intended results.

M.E have been commissioned to work with council staff in updating the Cost Benefit Model so that it reflects changes in recent research – notably the Health and Air Pollution in New Zealand (HAPINZ) study enabling council to assess different domestic air quality management options (relating specifically to domestic open fires and burners). The resulting CBA model uses outputs from council's Domestic Fire Emissions Prediction Model (DEPM; Metcalfe and Kuschel, 2010). These outputs are inputs into the CBA and the effects of the policy options are evaluated. This report summarises the results associated with four packages (policy options) as well as two 'basic' options. The basic options provide an overall context. These example packages are used to illustrate the wider context of the four packages and should be reviewed as potential options – the results associated with these packages are not discussed in any detail.

## 1.2 Caveats

The CBA model development is linked with the council's DEPM model. We rely on the DEPM for calculating a number of variables and use its outputs to estimate costs and benefits relying on the following variables:

- Burner numbers (per broad installation group),
- Emissions (total and spatial distribution as well as the emission factors and burn rates), and
- Retirements.

It is assumed that the DEPM:

- Offers robust and accurate outputs reflecting the different development paths,
- Accurately calculates the baseline, underlying trends and movements per burner type,
- Accurately estimates the emission trends and changes associated with the packages, and
- Uses appropriate scaling factors in estimating emissions.

M.E did not review the DEPM for accuracy or robustness and did not test the assumptions underpinning this model.

In terms of the health effects, we have calculated the effects by applying the methods and factors outlined by Kuschel and Mahon in the 2012 update of the 2007 Health and Air Pollution in New Zealand (HAPINZ) study (Kuschel and Mahon, 2010). The health costs (cost per case) are based

on the mentioned HAPINZ study. Importantly, the revised numbers and variables are mostly higher with the value of a statistical life almost five times greater than in the original study – this will have significant impact on the CB ratios calculated in this update.

This CBA covers the health effects of domestic emissions focusing solely on $PM_{10.}$ As mentioned, we use the methodology outlined in the 2010 HAPINZ studies (both the 2010 and 2012 versions; the 2010 version outlines the methodology and the 2012 version contains updated variables) and link the emissions calculated in the DEPM with this methodology to estimate the number of health cases associated with a net change in domestic burner numbers. A key assumption is that a link between domestic emission (and concentrations) and the health effects exist and that this relationship is covered adequately by the methodology outlined in the HAPINZ study.

As part of the original CBA work, council's consent database was reviewed to extract information about the spatial distribution of burner installations. The resulting information only covered the four of the legacy council areas and was only available for January 2009 to June 2011. This timeframe corresponds with the recent economic slowdown and shallow recovery, meaning that the usefulness of this data was limited. However, due to the lack of any other supplementary information we relied on the available information so caution is necessary when interpreting the results based on this data. This information was not updated during this update cycle and should be reviewed during the next updating process.

## 1.3 Information sources

Various information and data sources were consulted during the project (this update and the initial review) including:

- Reports prepared for Auckland Regional Council, such as:
    - The Health and Pollution in New Zealand reports (ARC technical report no 2010/004)
    - The Domestic Fire Emissions: Scenario Analysis Report (ARC internal Report No. 2010/007)
    - Auckland Sustainable Homes Assessment. Part 1: Insulation and Clean Heat Appliances. (ARC Technical Report No 2009/052/)
    - Auckland Council: Air Quality Domestic Options (2011)
    - Auckland Regional Council (2010d). Estimation of domestic fire emission in 2006. Prepared by J Metcalfe for the Auckland Regional Council, ARC technical report 2010/056, October 2010
- Statistics New Zealand (census data and population projections),The 2010 DEPM model (the actual model developed by Emissions Impossible for Auckland Council)
- NZIER Report (Clough et al, 2009)
- Telephone discussions

- Information supplied by Auckland Council.

## 1.4 Report structure

The rest of this report covers:

Section 2 describes the CBA model highlighting the key assumptions used in the model, the burner number trends underpinning the modelling and the model logic;

Section 3 summarises the CBA's key findings and the different packages are compared, and

In Section 4 some additional considerations, such as the wider economic implications of the policy, are outlined.

# 2.0 Assumptions and packages modelled

The Cost Benefit Analysis (CBA) of Auckland Air Quality Domestic Fire Emissions Options relied on results from council's Domestic Fire Emissions Prediction Model (DEPM). For the purposes of this study, the DEPM was run for the four packages (or scenarios) that have been defined during earlier research. Two additional packages, reflecting 1) removing old burners via the Point of Sale rule, and 2) removing old burners as well as open fires via the point of Sale Rule, were modelled. In addition to the DEPM assumptions, some further assumptions were required to complete the CBA. This section outlines these assumptions and summarises the logic of using these assumptions.

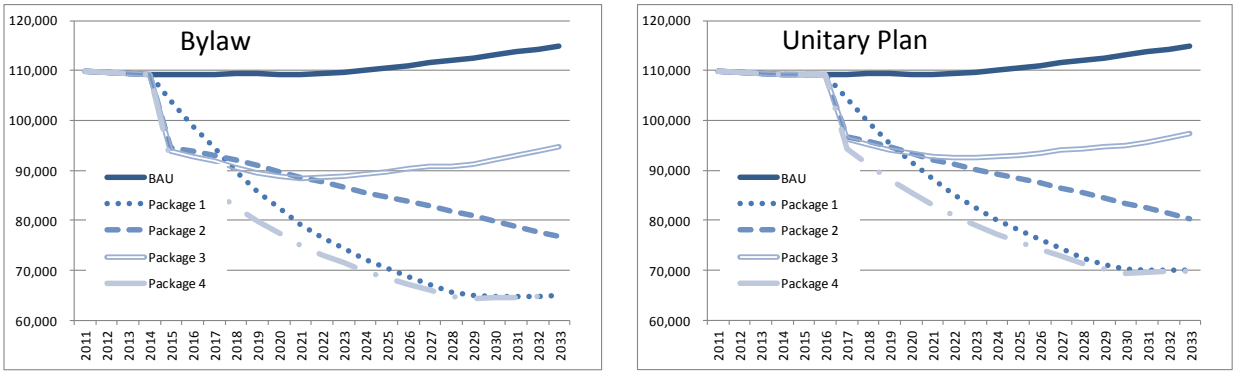
## 2.1 DEPM packages

A discussion of the DEPM and the assumptions underpinning it can be found in Metcalfe and Kuschel (2010) and is not replicated here. The four packages were set-up to reflect potential approaches to reduce domestic emissions to within Air Quality National Environmental Standards (AQNES). The packages included (a summary of each package is presented in Envelope 1):

- Package 1: Point of sale rule and no new installations except replacements,
- Package 2: Open fire prohibitions and no new installations except replacements,
- Package 3: Point of sale rule and open fire prohibition,
- Package 4: Point of sale rule, open fire prohibition, and no new installations except replacements.

Each package was run through the DEPM model and the results extracted. Importantly, two implementation mechanisms were identified and they have different 'starting times' which affect the total burners removed by 2033 – the date used in the DEPM. The two mechanisms are: 1) a bylaw and 2) the Unitary Plan. Each mechanism has a unique implementation timeframe with the bylaw option have a shorter implementation timeline and therefore starting to reduce burner numbers before the Unitary Plan option. This difference in starting points is shown in Figure 1. This figure also shows the trend in total burners for each package and the scale of change (i.e. reduction in burner numbers).

**Figure 1:** Trends in Burner Numbers



The input settings for each scenario can be found in the DEPM. Table  shows the burner trends with each package and Table 0.2 shows the burner numbers associated with the two implementation mechanisms.

**Table 1:** Projected retirements per burner age – bylaw mechanism (sourced from DEPM)

| | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Package 1: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 103,841 | 98,951 | 94,538 | 89,962 | 85,846 | 82,433 | 79,206 | 76,639 | 74,324 | 72,243 | 70,366 | 68,677 | 67,175 | 65,602 | 64,912 | 64,876 | 64,870 | 64,889 | 64,931 |
| Package 1: | Pre-1991 retired under programme | - | - | - | - | 957 | 749 | 553 | 329 | 160 | 70 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 1: | Post-1991 retired under programme | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,282 | 2,106 | 1,890 | 1,663 | 1,406 | 1,163 | 934 | 717 | 512 | 307 | 111 | - | - | - | - | - |
| Package 1: | Open fires retired under programme | - | - | - | - | 933 | 801 | 688 | 590 | 506 | 435 | 373 | 320 | 275 | 236 | 202 | 174 | 149 | 128 | 110 | 94 | 81 | 69 | 60 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 2: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 94,544 | 93,799 | 93,029 | 92,233 | 91,064 | 89,780 | 88,624 | 87,680 | 86,571 | 85,676 | 84,760 | 83,822 | 82,864 | 81,886 | 80,888 | 79,871 | 78,835 | 77,781 | 76,709 |
| Package 2: | Pre-1991 retired under programme | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 2: | Post-1991 retired under programme | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 2: | Open fires retired under programme | - | - | - | - | 15,558 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 3: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 93,880 | 92,731 | 91,802 | 90,490 | 89,448 | 88,946 | 88,491 | 88,577 | 88,812 | 89,192 | 89,702 | 90,334 | 90,894 | 90,900 | 91,213 | 92,123 | 93,016 | 93,890 | 94,746 |
| Package 3: | Pre-1991 retired under programme | - | - | - | - | 957 | 749 | 553 | 329 | 160 | 70 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 3: | Post-1991 retired under programme | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,282 | 2,106 | 1,890 | 1,663 | 1,406 | 1,163 | 934 | 717 | 512 | 307 | 111 | - | - | - | - | - |
| Package 3: | Open fires retired under programme | - | - | - | - | 15,558 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 4: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 91,951 | 88,874 | 86,018 | 82,777 | 79,807 | 77,378 | 74,995 | 73,152 | 71,459 | 69,911 | 68,493 | 67,196 | 66,032 | 64,747 | 64,307 | 64,483 | 64,660 | 64,837 | 65,013 |
| Package 4: | Pre-1991 retired under programme | - | - | - | - | 957 | 749 | 553 | 329 | 160 | 70 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 4: | Post-1991 retired under programme | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,282 | 2,106 | 1,890 | 1,663 | 1,406 | 1,163 | 934 | 717 | 512 | 307 | 111 | - | - | - | - | - |
| Package 4: | Open fires retired under programme | - | - | - | - | 15,558 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| BAU | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 109,301 | 109,449 | 109,303 | 109,117 | 109,126 | 109,410 | 109,586 | 110,029 | 110,499 | 110,992 | 111,505 | 112,035 | 112,579 | 113,137 | 113,704 | 114,280 | 114,862 |

