Indoor combustion health effects and costs

Peer review of estimated economic impacts

NZIER report to the Energy Efficiency & Conservation Authority

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Authorship

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Key Findings

Scope

The Energy Efficiency and Conservation Authority (EECA) commissioned the report *'Indoor Combustion in New Zealand Homes: Health Effects and Costs'*[1] (referred to as the '*Indoor Combustion: Health Costs'* report in the rest of this review) to estimate the health-related costs of emissions from wood burners, gas stoves, and unflued gas heaters in New Zealand.

The Indoor Combustion: Health Costs report is specifically aimed at '*providing indoor health impact costs – suitable for being included in the next update of the Treasury's Cost Benefit Analysis (CBAx) model.'*[2]

The scope of our review is limited to the following sections of the Indoor Combustion: Health Costs report: *'Chapter 4 Economic Analysis'* and comment on how the conclusions from Chapter 4 are presented in *'Chapter 5 Results'*.

We understand from EECA that the Indoor Combustion: Health Costs report was expected to apply the same methodology as used in the HAPINZ 3.0[3] report. While we accept this point, we comment on what we see as areas for improvement in the HAPINZ 3.0 methodology that have flowed through into the Indoor Combustion: Health Costs report.

Our approach was to check the report's analysis to confirm it was suitable to be included in the next update of the Treasury's Cost Benefit Analysis (CBAx) model.

Assessment – Indoor Combustion: Health Costs modelling

The economic modelling of the mortality and morbidity impacts in the Indoor Combustion: Health Costs report follows the approach used in HAPINZ 3.0 and applies the most recent estimate of the value of statistical life (VoSL).

We have not identified any technical errors in the updating approach, but we note the model uses the highest CBAx value for VoSL(which is the Waka Kotahi mid-point value) and this is not varied in the sensitivity analysis completed in Chapter 5. This decision needs to be carefully explained to ensure that it is a helpful addition to CBAx for the comparison of policy measures that extend lifespans.

Assessment – Weak case for use of VoSL from HAPINZ 3.0

HAPINZ 3.0 Chapter 6 notes the theoretical difference between the willingness to pay to avoid road accidents and to avoid shortening of life from air pollution:

1 Metcalfe J., Kuschel G., Wickham L., and Denne T., (2025). Indoor Combustion: Health Effects and Costs. Report prepared by Emission Impossible Ltd and Resource Economics for Energy Efficiency & Conservation Authority, June. 2025.

2 Op cit '1.1 Study scope', page 1.

3 Kuschel et al (2022). Health and air pollution in New Zealand 2016 (HAPINZ 3.0): Volume 2 – Detailed methodology. Report prepared by G Kuschel, J Metcalfe, S Sridhar, P Davy, K Hastings, K Mason, T Denne, J Berentson-Shaw, S Bell, S Hales, J Atkinson and A Woodward for Ministry for the Environment, Ministry of Health, Te Manatū Waka Ministry of Transport and Waka Kotahi NZ Transport Agency, March 2022.

In contrast, the increased risk of a fatality from air pollution applies particularly to older people so this raises the question of whether the road crash-based value is valid.[4]

While at first blush these questions may seem outside the scope of a review of whether the Chapters 4 and 5 appropriately applied and updated the methodology used in HAPINZ 3.0, they are crucial to assessing whether the analysis is adequate. This is because they are relevant to the suitability of the estimates of the health impacts of pollution based on VoSL for policy decisions allocating resources to improve health that are based on much more narrowly focused measures such as quality adjusted life years (QALYs).

Recommendations

Based on these findings NZIER recommends the following additions to the '*Indoor Combustion: Health Costs*':

- A statement that the NZTA VoSL values are above those used in the CBAx and include a calculation of the impacts using the CBAx value.
- Acknowledgement of the methodological shortcomings of applying VoSL to extension of lifespan from reduction in pollution.
- Policy makers should be made aware that the valuations of mortality costs presented are above the values used to compare other policy interventions to improve health outcomes.