**Table 2:** Projected retirements per burner age – Unitary Plan mechanism (sourced from DEPM)

| | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Package 1: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 104,283 | 99,828 | 95,454 | 91,702 | 88,303 | 85,222 | 82,583 | 80,204 | 78,054 | 76,113 | 74,363 | 72,544 | 71,169 | 70,156 | 70,047 | 70,044 | 70,066 |
| Package 1: | Pre-1991 retired under programme | - | - | - | - | - | - | 655 | 463 | 259 | 130 | 45 | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 1: | Post-1991 retired under programme | - | - | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,231 | 2,007 | 1,762 | 1,498 | 1,249 | 1,013 | 791 | 580 | 353 | 187 | 31 | - | - | - |
| Package 1: | Open fires retired under programme | - | - | - | - | - | - | 787 | 675 | 580 | 497 | 427 | 366 | 314 | 270 | 232 | 199 | 171 | 146 | 126 | 108 | 93 | 79 | 68 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 2: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 96,641 | 95,845 | 94,676 | 93,392 | 92,236 | 91,292 | 90,183 | 89,288 | 88,372 | 87,435 | 86,476 | 85,498 | 84,500 | 83,483 | 82,447 | 81,393 | 80,321 |
| Package 2: | Pre-1991 retired under programme | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 2: | Post-1991 retired under programme | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 2: | Open fires retired under programme | - | - | - | - | - | - | 13,117 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 3: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 96,187 | 95,189 | 94,055 | 93,357 | 92,853 | 92,529 | 92,529 | 92,689 | 92,992 | 93,429 | 93,993 | 94,228 | 94,734 | 94,918 | 95,734 | 96,609 | 97,465 |
| Package 3: | Pre-1991 retired under programme | - | - | - | - | - | - | 655 | 463 | 259 | 130 | 45 | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 3: | Post-1991 retired under programme | - | - | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,231 | 2,007 | 1,762 | 1,498 | 1,249 | 1,013 | 791 | 580 | 353 | 187 | 31 | - | - | - |
| Package 3: | Open fires retired under programme | - | - | - | - | - | - | 13,117 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Package 4: | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 94,259 | 91,332 | 88,270 | 85,645 | 83,212 | 80,960 | 79,033 | 77,264 | 75,639 | 74,148 | 72,784 | 71,296 | 70,204 | 69,435 | 69,536 | 69,713 | 69,890 |
| Package 4: | Pre-1991 retired under programme | - | - | - | - | - | - | 655 | 463 | 259 | 130 | 45 | - | - | - | - | - | - | - | - | - | - | - | - |
| Package 4: | Post-1991 retired under programme | - | - | - | - | - | - | 2,747 | 2,582 | 2,427 | 2,231 | 2,007 | 1,762 | 1,498 | 1,249 | 1,013 | 791 | 580 | 353 | 187 | 31 | - | - | - |
| Package 4: | Open fires retired under programme | - | - | - | - | - | - | 13,117 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| BAU | Total burners | 109,847 | 109,660 | 109,415 | 109,265 | 109,202 | 109,216 | 109,301 | 109,449 | 109,303 | 109,117 | 109,126 | 109,410 | 109,586 | 110,029 | 110,499 | 110,992 | 111,505 | 112,035 | 112,579 | 113,137 | 113,704 | 114,280 | 114,862 |

According to the DEPM model, Packages 1 and 4 would yield the biggest decline in burners followed by Package 2. Package 3 is expected to result in the smallest decrease in burner numbers.

**Envelope 1: Package summary**

Four policy packages have been defined in Metcalfe and Kuschel (2010) and each package combines different *policy options* to managing domestic emissions. The key policy options identified by Metcalfe and Kuschel (2010) are:

- 'Point of Sale rule': this type of rule would require all pre-National Environmental Standards (NES) wood-burners or open fires to be replaced with a NES compliant wood-burner or clean heat alternative when a house is sold.
- 'No new installations except replacements': under this rule, new wood-burners are only installed to replace existing wood-burners or open fires.
- 'Old Appliance phase out': this option reflects an increase in the rate of removal of open fires and older burners. The specific driver/incentive stimulating the increase is not specified.
- 'Open fire prohibition': this option reflects a total prohibition of the use of open fires from a certain date.

The packages modelled as part of this CBA reflects different policy option combinations and the package names reflect the associated policy options.

The DEPM also estimates total emissions ($PM_{10}$ concentrations) based on the estimated number of burners, type of burners, burn rates and emissions per burner type (and age). The resulting $PM_{10}$ concentration in each area is therefore a function of:

- The total burners,
- The age mix of burners in each air shed, and
- The burner rate per each area.

The above variables make it possible to estimate changes in $PM_{10}$ concentrations in each area. Next the population total (and age cohorts) is used to estimate the health incidences (health effects per population unit). Appendix 1 provides additional detail about how the health effects were estimated and monetised.

An important difference between the CBR reported in the original DEPM and the CBA model developed by M.E is how population is treated. M.E's model includes population growth whereas the (original) DEPM uses a 'static' population. The implication of this is that the M.E results would be higher because it includes population growth as well as the ageing of the population. The M.E approach relates $PM_{10}$ concentrations to a larger population base because it considers population ageing. Statistics New Zealand's population projections form the basis for all population estimates and meshblocks are used as the spatial unit. Meshblocks are used to capture the spatial patterns as defined in the DEPM.

It is stressed that the population projections and distribution across Auckland uses SNZ population projections. These projections, especially the spatial distribution of households across the city may not reflect work done by Auckland Council for the (draft) Spatial Plan. This is because the Statistics New Zealand projects are used and Auckland Council may develop its own set of in-house projections.

## 2.5 Costs and benefits

An important focus on any cost-benefit analysis is to translate benefits and cost into a common measurement unit and the most common approach is to express the costs and benefits in monetary terms i.e. as dollar values. Once the benefits and costs have been calculated it is then possible to subtract the costs from the benefits – if a positive value remains then the project is expected to have a positive impact.

One of the problems of CBA is that calculating the value of benefits and costs, while intuitively simple, can be difficult to implement and monetise. The assumptions about the costs and benefits, how these were estimated and how these were used in this CBA are summarised below.

### 2.5.1 Benefit assumptions

The benefits were estimated using the emissions (and $PM_{10}$ concentrations) calculated in the DEPM. The difference in health incidences (specifically the number of cases) between the BAU and the scenario were calculated and translated into Dollar values. Note that the CBA captures the 'change from the BAU' and not the 'total savings'. Table 3 shows the values used to translate the health savings into dollar values. These values differ from earlier studies and have been increased following an update of the HAPINZ.

It is important to note that these values are likely to change as this (health economics) is an emerging research field covering not only health cost (per case) but also the relationship between the health cost and environmental factors such as air quality (including not only $PM_{10}$ but also a wider range of emissions). This will also mean that the number of cases and the value associated with these are subject to change.

The difference between the BAU health incidences (cases) and the projected number of cases was interpreted as a benefit (i.e. fewer individuals experiencing negative health consequences due to lower $PM_{10}$ levels). This benefit was then multiplied with the cost per case giving the health benefit. The sum of the health benefits (across the different health effects) reflects the 'total benefit'. Under a 'do-nothing' scenario, the PM Death cost is estimated to be in the region of $624,3m (in 2011) (see Appendix 1).

**Table 3:** Health effect ($PM_{10}$ ) and cost per case

| Health Effect | | Cost |
|---|---|---|
| Premature mortality effects | PM Deaths | $3,560,000 |
| Chronic Obstructive Pulmonary Disease* | COPD* | $75,000* |
| Acute Respiratory Hospital Admissions | RHA | $4,535 |
| Acute Cardiovascular Hospital Admissions | CHA | $6,350 |
| Restricted Activity Day | RAD | $62 |

Source: HAPINZ 2010

* - This health effect was included in the original study but was excluded from the HAPINZ study. We used same value (cost) as in the earlier report. It is stressed that only the health effects of $PM_{10}$ have been considered which may understate the 'wider' health benefits.

### 2.5.2 Cost assumptions

Two different cost groups were included in the CBA – the cost to council and the cost to homeowners. Council's costs reflect the regulatory and enforcement costs and the homeowners' costs include the appliance cost as well any installation costs.

#### Council costs

Council has identified two implementation mechanisms that could be used to steer private sector (i.e. households) to replace burners to achieve the air quality targets. The two alternatives are:

- A bylaw change,
- A plan change (Unitary Plan)

The difference between the two mechanisms relates to the implementation timeframe and when burners are removed. A summary of council's costs is presented in Table 4: Council costs and a more detailed breakdown is presented in Appendix 2.

**Table 4:** Council costs

| Option | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Bylaw ($) | 48,000 | 236,900 | 51,250 | | |
| Plan change (Unitary Plan); ($) | 1,056,350 | - | - | 144,000 | 225,100 |
| **Enforcement** | | | | | |
| Staff | $100,000 (per year) | | | | |
| Overheads | $250,000 (per year) | | | | |
| Vehicles | $120,000 | | | | |
| Contingency | $18,000 (per year) | | | | |

Source: Information obtained from Auckland Council

In addition to council's direct cost, the private sector will also incur costs during the 'set-up stages'. These costs will be incurred when preparing submissions. The cost is driven by the number of submissions prepared and is expected to reflect varying levels of interest from the private sector. The cost to the private sector of preparing and making a submission is expected to range between $21,000 and $74,500 (see Appendix 2 for an outline of how these values were derived).