4 Kuschel et al (2022). Health and air pollution in New Zealand 2016 (HAPINZ 3.0): Volume 2, 'Methods for estimating VoSL', page 109

Contents

1 Introduction

1.1 Purpose

The Energy Efficiency and Conservation Authority (EECA) commissioned the *report 'Indoor Combustion in New Zealand Homes: Health Effects and Costs'*[5] (referred to as the *Indoor Combustion: Health Costs'* report in the rest of this review) to estimate the health-related costs of emissions from wood burners, gas stoves, and unflued gas heaters in New Zealand. The report is specifically aimed at providing indoor health impact costs – suitable for being included in the next update of the Treasury's Cost Benefit Analysis (CBAx) model.

1.2 Scope

This review is limited to *'Chapter 4 Economic Analysis'* and comment on how the conclusions from Chapter 4 are presented in *'Chapter 5 Results'* of the Indoor Combustion in New Zealand Homes report.

1.3 Approach

This economic peer review aims to provide an independent and constructive assessment of the analysis presented in the report. Specifically, it evaluates whether the economic methods and assumptions are appropriate, the calculations and results are reliable, and the findings are presented in a transparent and useful manner.

Where possible, the underlying calculations in the Economic Analysis chapter were replicated to validate the figures presented in the chapter. The model's results tables and dependant functions have been checked to confirm that values were correctly drawn for the results reported in chapter 5.

[5] Metcalfe J., Kuschel G., Wickham L., and Denne T., (2025). Indoor Combustion: Health Effects and Costs. Report prepared by Emission Impossible Ltd and Resource Economics for Energy Efficiency & Conservation Authority, June. 2025.

2 Indoor Combustion: Health Costs - modelling review

2.1 Economic analysis

The report's economic analysis chapter provides useful detail on the assumptions and base calculations that underpin the modelled results. The distinction between mortality and morbidity calculations - used to assess economic and fiscal costs respectively - appropriately separate the sources of estimated impacts.

The analysis focuses on providing current values, derived from the Health and Air Pollution in New Zealand 3.0 (HAPINZ 3.0) report.

2.2 Impact measures

2.2.1 Mortality - Highest Value of Statistical Life

The VoSL selected in the report is noted as the 'national estimate of VoSL in 2021' at $12,500,000. This is the Treasury's VoSL High CBAx value (found in Row 158). Treasury's categorisation reflects an understanding that the Waka Kotahi Monetised Benefits and Costs Manual's (MBCM) midpoint source value is considered high, rather than central within the context of CBAx evaluation.[6]

Over time the methodology for VoSL has changed, resulting in a higher valuation within the MBCM report. This is due to the focus shifting from individual assessment of private risk tolerance and willingness to pay, to seeking respondents' willingness to pay into a government programme to avert one annual occurrence of a given event (NZIER 2023). Willingness to pay study results are situation specific and difficult to extrapolate to valuation of other harm or loss.

The report does not provide an explanation as to why the high CBAx value is being used over the central value. We think it would be preferable to use the Treasurys' 'central' CBAx VoSL at $8,100,000 (or $10,168,258 in 2025 terms) as a starting point or at least to include this value in the sensitivity analysis.

2.2.2 Morbidity

The morbidity costs reported in HAPINZ 3.0 for 2019 were updated to 2025 value terms using Treasury's GDP inflator. The fiscal costs identified are in relation to the likely burden on the health system are in line with the HAPINZ 3.0 methodology. While they are appropriate measures of the cost of health care, whether these are the most appropriate health impacts as a result of indoor combustion is beyond the scope of this report. The report assumes the same health impacts for pollutants in the indoor as in the outdoor air environment [page 8]. The report sites other international studies in support of this approach, but does not discuss the applicability of ERFs developed for outdoor exposure in detail. HAPINZ 3.0 methodology replicated in the model highlights the calculation of