It is stressed that this CBA distinguishes between council costs and Private costs and does not consider different 'incentives' such as interest free loans, low interest financing or any other financial assistance packages that the council might use to increase the take-up of burners.

It is also stressed that the CBA covers $PM_{10}$ concentrations associated with domestic fires and not council's wider 'Retrofit Your Home' programme which includes activities such as insulation and installing heat pumps.

### Home-owner costs

The private costs i.e. the cost to the homeowner, includes installation and appliance costs as well as consenting costs. The consenting cost (i.e. the cost of the consent paid to council) is incurred by the household/homeowner investing in a new wood burning appliance. An analysis of recent consenting data revealed that the weighted average cost of consents is $236.87 (see Appendix 3). In the analysis this cost was applied as a 'standard' consent rate across Auckland.

The second cost to homeowners is the cost of the appliance and its installation. Numerous options exist and the cost is influenced by various factors, including the type of burner that is installed. The burner model (and subsequent cost of the appliance) is influenced by the size of the appliance (heat output range), accessories included and model type. In addition the installation cost is influenced by numerous factors, such as the flue design and requirements, removal of existing appliances, and the integration with existing heating appliances. We estimated an 'average cost' based on house size and heating requirements. An area where further analysis is required is how households respond to the

open fire ban and a phasing out of old appliances – in particular the costs incurred by households if such policy measures are implemented. Households could respond in a number of ways ranging from removing the appliance altogether to keeping the appliance but not using it. How households respond will have an impact on the cost-benefit ratio because the cost of removing is greater than simply not using it.

A graduated scale was used to estimate the likely heating requirements across households by using the number of bedrooms as proxy for house size. This information was derived from census data and appliances were matched to houses using the bedrooms as proxy for size. For example, the owner of a two bedroom house is more likely to select a small appliance. Similarly, the owner of a three bedroom house will need to select a burner reflecting the size and heating requirement of his/her house. Almost half of Auckland houses are three bedroom dwellings meaning that the burners (appliances) that could meet the heating needs are diverse ranging from small-medium to medium-large appliances. Such diversity was catered for by using a 'weighting approach' to reflect the probability that a household might use a particular size. The relationship between house size (reflected by number of bedrooms) and potential appliance is shown in table 5.

**Table 5:** Appliance cost structure

| | **One Bedroom** | **Two Bedrooms** | **Three Bedrooms** | **Four Bedrooms** | **Five Bedrooms** | **Six Bedrooms** | **Seven Bedrooms** | **Eight/+ Bedrooms** | Installation Costs | Appliance |
|---|---|---|---|---|---|---|---|---|---|---|
| **Small** | 0.0% | 95.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2,200 | 2,200 |
| **Small-Medium** | 0.0% | 5.0% | 20.0% | 5.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2,500 | 2,775 |
| **Medium** | 0.0% | 0.0% | 60.0% | 80.0% | 5.0% | 0.0% | 0.0% | 0.0% | 2,800 | 3,125 |
| **Medium-Large** | 0.0% | 0.0% | 20.0% | 15.0% | 80.0% | 5.0% | 2.5% | 1.0% | 3,100 | 4,200 |
| **Large** | 0.0% | 0.0% | 0.0% | 0.0% | 15.0% | 95.0% | 97.5% | 99.0% | 3,200 | 4,300 |
| **Total** | 0% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | |
| **Appliance** | - | 2,229 | 3,270 | 3,269 | 4,161 | 4,295 | 4,298 | 4,299 | | |
| **Installation Costs** | - | 2,215 | 2,800 | 2,830 | 3,100 | 3,195 | 3,198 | 3,199 | | |
| **App *plus* Install** | **-** | **4,444** | **6,070** | **6,099** | **7,261** | **7,490** | **7,495** | **7,498** | | |

Source: Calculations based on SNZ Census; Information received from council; Mike Gaudin, information received from Industry (via council)

The above cost structure was also applied to each of the ten air quality areas covering Auckland capturing the mix of bedrooms in each as well as the likely appliance costs. This cost was expressed using a weighted average for each air quality area. The average cost across Auckland for an appliance and its installation is $ 5,897 (incl GST). The operational costs i.e. the cost of heating the home and the cost of fuel was not included in this analysis. Changing the appliance or installation costs will alter the results presented in the next section.

The next section summarises the scenario modelling results.

# 3.0 Key findings

This section summarises the key findings of the CBA. Both the discounted and undiscounted values are presented to present a full picture of the cost and benefit profile. Importantly the discounting process reduces the weight of future benefits. Under a discounting process, benefits felt sooner are viewed as more important. This is a function of the discounting process and is the reason why the undiscounted figures are presented. With reference to the benefit-cost ratio, the benefits are divided by the costs. The policy options with a benefit-cost ratio greater than 1 have greater benefits than costs; hence, they have positive *net* benefits. The higher the ratio, the greater the benefits relative to the costs. The results are presented using 'Total' and 'Net Present Value' (NPV) terms. A discount rate of 8% was used and it is in-line with the Treasury's default discount rate. A comparison of the packages follows.

## 3.1 Findings – comparison

When comparing the package outcomes, it is important to consider and interpret the results holistically. Appendix 4 through to Appendix 7 summarises the costs and benefits associated with each package and Appendix 8 provides the data used to prepare the following figures. The four packages and the two implementation mechanisms are compared below reflecting:

- The Cost Benefit Ratio using a discount rate of 8% (Figure 1)
- The Cost Benefit Ratio using the total (undiscounted) value (Figure 2)
- The benefits discounted at 8% (Figure 3)
- The total (undiscounted) benefits (Figure).

**Figure 1:** Cost Benefit Ratio (discounted at 8%)

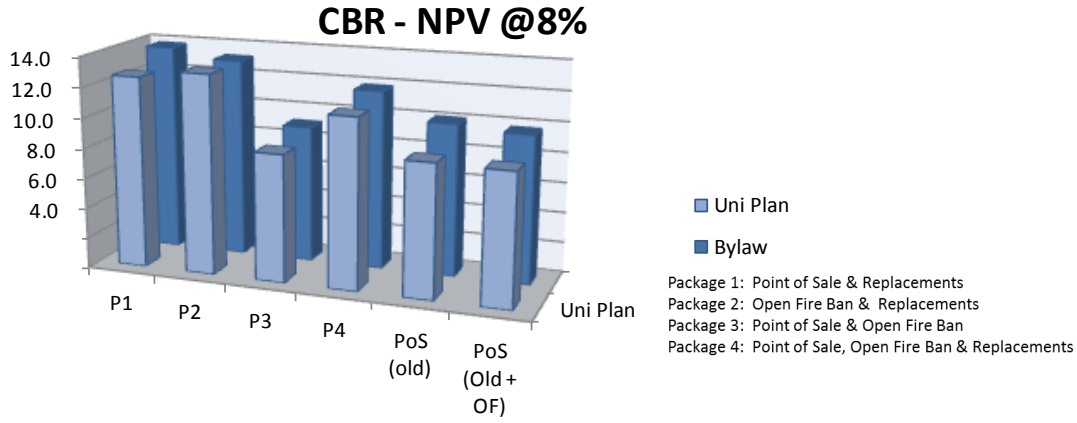


**Figure 2:** Cost Benefit Ratio (Total and undiscounted)

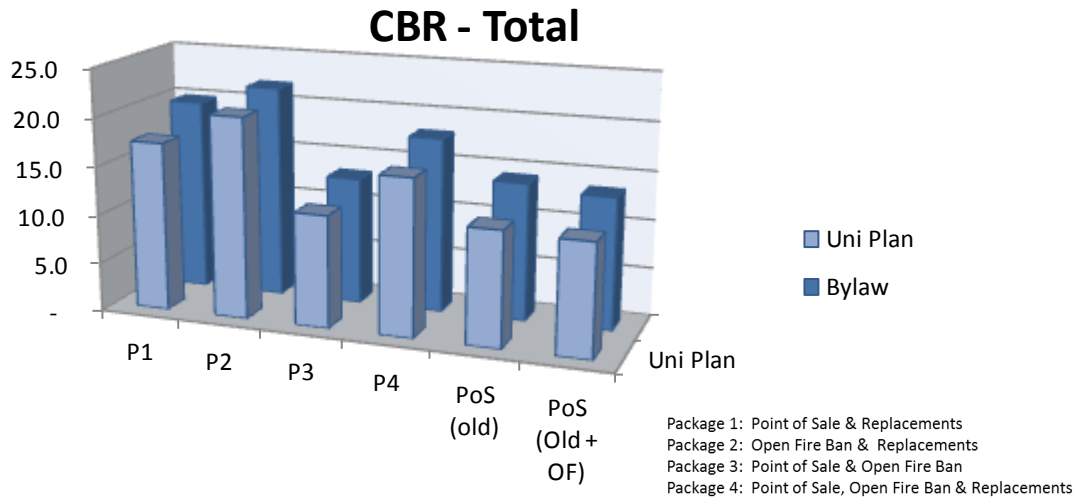



**Figure 3:** Benefits (discounted at 8%)

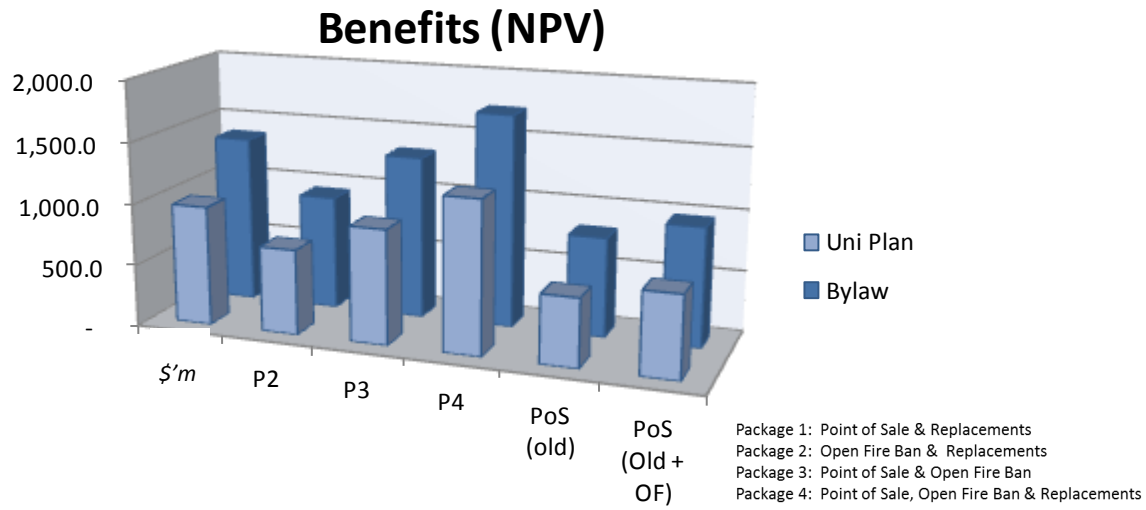
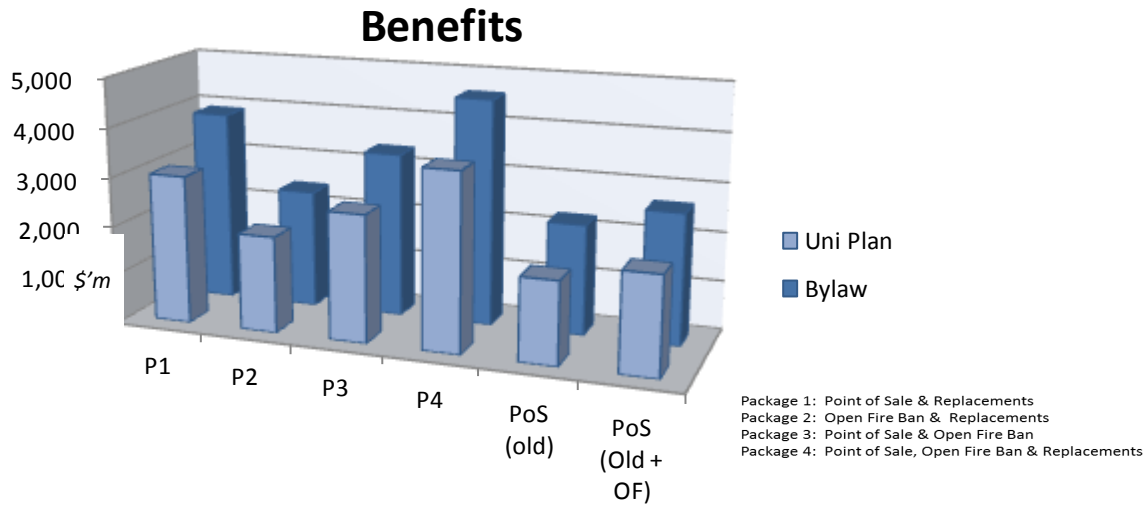


**Figure 4**: Benefits (total and undiscounted)




The following key points are made about the different options:

1. Package 1 implemented using a Bylaw approach has the highest $CBR_{NPV}$ of 14. Package 3 implemented with the Unitary Plan yields the lowest $CBR_{NPV}$ of 9. The average $CBR_{NPV}$ across the options is 10.9. Importantly, the CBR only compares the benefits and costs of each package. It does not consider the scale of benefits associated with each package (see point 3 below).
2. In terms of $CBR_{Total}$ (undiscounted), Package 2 implemented using a Bylaw has the highest CBR coming in at 22 against the lowest $CBR_{Total}$ of 12 (package 3 under the Unitary Plan). The average $CBR_{Total}$ is 15.9.
3. Package 4 has the highest benefits i.e. health effects. In undiscounted terms, this Package is projected to have health benefits of $4.59bn over the study period (2012 to 2031). Expressing this benefit in NPV terms shows that this Package is $1.73bn. Package 1 is projected to generate the second highest benefit with a NPV benefit of $1.37bn, some $360m less than Package 4. Undiscounted this difference is around $689m.

Combining these observations shows that any package (or a hybrid package) will have a positive return due to:

- The comparatively large benefit (and health effect),
- The comparatively high CBRs for the packages,
- Package 3 shows a comparatively small benefit but positive CBR.

## 3.2 Comparison of packages

The packages have different benefit and cost features and selecting the preferred option would need to informed by council's policy position and expected outcomes. Table 3.1 highlights some key points

about each package. The comparison focuses on the Cost-benefit ratio (in NPV terms) – this metric reflect the relative efficiency of the package i.e. how much benefit is achieved and how much the package would cost.

**Table 6:** Comparison

| Package | CBR ($m NPV) | Costs ($m NPV) | Benefits ($m NPV) | Comment |
|---|---|---|---|---|
| Package 1: Point of sale rule and no new installations except replacements | 14 | $99 | $1,368 | This package has the highest CBR. The overall benefits are high and the costs associated with this option are low compared to the other options. |
| Package 2: Open fire prohibitions and no new installations except replacements | 13 | $71 | $933 | This package returns the lowest cost and benefit but has the second highest CBR. |
| Package 3: Point of sale rule and open fire prohibition | 9 | $146 | $1,327 | This package has good. However, this package has comparatively high costs lowering the CBR – This package has the lowest CBR ratio of the four packages (but as mentioned, the second highest benefits) |
| Package 4: Point of sale rule, open fire prohibition, and no new installations except replacements. | 12 | $146 | $1,728 | Package 4 delivers the highest benefit but it costs the most. This package has the third highest CBR. |

Based on the above, the following observations can be made:

- If the aim is to maximise benefit then Package 4 and Package 1 should be selected,
- If the aim is to minimise cost (while improving air quality using domestic fires) then Package 2 or Package 1 should be pursued,
- If the overall efficiency of the package is the principle driver of the decision then the package with the best CBR should be selected – Package 1 followed by Package 2.

The differences between the packages reflect difference between the packages in terms of: the intensity with which change is affected (how many burners are removed), the timing (how quickly burners are removed) and type of burners removed (removing all burners or removing only the old burners). Importantly, the above analysis does not consider any 'implementation features/incentives' and other characteristics such as the level of intervention. The council would need to take such characteristics into account when selecting a package (or combination of packages). For example, the health benefits associated with a banning of open fires from a specific point in time will lead to a step change in $PM_{10}$ pollution. However, such an approach might encounter public resistance because of the effect on households' heating choice.

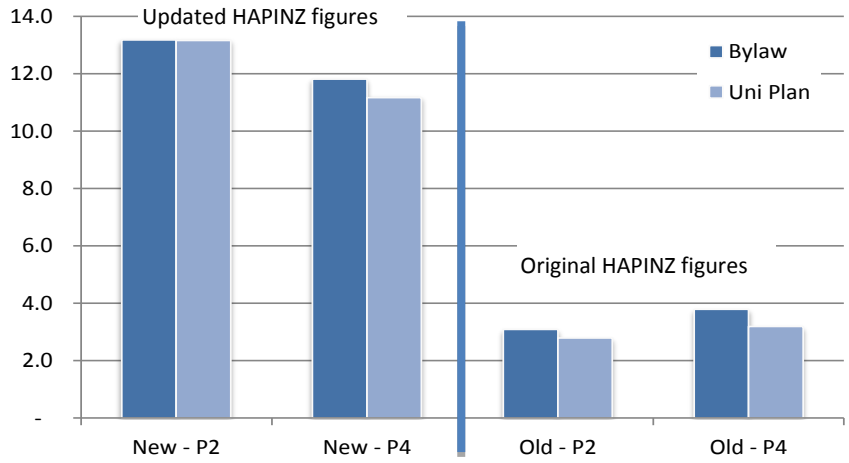
## 3.3 Comparison of previous report

As indicated in the 2011 report, any change in values from the HAPINZ report update and health costs would affect the CBA. In the 2011 report, we used early indications of how the costs were likely to change. Based on that assessment, the CBRs were expected to increase by a factor of between three and four. The overall scale of change, and the impact on the CBR, appears to have been of the correct magnitude. The main difference is associated with the Value of a Statistical Life (VOSL) – originally the value of a life was put at $750,000 and this was updated to $3.56m. Table 3.2 summarises the CBR for packages two and four using the original health costs and applying the implementation mechanisms associated with this report. The scale of change (particularly the VOSL) increases the CBR substantially.

**Table 3.1:** Comparison (using previous HAPINZ parameters)

| CBA Package 2 | | | |
|---|---|---|---|
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 109.9 | 94.7 |
| | Benefit | 572.5 | 562.3 |
| | CBR | 5.2 | 5.9 |
| **NPV** | Cost | 70.8 | 52.7 |
| | Benefit | 222.1 | 199.5 |
| | CBR | 3.1 | 3.8 |
| CBA Package 4 | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 255.1 | 224.1 |
| | Benefit | 1,090.2 | 1,034.5 |
| | CBR | 4.3 | 4.6 |
| **NPV** | Cost | 146.2 | 110.9 |
| | Benefit | 411.2 | 356.6 |
| | CBR | 2.8 | 3.2 |

**Figure 5:** Comparison of results (CBR-NPV)




A sensitivity analysis was completed during the original study and the results of that sensitivity analysis can be found in Appendix 9. We expect the overall direction and scale of change would be similar if the updated HAPINZ figures are used.

## 3.4 Uncertainties

As indicated earlier, this analysis relies on the DEPM model and therefore the uncertainties associated with that model will flow through into the results of this CBA. The main uncertainties are:

- Fuel consumption rates (Wood burner and open fire consumption estimates), and
- Emission factors.

Changing the variables associated with the above will have an impact on the BCR. The following table summarises the likely direction of the impacts. Importantly the DEPM report (TR2010/056) states that all errors have been calculated based on a 95% confidence interval for a normal distribution.