[6] The "mid-point" term used in explanation of Treasury's CBAx row 158 High VOSL figure stems from the source study of these values containing two ambiguous results for VOSL – a high of $16.9 million and a low of $8.1 million – from which NZTA has chosen the midpoint or average of the two, at $12.5 million, as its base VOSL (in 2021 $ terms) for transport appraisals. That CBAx also contains what it calls the "central" VOSL in row 157 that coincides with the NZTA's low source value of $8.1 million. This suggests Treasury has some doubts about the validity of the higher mid-point VOSL for widespread use in CBAx and sees some merit in providing a lower value which it describes as its Central VOSL.

relative exposure response factors (ERFs) and their confidence intervals, based on 2016 outdoor airshed monitoring data. These outdoor ERFs are then calculated for the effected population giving the morbidity cost in the report.

2.2.3 Marginal impacts

Greater consideration could be given to the use of cessation lag assumptions. HAPINZ 3.0 emphasises the lagged effects of pollutant exposure due to the cumulative nature of respiratory health impacts. However, these need to be balanced against the delayed timeframes in which costs are borne by individuals.

For example, the US Environmental Protection Agency[7] (US EPA) methodology accounts for proportionally higher immediate effects of pollutants, implying that the benefits of reduced exposure occur in the near term. However, this contrasts with the long-term cumulative nature of respiratory health effects. A more explicit examination of how to balance near-term weighted costs with delayed and lifetime impacts would strengthen the robustness of the analysis.

2.3 Model functioning and results

2.3.1 Overall findings

The report provides the outputs of the model outputs for baseline and user-defined scenarios, drawing on relevant sources. For example, the estimated number of appliances is based on Stats NZ Census data and EECA reporting, extrapolated to 2025.

The model selects exclusively the unlagged VoSL for use in the result findings. The report is therefore using the highest economic value discussed within the economic analysis chapter.

Given the context of this report - where long-term health impacts are a central concern – a discussion of other context specific willingness to pay metric would be more appropriate. Including a rationale for prioritising VoSL over other measures would strengthen the analysis.

Similarly, while lagged valuations at a 2% discount rate are discussed in chapter 4, the model applies only unlagged high values in calculating air pollution costs. This assumption should likewise be made clearer in the findings.

2.3.2 Sensitivity testing

The sensitivity analysis based on HAPINZ 3.0 per-appliance annual exposure increments and household composition is useful. The approach provides insight into the reliability of results should the assumed appliance pollution or household composition expectations shift.

7 USEPA (2004). *Advisory Council on Clean Air Compliance Analysis Response to Agency Request on Cessation Lag*. Letter from the Chair Advisory Council on Clean Air Compliance Analysis and Chair of Health Effects Subcommittee to Michael O Leavitt, Administrator US Environmental Protection Agency, Washington DC, 6 December 2004. https://www.epa.gov/nscep

3 Suitability of VoSL

3.1 VoSL conceptual basis differs

The VoSL is a measure of willingness to pay to reduce the acute risk of immediate death in accidents for the general population while travelling. This is conceptually quite different from willingness to pay for reduction in the of risk of chronic exposure to environmental hazard that defers death at some time in the future.

The limitations of road safety VoSL are acknowledged in the HAPINZ 3.0 report[8]

COMEAP also notes that air pollution mostly affects older people.[9] This means it cannot be compared simply with the effects of road traffic accidents, suicide, or HIV/AIDS, which typically affect younger people. They suggest that implicit in any communication about deaths is some understanding of age at death or, equivalently, the loss of life implied by death at various ages. This is best captured explicitly – which, in effect, means discussion in terms of total population survival time (or of life years gained or lost).