Table 3.2: **Effects of uncertainties**

| Uncertainty | Comment and effects |
|---|---|
| **Fuel consumption rates (wood burner and open fires)** | If more fuel is used (i.e. the fuel burn rates are understated) then implementing the policies will increase the estimated CBRs. This is because by burning more fuel (wood), more particles will be released into the atmosphere, in turn increasing $PM_{10}$ concentrations and the negative health effects. The inverse also applies i.e. if fuel consumption is overstated then implementing the policies will have a smaller effect. |
| **Emission factors** | The emission factors used in the DEPM reflect real life wood burner emissions and the authors of that report state that they have 'reasonable confidence' in the emission factors. However, they indicate that the emission factors are sensitive to factors such as operator behaviour and fuel quality. Increasing the emission factors (i.e. more emissions per unit of fuel burned) will lead to higher emissions. In turn this means that by removing burners the overall effects of the policy interventions will be greater (i.e. the CBR will improve). Similarly, the inverse also holds, if the emission factors are lower (less g/kg) then the resulting CBR will be lower (less pollution will be removed because the emission factors are better i.e. the burners burn cleaner) |

# 4.0 Other considerations and issues

This CBR analysed the four Packages modelled in the DEPM, showing that all the policy options will contribute towards improving Auckland's air quality (via changing domestic emission). Due to the nature of the packages and the resulting CBRs, a number of options exist and council can make a case for following Packages one, two and four. These packages have comparatively large benefits as well as high CBRs. It is important to realise that in addition to the health benefits a range of other economic and non-economic benefits can be expected. These benefits arise from improvements in air quality.

## 4.1 Wider economic impacts

It is important to realise that the CBR presented above only covers the health benefits and the cost of implementing the programme (council's cost) as well as cost to the homeowner of installing the appliance (including the associated costs). These expenditures and savings are expected to have additional and wider economic impacts.

Any (wider) impact assessment would need to carefully consider how to estimate the additional demand caused by the programme. Any economic impact assessment has to ensure that only the 'net additional' cause specifically by the intervention is measured. This is sometimes referred to as 'additionality' meaning that activities that 'would have taken place anyway' and displaced activities are accounted for. If the intervention does either, then the economic impact would be necessary to adjust the 'economic' shock caused by the intervention downwards.

While wider economic impacts will be felt if council's intervention (programmes) has a stimulatory effect on the economy, it is stressed that economic impacts are not necessarily benefits. The economic impacts measuring changes in the level of economic activity do not consider environmental externalities and impacts. In addition a key issue that is not always addressed in conventional economic impact assessment is the issue of who pays and who benefits. The 'who pays'-question can also be expanded to include an analysis of the sources of funding (savings or debt funding). In this CBA the wider public benefits due to household (private) investments is captured and it is this investment that will cause additional economic impacts as the spending flows through the economy. Examples of these wider impacts are outlined in table 4.1.

It is evident that the CBA uses a relatively narrow definition of benefits (only the health benefits) but this minimises the risk of double counting. Further, this definition aligns with earlier work (notably HAPINZ) and including the above impacts would lift the CBR.

**Table 4.1:** Wider economic impacts

| Impact | Description and considerations |
|---|---|
| Construction effect | Under the different packages some burners are replaced and new burners are installed. This activity will have a construction impacts. The construction impact will be due to the increasing demand for building activity driven by the need to remove/install the appliances into homes. When considering that the construction trade services has a Type II Value added multiplier of 2.87 then it any extra spending will flow through the rest of the economy. Including the construction effect into the CBR would increase it. |
| Retail effect | Because the appliances would be purchased by households/owners from retailers again giving rise to some additional economic impacts via the multiplier effect (housewares and appliances' multiplier Type II VA Multiplier is 2.13). The retail sector's multiplier is comparatively low as it reflects the final point before consumption by households. |
| Changes in household disposable income | Substitution between heating sources, or introducing a new source altogether would change households' budgets. If a household switches to a more energy efficient source then it is likely to spend a smaller portion of its household budget on heating meaning that the household saves. Importantly this 'savings' would need to cover the investment (cost of installing the appliance) so the true savings would only be felt after the 'payback' period. If the appliance was cash (or savings) funded then the changes in disposable income would need to be greater than the interest earned (on the savings used) otherwise the household would be comparatively worse off. |
| Labour force effects | Unhealthy individuals have difficulty in contribution to the labour market. While some of the health costs are covered, the cost of a lost 'labour unit' is not included in the analysis. |

Multipliers sourced from M.E GRIT model and is for the Auckland Council area

## 4.2 Other considerations

As part of this CBR the spatial distribution of recent consenting activity was related with the deprivation indices across Auckland. The available data limited (see Section 1.2) our ability to complete a full, city-wide analysis. Using available information shows that the consents tended to be concentrated in areas with the low deprivation indices with 47.6% of the consents being in areas with deprivation indices between 1 and 3 (see Appendix 10).

This poses some other questions about the use of burners as source of heating and specifically the implications for household budgets and the type of fuel used. It is conceivable that some households aiming to reduce their heating costs (i.e. the cost of fuel) might use unsafe fuel (treated timber). Burning treated timber can release arsenic which can then be inhaled. According to Peters (1984) around 0.1g of arsenic accumulated over a two month period can result in death, and arsenic is carcinogenic at much lower concentrations. It will be important to understand the scale of this issue in Auckland as the health implications could be significant and this could be a topic of further research.

In defining its preferred option (package to implement), council would need to consider not only the cost benefit analysis but also the wider implications. Some of the considerations associated with each package are outlined in table 4.2.

**Table 4.2:** Other considerations

| | |
|---|---|
| Point of Sale rule | Lowering of extractable equity as some of it is used to 'upgrade' the burner before selling. |
| | Potential forced loss of a suitable heating system. If for example a property is prepared for sale by simply removing the burner then it could leave the new owners with inadequate warmth (leading to other health problems). |
| | Potentially long period to remove all burners as old burners are only upgraded at the end of their useful life or when the particular house is sold. |
| | People residing in rental properties may miss out on upgraded heating systems. |
| | The timing of this rule (coinciding with the sale of a property) might be an easy time to install new heating sources due to the timing of the cash flow. The practical arrangements would need to be worked out. For example the timelines between, unconditional contract, settlement and the installation activities would need to be clarified. |
| Open Fire Ban | Loss of future heating option |
| | Households with no alternative main heating sources to open fires will face the costs of having to purchase other heating system(s). This cost might be prohibitive forcing the households to 'under heat' their homes leading to other health consequences. |
| | Use of alternative heating forms will improve household air quality and warmth with consequent health gains |
| | Increased electricity or gas charges will adversely impact household budgets. Future supply problems for these energy sources will also impact households |
| | The ban could trigger a strong uptake of other heating sources which could lead to price pressures. |
| Replacements | Some households may attempt to extend the useful life of their burners beyond design specifications. This might give rise to other risks such as house fires caused by appliance failures. |
| | By using old technology burners, households might have higher heating bills – the payback period of replacing burners could limit the scale of any voluntary replacement activity. |
| Other considerations | Changes in heating prices could adversely impact household budgets putting pressure on households. . |
| | Fuel supply security (and shocks) will impact on households and their budgets. |
| | Large-scale installations of clean heat sources (specifically heat pumps) could lead to a 'net increase' in emissions[1] because the appliance is now used more extensively and is also used in the summer for cooling purposes. |

In addition to the package specific considerations, council would also need to consider the impact on specific community groups and sectors of society. As part of this study, the spatial distribution of consenting activities was looked at and it was found that a large portion of installation activity was undertaken in the lower decile areas.

Care would need to be taken to ensure that management options support council's intended outcomes. This would need to include effective options to mitigate any negative socio economic impacts and the main driver of these impacts. A literature review showed that a key reason for households not adopting newer heating solutions is the financial considerations. A potential unintended consequence of the policy to remove (change) burners used in Auckland's homes is that

[1] This would depend on the electricity mix – hydro, geothermal or coal based electricity generation.

some households might opt to remove the burner without installing another heating source (burner or otherwise). This will then lead to cold homes – with a different set of health (community costs).

Any policy and incentive package would need to consider the trade-offs between the community wide benefits (i.e. the health savings) and the household budgets being impacted (the private costs).

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# 6.0 Appendices

## Appendix 1: Approach

Estimating the health effects was done by combining the DEPM outputs, specifically burner numbers and burn rates, with population estimates (at a meshblock/Census Area Unit level) and applying the health effect formulas outlined in the HAPINZ study. We used the latest available population projections running from 2006 to 2031 to estimate the number of people that would be exposed to the $PM_{10}$ concentrations as implied by the DEPM model. With reference to the health effects, we replicated the HAPINZ formulas in our model recalculating the number of people that would be negatively affected by the $PM_{10}$ concentrations. This provided a number of people that were affected by the health conditions used in the report (Premature mortality effects, Chronic Obstructive Pulmonary Disease, Acute Respiratory Hospital Admissions, Acute Cardiovascular Hospital Admissions, and Restricted Activity Day). Next, the total cost per health incident was estimated by multiplying the number of health incidents with the health costs (per incident) as outlined in the HAPINZ report.

The health effects associated with each package (i.e. council's policy position) were modelled and because each package is expected to reduce the number of burner, it is assumed that the $PM_{10}$ concentrations would reduce. In turn, this will lead to lower health cost because fewer people will suffer from air quality related health effects. This 'improvement' (or reduction) in the number of people with air quality health effects is interpreted as the benefit and is measured against a baseline (or a do-nothing) scenario. This baseline reflects the current situation in terms of the number of people exposed to the estimated $PM_{10}$ concentrations (based on the DEPM results), the estimated health effects (using the HAPINZ formulas) and the projected population numbers.

# Appendix 2: Council costs

**BYLAW**

| | Direct Costs | Total Cost (Including Council Overheads) | Timeframe |
|---|---|---|---|
| Paper to proceed with Bylaw | $1,600 | $4,000 | 2013 |
| Draft bylaw | $9,600 | $24,000 | 2013 |
| Statement of proposal preparation | $8,000 | $20,000 | 2013 |
| Council Paper | $3,200 | $8,000 | 2014 |
| Notification | $44,520 | $111,300 | 2014 |
| Analyse submissions | $24,800 | $62,000 | 2014 |
| Hearings | $12,640 | $31,600 | 2014 |
| Deliberations report | $8,000 | $20,000 | 2014 |
| Report To council to confirm Bylaw | $1,600 | $4,000 | 2014 |
| Final report distribution | $10,500 | $26,250 | 2014 |
| Public Notice Bylaw Approval | $10,000 | $25,000 | 2015 |
| Total | $134,460 | $336,150 | |

| Private cost of Submitting | | | | |
|---|---|---|---|---|
| 500 Submissions | Share of submission | Time spent preparing Submission | Cost of making a submission | Total Cost ($) |
| 450 | 90% | 0.5 | 20 | 4,500 |
| 45 | 9% | 5 | 20 | 4,500 |
| 5 | 1% | 16 | 150 | 12,000 |
| Private Cost | | | | 21,000 |

**Plan Change: Unitary Plan**

| | Direct Costs | Total Cost (Including council Overheads) | Timeframe |
|---|---|---|---|
| Paper to proceed with Regional Plan Change | $1,600 | $4,000 | 2013 |
| Draft Plan Provisions | $9,600 | $24,000 | 2013 |
| Section 32 Report | $8,000 | $20,000 | 2013 |
| Council Paper | $3,200 | $8,000 | 2013 |
| Notification | $24,040 | $60,100 | 2013 |
| Summary of Decisions Requested | $35,600 | $89,000 | 2013 |
| Further Submissions and S42A report | $18,800 | $47,000 | 2013 |
| Hearings | $321,700 | $804,250 | 2013 |
| Final Report | $8,000 | $20,000 | 2016 |
| Final Report Distribution | $10,000 | $25,000 | 2016 |
| Public Notification | $20,040 | $50,100 | 2016 |
| Appeal Summary | $19,560 | $48,900 | 2016 |
| Contested hearing | $55,200 | $138,000 | 2017 |
| Section 17 council Approval | $14,800 | $37,000 | 2017 |
| Public Notification | $20,040 | $50,100 | 2017 |
| TOTAL | $570,180 | $1,425,450 | |

# Appendix 3: Consenting cost (weighted average)

| Average per Legacy council | | | | |
|---|---|---|---|---|
| Consent Title | ACC | NSC | RDC | WCC |
| Heating appliances solid fuel heater | 185.3 | - | - | - |
| Fireplace | - | 194.5 | - | - |
| Chimney and Fireplace | - | - | 296.6 | - |
| Solid Fuel Heaters | - | - | - | 313.7 |
| | | | | |

| Counts | | | | | |
|---|---|---|---|---|---|
| | ACC | NSC | RDC | WCC | % of Count |
| Heating appliances solid fuel heater | 427 | - | - | - | 26.9% |
| Fireplace | - | 516 | - | - | 32.6% |
| Chimney and Fireplace | - | - | 317 | - | 20.0% |
| Solid Fuel Heaters | - | - | - | 325 | 20.5% |
| | | | | | |

| Weighted Average Consent cost | $ 236.87 |
|---|---|

# Appendix 4: Package 1

| Package 1: | Unitary Plan | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COSTS** | **Policy Implementation** | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 1.06 | - | - | 0.14 | 0.23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | - | - | 0.02 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | - | - | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | **Private Cost** | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | - | - | 0.98 | 0.87 | 0.77 | 0.67 | 0.59 | 0.50 | 0.43 | 0.36 | 0.29 | 0.23 | 0.18 | 0.12 | 0.07 | 0.03 | 0.02 |
| | Installation cost | - | - | - | - | - | - | 24.67 | 21.95 | 19.31 | 16.94 | 14.80 | 12.70 | 10.82 | 9.06 | 7.43 | 5.90 | 4.48 | 2.98 | 1.87 | 0.83 | 0.55 |
| | **Total Costs** | **-** | **-** | **1.06** | **-** | **-** | **0.17** | **26.53** | **23.44** | **20.72** | **18.29** | **16.08** | **13.93** | **11.99** | **10.19** | **8.52** | **6.97** | **5.52** | **3.99** | **2.87** | **1.82** | **1.57** |
| **BENEFITS** | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | - | - | 32.75 | 62.90 | 89.29 | 112.16 | 133.00 | 153.54 | 171.44 | 190.04 | 207.33 | 223.36 | 238.19 | 251.66 | 261.39 | 266.61 | 262.43 | 257.17 |
| | COPD | - | - | - | - | - | 1.02 | 1.95 | 2.75 | 3.44 | 4.06 | 4.67 | 5.19 | 5.72 | 6.21 | 6.66 | 7.08 | 7.45 | 7.72 | 7.85 | 7.70 | 7.53 |
| | RHA | - | - | - | - | - | 0.02 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.12 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| | CHA | - | - | - | - | - | 0.01 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| | RAD | - | - | - | - | - | 0.10 | 0.20 | 0.28 | 0.35 | 0.42 | 0.48 | 0.53 | 0.59 | 0.64 | 0.68 | 0.73 | 0.76 | 0.79 | 0.81 | 0.79 | 0.77 |
| | **Total Benefits** | **-** | **-** | **-** | **-** | **-** | **33.90** | **65.11** | **92.41** | **116.07** | **137.61** | **158.83** | **177.32** | **196.53** | **214.37** | **230.92** | **246.21** | **260.11** | **270.14** | **275.51** | **271.16** | **265.70** |

| Package 1: | Bylaw | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COSTS** | **Policy Implementation** | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 0.05 | 0.24 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | 0.02 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | 0.56 | 0.58 | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | **Private Cost** | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | 1.08 | 0.96 | 0.86 | 0.75 | 0.65 | 0.56 | 0.48 | 0.41 | 0.34 | 0.28 | 0.22 | 0.16 | 0.11 | 0.06 | 0.03 | 0.02 | 0.02 |
| | Installation cost | - | - | - | - | 27.24 | 24.30 | 21.61 | 18.89 | 16.40 | 14.22 | 12.15 | 10.29 | 8.58 | 6.98 | 5.48 | 4.09 | 2.72 | 1.43 | 0.66 | 0.56 | 0.48 |
| | **Total Costs** | **-** | **-** | **0.05** | **0.26** | **28.93** | **25.85** | **23.07** | **20.27** | **17.70** | **15.46** | **13.32** | **11.42** | **9.66** | **8.03** | **6.50** | **5.08** | **3.69** | **2.37** | **1.61** | **1.54** | **1.49** |
| **BENEFITS** | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | 34.98 | 67.23 | 96.93 | 128.91 | 151.51 | 171.77 | 190.49 | 207.57 | 223.61 | 240.48 | 256.15 | 270.69 | 282.75 | 293.10 | 294.77 | 290.47 | 285.73 | 280.59 |
| | COPD | - | - | - | 1.10 | 2.11 | 3.02 | 4.00 | 4.67 | 5.27 | 5.82 | 6.31 | 6.77 | 7.24 | 7.68 | 8.08 | 8.40 | 8.68 | 8.70 | 8.55 | 8.39 | 8.21 |
| | RHA | - | - | - | 0.02 | 0.04 | 0.05 | 0.07 | 0.09 | 0.10 | 0.11 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.16 | 0.15 | 0.15 |
| | CHA | - | - | - | 0.01 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| | RAD | - | - | - | 0.11 | 0.22 | 0.31 | 0.41 | 0.48 | 0.54 | 0.60 | 0.65 | 0.69 | 0.74 | 0.79 | 0.83 | 0.86 | 0.89 | 0.89 | 0.88 | 0.86 | 0.84 |
| | **Total Benefits** | **-** | **-** | **-** | **36.23** | **69.62** | **100.35** | **133.44** | **156.81** | **177.75** | **197.09** | **214.73** | **231.28** | **248.69** | **264.86** | **279.84** | **292.28** | **302.94** | **304.64** | **300.16** | **295.24** | **289.90** |

# Appendix 5: Package 2

| Package 2: | Unitary Plan | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COSTS** | **Policy Implementation** | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 1.06 | - | - | 0.14 | 0.23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | - | - | 0.02 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | - | - | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | **Private Cost** | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | - | - | 3.11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Installation cost | - | - | - | - | - | - | 78.38 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | **Total Costs** | **-** | **-** | **1.06** | **-** | **-** | **0.17** | **82.37** | **0.63** | **0.65** | **0.67** | **0.70** | **0.72** | **0.75** | **0.77** | **0.80** | **0.83** | **0.86** | **0.89** | **0.92** | **0.96** | **0.99** |
| **BENEFITS** | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | - | - | 92.98 | 93.90 | 95.40 | 97.45 | 100.04 | 103.16 | 106.81 | 110.97 | 115.60 | 120.71 | 126.28 | 132.11 | 138.36 | 145.03 | 152.10 | 159.57 |
| | COPD | - | - | - | - | - | 2.90 | 2.91 | 2.94 | 2.99 | 3.06 | 3.14 | 3.23 | 3.34 | 3.46 | 3.60 | 3.75 | 3.91 | 4.09 | 4.27 | 4.46 | 4.67 |
| | RHA | - | - | - | - | - | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 |
| | CHA | - | - | - | - | - | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 |
| | RAD | - | - | - | - | - | 0.30 | 0.30 | 0.30 | 0.31 | 0.31 | 0.32 | 0.33 | 0.34 | 0.36 | 0.37 | 0.38 | 0.40 | 0.42 | 0.44 | 0.46 | 0.48 |
| | **Total Benefits** | **-** | **-** | **-** | **-** | **-** | **96.26** | **97.20** | **98.74** | **100.84** | **103.51** | **106.72** | **110.48** | **114.75** | **119.53** | **124.79** | **130.53** | **136.55** | **143.00** | **149.87** | **157.17** | **164.86** |

| Package 2: | Bylaw | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COSTS** | **Policy Implementation** | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 0.05 | 0.24 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | 0.02 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | 0.56 | 0.58 | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | **Private Cost** | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | 3.69 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Installation cost | - | - | - | - | 92.97 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | **Total Costs** | **-** | **-** | **0.05** | **0.26** | **97.26** | **0.58** | **0.60** | **0.63** | **0.65** | **0.67** | **0.70** | **0.72** | **0.75** | **0.77** | **0.80** | **0.83** | **0.86** | **0.89** | **0.92** | **0.96** | **0.99** |
| **BENEFITS** | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | 105.00 | 104.87 | 105.35 | 106.52 | 108.26 | 110.56 | 113.39 | 116.76 | 120.66 | 125.06 | 129.95 | 135.31 | 141.12 | 147.18 | 153.66 | 160.56 | 167.86 | 175.55 |
| | COPD | - | - | - | 3.30 | 3.28 | 3.28 | 3.30 | 3.34 | 3.39 | 3.46 | 3.55 | 3.65 | 3.77 | 3.89 | 4.04 | 4.19 | 4.36 | 4.54 | 4.73 | 4.93 | 5.14 |
| | RHA | - | - | - | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 |
| | CHA | - | - | - | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 |
| | RAD | - | - | - | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.36 | 0.36 | 0.37 | 0.39 | 0.40 | 0.41 | 0.43 | 0.45 | 0.47 | 0.48 | 0.51 | 0.53 |
| | **Total Benefits** | **-** | **-** | **-** | **108.74** | **108.59** | **109.07** | **110.26** | **112.05** | **114.40** | **117.32** | **120.78** | **124.80** | **129.33** | **134.36** | **139.88** | **145.88** | **152.12** | **158.81** | **165.92** | **173.45** | **181.38** |