The 'Indoor Combustion: Health Effects and Costs' does not seem to acknowledge this point. The report could be improved by acknowledging that the use of VoSL is likely to produce higher estimates of health costs relative to the other measures that could be used. Also, the literature review does not appear to have considered research on willingness to pay to avoid air pollution. We acknowledge that the literature is sparse and that the methodology is different from HAPINZ 3.0. Examples of the comments we found include:

- *The results concerning willingness to pay to abate pollution are in line with Welsch (2003) and Ferreira and Modo (2010), in which individuals were willing to pay a maximum of US$900 per year to abate one μg/m3 of NO2 and US$870 to abate a one μg/m3 of PM10 annually, respectively.* [10].
- *The BNZP policy compared with BAU gave 4.9 (95 % confidence interval 1.0–9.0) million life-years gained (LYG) (UK population, to 2154), including 1.1 (0.7–1.6) million LYG from active travel improvements. Avoided COPD and childhood asthma cases were 201,000 (150,000 – 250,000) and 192,000 (64,600–311,000). The monetised air quality morbidity benefits (£52.1 (36.4 – 67.8) billion) substantially added to the air quality mortality benefits (£77.9 (42.9 to 90.8) billion). Total yearly monetised benefits for*

8 Kuschel et al (2022). Health and air pollution in New Zealand 2016 (HAPINZ 3.0): Volume 2 – Detailed methodology. Report prepared by G Kuschel, J Metcalfe, S Sridhar, P Davy, K Hastings, K Mason, T Denne, J Berentson-Shaw, S Bell, S Hales, J Atkinson and A Woodward for Ministry for the Environment, Ministry of Health, Te Manatū Waka Ministry of Transport and Waka Kotahi NZ Transport Agency, March 2022. Page 107

9 *'We find this result through the simple assumption that the percentage impact is the same at all ages and there is a higher initial death rate amongst older people.'*

10 Maarraoui G. et al (2023), 'Willingness to Pay for Clean, Air: Evidence from the UK', IMF Working Papers WP/2**3/35**, see page 25. The abstract from the report is: *This paper uses life satisfaction data to help the design of climate mitigation policies in the United Kingdom. We assess the effects of the exposure to ambient pollutants on long-term life satisfaction and short-term mental health in the UK. We estimate augmented Cobb-Douglas utility functions using pooled and random effects ordinal logit models. Results show that increases in NO2, PM10 and PM2.5 significantly decrease the odds of longterm happiness and short-term mental health in the UK. The willingness to pay for clean air is also significant and increases with level of education. These measurements derived can be used as benchmarks for pollution abatement subsidies or pollution taxes and can help in projecting a more comprehensive assessment of costs and benefits.*

BNZP vs BAU summed to 2154 (air pollution/active travel) were £153 (122 to 184) billion (core); 278 (228 to 334) billion (+outcomes with weaker evidence)..[11]

3.2 Mismatch with other annual value of life measures

At a national level use of high values will skew decisions about where health and safety resources are directed. Researchers should explain why the derivation and application of VoSL as described are appropriate and provide guidance on how the large differences between willingness to pay measures for what are gains in health or life years should be viewed when deciding how to allocate funds between interventions.

Treasury's CBAx database has the value of a Quality Adjusted Life Year (QALY) gained of $44,783 in 2025 terms. This is drawn from the values applied by Pharmac in determining worth of medications funded. While again not directly applicable to indoor pollution harm, this health measure is significantly lower that the report's VoLY of $914,488.

The rationale and methodology behind the VoLY sensitivity analysis could also be developed further. Explaining the choice of GDP per capita for the lower bound and a 35% increase for the upper bound would enhance confidence in the robustness of the valuation[12].

11 Walton et al (2024) ' Health and associated economic benefits of reduced air pollution and increased physical activity from climate change policies in the UK', Environment International 196 (2025) 109283.

12 Affordability can be expected to affect the value of safety or longevity improvements, in the sense that over time, public willingness to pay for such improvements will vary with income levels. But treating GDP per capita as a hard limit on affordability is inconsistent with the basis of VOSL in the CBAx database which, being derived from a survey of respondents' willingness to pay for such improvements, may also reflect opportunity costs for respondents which, being forgone, do not count towards GDP.

4 Overall findings

The Economic Analysis and Results chapters of the Indoor Combustion in New Zealand Homes report provide an outline of the approach to evaluation of the health-related costs of emissions from wood burners, gas stoves, and unflued gas heaters in New Zealand.