# Appendix 6: Package 3

| Package 3: | Unitary Plan | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COSTS | Policy Implementation | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 1.06 | - | - | 0.14 | 0.23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | - | - | 0.02 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | - | - | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | Private Cost | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | - | - | 3.90 | 0.71 | 0.63 | 0.55 | 0.49 | 0.42 | 0.35 | 0.30 | 0.24 | 0.19 | 0.14 | 0.08 | 0.04 | 0.01 | - |
| | Installation cost | - | - | - | - | - | - | 98.35 | 17.91 | 15.84 | 13.97 | 12.24 | 10.51 | 8.94 | 7.45 | 6.04 | 4.72 | 3.46 | 2.10 | 1.12 | 0.19 | - |
| | **Total Costs** | **-** | **-** | **1.06** | **-** | **-** | **0.17** | **103.12** | **19.25** | **17.12** | **15.20** | **13.43** | **11.65** | **10.04** | **8.52** | **7.09** | **5.73** | **4.46** | **3.08** | **2.09** | **1.15** | **0.99** |
| BENEFITS | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | - | - | 107.58 | 121.09 | 131.84 | 139.91 | 146.67 | 153.72 | 158.63 | 164.64 | 169.65 | 173.67 | 176.67 | 179.19 | 178.51 | 176.21 | 165.67 | 154.28 |
| | COPD | - | - | - | - | - | 3.35 | 3.76 | 4.07 | 4.29 | 4.48 | 4.67 | 4.80 | 4.96 | 5.08 | 5.18 | 5.25 | 5.31 | 5.27 | 5.19 | 4.86 | 4.52 |
| | RHA | - | - | - | - | - | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.08 |
| | CHA | - | - | - | - | - | 0.04 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 |
| | RAD | - | - | - | - | - | 0.34 | 0.39 | 0.42 | 0.44 | 0.46 | 0.48 | 0.49 | 0.51 | 0.52 | 0.53 | 0.54 | 0.54 | 0.54 | 0.53 | 0.50 | 0.46 |
| | **Total Benefits** | **-** | **-** | **-** | **-** | **-** | **111.38** | **125.35** | **136.45** | **144.78** | **151.75** | **159.02** | **164.07** | **170.26** | **175.42** | **179.54** | **182.62** | **185.20** | **184.49** | **182.09** | **171.18** | **159.40** |

| Package 3: | Bylaw | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COSTS | Policy Implementation | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 0.05 | 0.24 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | 0.02 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | 0.56 | 0.58 | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | Private Cost | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | 4.54 | 0.77 | 0.69 | 0.61 | 0.53 | 0.46 | 0.39 | 0.33 | 0.28 | 0.22 | 0.17 | 0.12 | 0.07 | 0.03 | - | - | - |
| | Installation cost | - | - | - | - | 114.62 | 19.52 | 17.50 | 15.37 | 13.38 | 11.62 | 9.92 | 8.38 | 6.93 | 5.57 | 4.28 | 3.05 | 1.83 | 0.66 | - | - | - |
| | **Total Costs** | **-** | **-** | **0.05** | **0.26** | **119.78** | **20.87** | **18.79** | **16.60** | **14.56** | **12.76** | **11.01** | **9.44** | **7.96** | **6.56** | **5.25** | **4.01** | **2.76** | **1.58** | **0.92** | **0.96** | **0.99** |
| BENEFITS | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | 121.51 | 135.91 | 148.94 | 165.32 | 173.15 | 179.35 | 184.61 | 188.71 | 192.17 | 196.77 | 200.44 | 203.15 | 204.14 | 205.07 | 200.02 | 189.24 | 178.25 | 167.03 |
| | COPD | - | - | - | 3.82 | 4.26 | 4.64 | 5.13 | 5.34 | 5.51 | 5.64 | 5.74 | 5.81 | 5.92 | 6.01 | 6.06 | 6.06 | 6.07 | 5.91 | 5.57 | 5.23 | 4.89 |
| | RHA | - | - | - | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.09 |
| | CHA | - | - | - | 0.05 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 |
| | RAD | - | - | - | 0.39 | 0.44 | 0.48 | 0.53 | 0.55 | 0.56 | 0.58 | 0.59 | 0.60 | 0.61 | 0.62 | 0.62 | 0.62 | 0.62 | 0.61 | 0.57 | 0.54 | 0.50 |
| | **Total Benefits** | **-** | **-** | **-** | **125.84** | **140.74** | **154.21** | **171.13** | **179.21** | **185.59** | **191.00** | **195.22** | **198.76** | **203.49** | **207.25** | **210.02** | **211.02** | **211.96** | **206.71** | **195.55** | **184.18** | **172.58** |

# Appendix 7: Package 4

| Package 4: | Unitary Plan | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COSTS | Policy Implementation | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 1.06 | - | - | 0.14 | 0.23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | - | - | 0.02 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | - | - | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | Private Cost | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | - | - | 3.90 | 0.71 | 0.63 | 0.55 | 0.49 | 0.42 | 0.35 | 0.30 | 0.24 | 0.19 | 0.14 | 0.08 | 0.04 | 0.01 | - |
| | Installation cost | - | - | - | - | - | - | 98.35 | 17.91 | 15.84 | 13.97 | 12.24 | 10.51 | 8.94 | 7.45 | 6.04 | 4.72 | 3.46 | 2.10 | 1.12 | 0.19 | - |
| | **Total Costs** | **-** | **-** | **1.06** | **-** | **-** | **0.17** | **103.12** | **19.25** | **17.12** | **15.20** | **13.43** | **11.65** | **10.04** | **8.52** | **7.09** | **5.73** | **4.46** | **3.08** | **2.09** | **1.15** | **0.99** |
| BENEFITS | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | - | - | 113.82 | 133.81 | 151.29 | 166.34 | 180.32 | 194.85 | 207.49 | 221.49 | 234.74 | 247.24 | 258.98 | 269.72 | 277.07 | 280.21 | 274.22 | 267.37 |
| | COPD | - | - | - | - | - | 3.55 | 4.15 | 4.67 | 5.11 | 5.51 | 5.92 | 6.28 | 6.67 | 7.04 | 7.38 | 7.69 | 7.99 | 8.18 | 8.25 | 8.05 | 7.83 |
| | RHA | - | - | - | - | - | 0.06 | 0.08 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.12 | 0.13 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 |
| | CHA | - | - | - | - | - | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.10 |
| | RAD | - | - | - | - | - | 0.36 | 0.43 | 0.48 | 0.52 | 0.57 | 0.61 | 0.64 | 0.68 | 0.72 | 0.76 | 0.79 | 0.82 | 0.84 | 0.85 | 0.83 | 0.80 |
| | **Total Benefits** | **-** | **-** | **-** | **-** | **-** | **117.84** | **138.52** | **156.58** | **172.13** | **186.57** | **201.56** | **214.61** | **229.05** | **242.72** | **255.60** | **267.71** | **278.78** | **286.34** | **289.57** | **283.34** | **276.24** |

| Package 4: | Bylaw | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COSTS | Policy Implementation | | | | | | | | | | | | | | | | | | | | | |
| | Council -Design and establishment | - | - | 0.05 | 0.24 | 0.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Private sector inputs | - | - | - | 0.02 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Enforcement | - | - | - | - | 0.56 | 0.58 | 0.60 | 0.63 | 0.65 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.92 | 0.96 | 0.99 |
| | Private Cost | | | | | | | | | | | | | | | | | | | | | |
| | Regulatory costs | - | - | - | - | 4.54 | 0.77 | 0.69 | 0.61 | 0.53 | 0.46 | 0.39 | 0.33 | 0.28 | 0.22 | 0.17 | 0.12 | 0.07 | 0.03 | - | - | - |
| | Installation cost | - | - | - | - | 114.62 | 19.52 | 17.50 | 15.37 | 13.38 | 11.62 | 9.92 | 8.38 | 6.93 | 5.57 | 4.28 | 3.05 | 1.83 | 0.66 | - | - | - |
| | **Total Costs** | **-** | **-** | **0.05** | **0.26** | **119.78** | **20.87** | **18.79** | **16.60** | **14.56** | **12.76** | **11.01** | **9.44** | **7.96** | **6.56** | **5.25** | **4.01** | **2.76** | **1.58** | **0.92** | **0.96** | **0.99** |
| BENEFITS | Health Savings | | | | | | | | | | | | | | | | | | | | | |
| | PM Death | - | - | - | 127.51 | 148.15 | 167.65 | 190.75 | 205.56 | 218.99 | 231.72 | 243.55 | 254.99 | 267.83 | 279.98 | 291.43 | 300.80 | 308.76 | 308.35 | 302.22 | 295.91 | 289.37 |
| | COPD | - | - | - | 4.01 | 4.64 | 5.23 | 5.92 | 6.34 | 6.72 | 7.08 | 7.40 | 7.71 | 8.06 | 8.39 | 8.70 | 8.94 | 9.14 | 9.10 | 8.90 | 8.69 | 8.47 |
| | RHA | - | - | - | 0.07 | 0.08 | 0.10 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 | 0.16 | 0.16 | 0.15 |
| | CHA | - | - | - | 0.05 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 |
| | RAD | - | - | - | 0.41 | 0.48 | 0.54 | 0.61 | 0.65 | 0.69 | 0.73 | 0.76 | 0.79 | 0.83 | 0.86 | 0.89 | 0.92 | 0.94 | 0.93 | 0.91 | 0.89 | 0.87 |
| | **Total Benefits** | **-** | **-** | **-** | **132.06** | **153.41** | **173.58** | **197.46** | **212.76** | **226.61** | **239.75** | **251.95** | **263.74** | **276.98** | **289.50** | **301.29** | **310.93** | **319.12** | **318.67** | **312.31** | **305.75** | **298.98** |