The report is specifically aimed at providing indoor health impact costs – suitable for being included in the next update of the Treasury's Cost Benefit Analysis (CBAx) model.

The economic analysis in the 'Indoor Combustion: Health Effects and Costs' relies on the methodology used in the HAPINZ 3.0[13] report. The issues we have raised in the peer review with respect to the use of VoSL were discussed in the HAPINZ 3.0 methodology report and alternative approaches considered. The 'Indoor Combustion: Health Effects and Costs' should at least note that these are open issues.

While the analysis draws on standard frameworks for assessing economic value of these health-related impacts, we think the estimates have an upward bias and that they will be harder than necessary to integrate into the CBAx model due to:

- The selection of the high VoSL CBAx value, where the central value would be more appropriate.
- The lack of justification in applying a willingness to pay based value derived for transport accidents in substantively different health outcome contexts.
- The lack of consideration of VoLY consistency with other CBAx life year measures such as QALY.

At a national level use of high values could skew decisions about where health and safety resources are directed. This a general problem that arises from the use of different estimates of the value of avoiding premature death, or injury or adverse impacts of disease and is not unique to 'Indoor Combustion: Health Effects and Costs'. Researchers should explain why the derivation and application of VoSL and VoLY as described are appropriate and provide guidance on how the large differences between willingness to pay measures for what are gains in health or life years should be viewed when deciding how to allocate funds between interventions.

Policy makers should be explicitly made aware that the highest possible valuations of mortality costs are being presented.

[13] Kuschel et al (2022). Health and air pollution in New Zealand 2016 (HAPINZ 3.0): Volume 2 – Detailed methodology. Report prepared by G Kuschel, J Metcalfe, S Sridhar, P Davy, K Hastings, K Mason, T Denne, J Berentson-Shaw, S Bell, S Hales, J Atkinson and A Woodward for Ministry for the Environment, Ministry of Health, Te Manatū Waka Ministry of Transport and Waka Kotahi NZ Transport Agency, March 2022. Downloaded from ….

Appendix A Minor model corrections

4.1 Model calculations

As part of the peer-review process the underlying calculation of the model have been assessed. Overall, the model functioned well, drawing from the relevant data input tables and dependant sensitivity functions.

Minor discrepancies between calculations and reported figures have been noted in Table 1. Most inconsistencies are likely to be human error in displaying the findings (i.e. a typo when taking the findings from the model). None of these errors substantively effect the overall analysis and can be readily corrected.

Table 1 Errors

Page number	Comment
Page 26	**Table 6: VoLY values for sensitivity analysis** - The central VoLY 2025$ should be $914,487, rather than the presented $914,488.
Page 27	**Table 7: Morbidity values for sensitivity analyses** - HAPINZ 3.0 table 21 'Default values, plus their associated ranges, used in the HAPINZ 3.0 Health Effects Model (costs in 2019 NZ$)' has the unit of measure for asthma hospitalisations as per admission rather than the reported $ per case.
Page 29	**Table 9: Circumstances under which lagged or unlagged values are used** - A 2% discount rate as a percentage of unlagged effect to be 93.3% (rather than 93.4%). Similar across 5% and 8% discount rates.
Page 29	**Table 10: VoSL and VoLY values for policy analysis using the USEPA lag structure and a 2% discount rate** - Irrespective of the percentage of unlagged effect, lag rate used, table 10 contained inconsistencies. These calculations are unable to be confirmed.
Page 31	**Table 12: Annual indoor air pollution costs by appliance** - Gas stove total reported inconsistently between model and report
Page 32	**Table 15: New Zealand annual indoor air pollution impacts by appliance** - Asthma prevalence (<18 years) reported inconsistently between model and report
Page 33	**Table 17: Effect of exposure increments on the total annual indoor air pollution costs by appliance** – Gas stove and gas unflued heater reported inconsistently between model and report
Page 34	**Table 18: Effect of household composition on the total annual indoor air pollution costs by appliance** - Gas stove reported inconsistently between model and report

Source: NZIER