# Appendix 8: Findings – individual packages

The CBA for each individual package is presented below highlighting the CBA under different implementation considerations. It is important to realise that the cost associated with council implementation does not vary across packages. This implies that the CB ratios are expected to have a similar pattern i.e. be the highest for the bylaw option and the lowest for the Unitary Plan option.

| CBA Package 1 | | | |
|---|---|---|---|
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 196 | 174 |
| | Benefit | 3,896 | 3,012 |
| | CBR | 20 | 17 |
| **NPV** | Cost | 99 | 77 |
| | Benefit | 1,368 | 972 |
| | CBR | 14 | 13 |
| CBA Package 2 | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 110 | 95 |
| | Benefit | 2,407 | 1,955 |
| | CBR | 22 | 21 |
| **NPV** | Cost | 71 | 53 |
| | Benefit | 933 | 693 |
| | CBR | 13 | 13 |
| CBA Package 3 | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 255 | 224 |
| | Benefit | 3,344 | 2,583 |
| | CBR | 13 | 12 |
| **NPV** | Cost | 146 | 111 |
| | Benefit | 1,327 | 932 |
| | CBR | 9 | 8 |
| CBA Package 4 | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 255 | 224 |
| | Benefit | 4,585 | 3,597 |
| | CBR | 18 | 16 |
| **NPV** | Cost | 146 | 111 |
| | Benefit | 1,728 | 1,239 |
| | CBR | 12 | 11 |
| Point of sale (old burners only) | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 158 | 143 |
| | Benefit | 2,243 | 1,678 |
| | CBR | 14 | 12 |
| **NPV** | Cost | 80 | 63 |
| | Benefit | 809 | 554 |
| | CBR | 10 | 9 |
| Point of sale (old burners and open fires) splits | | | |
| $'m | | Bylaw | Unitary Plan |
| **Total** | Cost | 196 | 174 |
| | Benefit | 2,655 | 1,998 |
| | CBR | 14 | 12 |
| **NPV** | Cost | 99 | 77 |
| | Benefit | 967 | 665 |
| | CBR | 10 | 9 |

# Appendix 9: Sensitivity to change in the discount rate

The sensitivity of the $CBR_{NPV}$ to changes in the cost per case was tested by adjusting the cost of each variable up and down by 10% and running the model for each package. As expected the effect on the $CBR_{NPV}$ is similar for all the packages. Reducing the health cost and the incidence rates by 10% lowers the CBR to 81% of the baseline[2]. Conversely, increasing the health costs and incidence rates by 10% each lifts the CBR to 121% of the baseline.

During the initial research, we found that the CBR is more sensitive to changes in fuel burn rates, emissions factors, and total burner numbers. The main findings (in the initial research[3]) regarding efficiency gains and the CBR were:

- A 10% reduction in the fuel burn rate (more efficient burners) lifts the $CBR_{NPV}$ by 13.6%.
- A 5% increase in the fuel burn rate (i.e. a less efficient burning) translates into a 6.8% lowering of the $CBR_{NPV.}$
- Improving the emissions factor (the productivity of the burners i.e. 'cleaner' burning) by 5% leads to a 6.8% improvement in the $CBR_{NPV}$
- Improving both the fuel burn rates and emissions factor by 5% each would lead to a 13.2% improvement in the $CBR_{NPV.}$

In addition, by changing the discount rate used to express future benefits in current values, the discounted NPV changes. The results presented in the body of the report are based on a discount rate of eight per cent – in-line with Treasury's recommended discount rates. The following tables show the $CBR_{NPV}$ using different discounting rates. As expected, a lower discount rate reduces the size of both the costs and benefits by less than a higher discount rate. This is a reflection of nature of the discounted cash flow analysis and is as expected. Importantly, discounting reflects future financial values in 'today's terms' so a smaller discount rate would have a 'smaller reducing effect'.

| Package 2 - Different Discount Rates | | | |
|---|---|---|---|
| | | Bylaw | Unitary Plan |
| **6%** | Cost | 78.5 | 60.5 |
| | Benefit | 1,156.9 | 881.0 |
| | CBR | 14.7 | 14.6 |
| **8%** | Cost | 70.8 | 52.7 |
| | Benefit | 932.9 | 693.0 |
| | CBR | 13.2 | 13.2 |
| **10%** | Cost | 64.1 | 46.0 |
| | Benefit | 762.1 | 551.4 |
| | CBR | 11.9 | 12.0 |

[2] The baseline in this case refers to the $CBR_{NPV}$ of each package.
[3] We did not update this part of the research.

| Package 4 - Different Discount Rates | | | |
|---|---|---|---|
| | | Bylaw | Unitary Plan |
| **6%** | Cost | 166.5 | 130.9 |
| | Benefit | 2,160.9 | 1,588.3 |
| | CBR | 13.0 | 12.1 |
| **8%** | Cost | 146.2 | 110.9 |
| | Benefit | 1,727.7 | 1,239.2 |
| | CBR | 11.8 | 11.2 |
| **10%** | Cost | 129.1 | 94.5 |
| | Benefit | 1,398.5 | 977.8 |
| | CBR | 10.8 | 10.3 |
| | | | |

Overall, the sensitivity analysis[4] shows a five per cent change in each variable[5] would:

- 5% change in the health cost would change the $CBR_{NPV}$ by 5%
- 5% change in the number of cases would change the $CBR_{NPV}$ by 5%
- 5% change in the fuel burn rate would change the $CBR_{NPV}$ by 6.8%
- 5% change in the emission factor would change the $CBR_{NPV}$ by 6.8%.

If the above variables are all adjusted by 5% (down) then the impact on the $CBR_{NPV}$ is a downward movement of 9.75%. However if these variables are all increased by 5% then the $CBR_{NPV}$ is 10.25% higher. This implies that the calculations are slightly more sensitive to upward adjustments.

Finally, the CBR is calculated using SNZ's medium population projections. Under Package 4, the low population projections reduce the $CBR_{NPV}$ by 5.4% while using the high projections lifts the $CBR_{NPV}$ by 5.5%. These changes are mainly due to changes in the number of individuals exposed to harmful particulate emissions and do not necessarily reflect the effects of changes to domestic emissions.

[4] From the previous research
[5] This comparison is based on Package 4

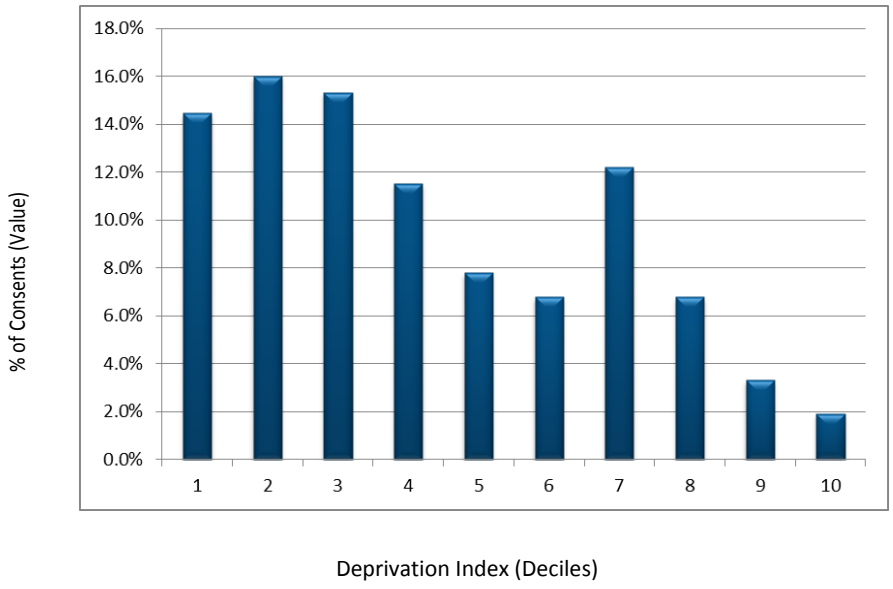
# Appendix 10: Distribution of consent per deprivation index (January 2009 – June 2011)

The spatial distribution of recent consent activity across Auckland was associated with the social deprivation index using the addresses of the consents. council provided a list of recent consent data covering four of the previous council areas and the consents were coded to meshblocks and census area units. This made it possible to explore the link between social deprivation (as expressed in the deprivation index) and the uptake of wood-burners. It is stressed that the consent dataset covered the January 2009 to June 2011 period[6]. The following figure shows the share of consents (over the total area and period) approved by deprivation decile

A key point from the above is the concentration of the activities in the lower decile areas – almost half of consents is concentrated in the lower decile areas. Potential reasons for this include:

- The higher decile areas might already have heating appliances (including heat pumps) in place
- The lower income areas have a higher share of activity (possibly) due to perceptions of lower operating costs of burners (compared to heat pumps for example).
- Another reason for the concentration in deciles 1 – 3 could be due to perceived fuel cost and availability issues.
- Decile one areas (comparatively poor areas) captured a lower share of consents (by value) and this could be due to various reasons; including:
  - Lower total disposable household income reduces the affordability and likelihood to install/upgrade a burner
  - Some properties in the lower decile areas are associated with social housing and agencies such as Housing New Zealand have been installing heat pumps in some of these areas.

Decile 7 captures a relatively high share of consents. However, this might be an anomaly caused by the period covered by the dataset.




[6] Note that this period aligns with the economic slowdown and recovery.